



PROCEEDINGS BOOK

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**INTERNATIONAL ENGINEERING AND TECHNOLOGY
MANAGEMENT SUMMIT**

2022

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**İSTANBUL TECHNICAL UNIVERSITY
&
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PREFACE

The 4th INTERNATIONAL ENGINEERING AND TECHNOLOGY MANAGEMENT SUMMIT, organized jointly by Istanbul Technical University and Bahcesehir University was held in Istanbul, Türkiye during October 20-21, 2022 in collaboration with American Society for Engineering Management (ASEM) and Politechika Poznanska (Poznan Technical University).

While organizing our engineering and technology management summits, we aimed to contribute to identifying and finding solutions to business problems that arise in engineering applications and technology use. We wanted to serve the field by analyzing these problems and solutions by taking into account today's rapid changes and developments, discussing the future situation and creating, increasing and diversifying the necessary environments to accomplish them.

The theme for ETMS 2022 is “BUSINESS, SOCIETAL, ENVIRONMENTAL OPPORTUNITIES and CHALLENGES in the DIGITAL AGE”. Digitalization became both the imperative and the driving force for all organizations in today’s world. Entering uncharted waters, organizations face new opportunities and challenges. As, how we do business, communicate, interact, influence and are influenced are changing, future will demand very different competencies compared to those we have today. During the summit, the digital age and the opportunities and challenges that come with it, was discussed from business, technological, societal and environmental perspectives. We would like to emphasize the changing and transforming role of the engineering management field and what might lie ahead for the profession in the new digital age.

The realization of this Summit undoubtedly required a lot of effort and support. We would like to thank everyone who supported and contributed to our summit, the ITU and BAU Rectors, the honorary chairman of our summit, ASEM administration and colleagues from Poznan Technical University for their support, the invited speakers for their speeches, the chairs for organizing invited sessions.

We would like to thank our moderators, authors, academics, researchers, students, professionals and all participants, and also to each of our organizing committee members. The book covers the abstracts and full papers in English or Turkish as the authors submitted to the summit. All submissions have been evaluated through a blind review process. Hoping the online book will be enjoyable and useful to all who are interested in research and studies and applications in the field of Engineering and Technology Management.

Best Regards,

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CONTENT

Full Papers

<i>Title</i>	<i>Page No</i>
A Data Science Project Management Methodology: From Development to Production Kadiođlu A. M., Takcı H.	2
A Digital Business Model Framework for Public Bus Transportation: Istanbul Case Study Buran B., Erçek M.	11
A New Perspective to Innovation Competitions: IdeaSprint Aktay-Kantaroglu D., Temel-Çakır A., Ekşi A., Göksel A. A., Koç H. Y., Jane O.	18
A Supervised Machine Learning Approach for Stock Transfer between Stores Coşar-Soğukuyu D. Y., Şenvar Ö., Bergin O., Mürsel A., Aysoysal B., Polat M. F., Serthaş S., Altıntaş D., Kocas B., Demirkale H.	25
Agency Problem as a Barrier in Digitalization and Organizational Learning Aksu A., Koçak G., Yelođlu H. O.	32
An Overview to Stochastic Modelling for Industrial Engineering Considering Utilization of Artificial Intelligence and Learning Systems Bulu M., Şenvar Ö.	42
Analysis of the Innovation Performances of Turkish States According to the Global Innovation Index Data with the Entropy Weighted TOPSIS Method Karahan M., Duran S.	46
Analyzing Market Potential of Particle Board by Using Data Envelopment Model for Turkey İnsel R., Çebi F.	55
Application of Digital Image Analysis to Automate Aggregate Gradation Evaluation Şeyhibrahim D., Şanal İ.	62
Applying the Principles of Engineering Management to Ethical Issues: The Case of Patient Centered Care Hallo L., Gorod A.	69
Assessing the Potential of Sustainability in Transport Sector Using Fuzzy Set Theory and Monte Carlo Simulation Al-dalain R., Çelebi D.	76
A Test Foresight Study in the European Region Çakır S., Yelođlu H. O.	82
Complications In Big Data-Based Communication In The Wake Of COVID-19: A Comparison Of North American And Nordic Practices Of Multinational Healthcare Corporations Ripley-Johnson E., Castaño-Martínez M., Öztürkcan S.	93
Corporate Big Data Analytics Capabilities and Performance Relationship: A Research for Turkey Pala İ. B., Yıldırım N., Gürgöze N. H.	100

Designing a Roadmap for Corporates to Manage Effectively In-House Ideas with an Intrapreneurship Structuring	108
İnsel R., Çebi F.	
E-Ticaret İşletmelerinde Sipariş İşleme Problemleri için Depo Otomasyon Çözümleri ve Bir Vaka Çalışması	113
Aydın B., Yüksel H.	
EGO-Driven Decision vs Strategy Audit Based Decision in the Case of International Crises	120
Hallo L., Duh G.	
Emerging Methods and Future Applications of Contemporary Knowledge Representation: A Literature Review	128
Dalkılıç A. O., Alkış-Bayhan N.	
Evaluation of Apps' Usage in Humanitarian Sector: A SWOT Analysis and Decision-Making Framework Development	135
Bal S.	
Examining the aspects impacting the engagement of volunteers on volunteering match platforms	141
Orhan M., Bayraktaroğlu A. E.	
Food Waste And The Situation In Turkey	146
Sezgit H., Camgöz-Akdağ H.	
Global Advances in Engineering Management	151
Hallo L., Gorod A., Overschee W. V., Shukla A.	
IIOT Vendor Selection Framework Using Novel Hybrid CRITIC-ELECTRE Multi Criteria Decision Making Model	157
Ömerali M., Kaya T.	
Implementation of Lean Principles to Warehouse Design in The Textile Industry: A Real Case Study	175
Yıldız U., Cömert-Deniz G., Camgöz-Akdağ H.	
İnşaat Sektöründe Dijital Dönüşüm Sürecine Etki Eden Faktörlerin Dematel Yöntemi ile Değerlendirilmesi	183
Öztürk E.	
Investigation of New Approaches for Collaborative R&D and Innovation	193
Petekkaya E. Y., Felekoğlu B.	
Kent İçi Raylı Ulaşım Sistemlerinde Metro İstasyonlarının Yapısal ve Mimari Tasarım Kriterleri Üzerinde İnceleme	200
Karaağaç M., Umu S. U., Öztürk M. M.	
Kentsel Dönüşümde Önceliklendirmeye Yönelik Sayısal Bir Yaklaşım: İstanbul'da Bir Uygulama	207
Altunel A., Karaçam K., Beldek T., Konyaloğlu K., Çebi F., Evcimen İ. V.	
Laser Scanning In Construction Management: A Review	218
Al-tameemia H.	
Mağaza Tabanlı Talep Tahmini: Topluluk Öğrenmesi Yaklaşımları ile Zaman Serisi Yaklaşımı Karşılaştırılması	225
Tekin A. T., Sarı C.	
Perakende Mağazacılığında Fijital Alışveriş Deneyimleri: Hazır Giyim Perakendeciliği Sektöründe Niteliksel Bir Araştırma	231
İsmayilzade A., Özeren E.	

Performance Analysis of BRICS-T Countries within The Scope of Logistics Performance Index with Entropy Weighted TOPSIS Method Karahan M., Dinç H., Karahan M. S.	238
Pharmacy Segmentation Based on RFM Model via Clustering Approach Aldoğan N., Tekin A. T., Çebi F.	247
Set Covering Approach to the Selection of Cargo Delivery Point: Real Case Study Deniz-Cömert G., Özyiğit C., Özcan T.	253
Shelf Space Allocation and Layout Optimization in Retail Management Ayan E., Biçer E., Özcan T., Konyalıoğlu A. K., Beldek T.	259
Stock Market Performance Evaluation of Listed Food and Drink Companies in ISE via MCDM Methods İşık C., Türkkkan M., Marbou S., Gül S.	267
System of Systems (Sos) Approach in Defining the Boundary of Stakeholder Involvement in Smart City Governance Nguyen T., Hallo L., Gorod A.	281
The Impact of Digital Technology on Capacity and Operations Planning of the Transport Sector Eldemir F., Al-dalain R., Ismail I.	288
The Sustainability in Istanbul City Al-dalain R., Çelebi D.	294
Tramvay Durakları Hizmet Performansının Çok Kriterli Karar Verme Yaklaşımı ile Ele Alınması Öztaş N., Umu S. U., Yaşlı F.	300
Trust, Leadership, and National Culture in Engineering Endeavours Hallo L.	307
Türkiye'nin İlk Metaverse Girişimcilik Maratonu Katılımcıları Üzerine Bir Araştırma Göktaş P., Şengöl S. N., Kılınç Z.	313
Uzaktan Çalışma Ortamlarında İş Tatminini Etkileyen Faktörler Öztürk E.	320
Yaratıcılığın Inovasyona Etkisinin Değerlendirilmesi: Steve Jobs Örneği Selçuk K., Saatçioğlu Ö.	327

Abstracts

<i>Title</i>	<i>Page No</i>
An Agile Approach to Project Leadership: Complexities and KSA Perspective Gulati R., Hallo L.	333
Considering Privacy in Systems Thinking Assessment Kordova S., Hirschprung R. S.	334
Data Analytics for Quality Products in an Industrial IoT Environment Kaplan T., Jabarnejad M.	335
Dijital Kültür ve Örgütsel Değişim Ayça B.	336
Emerging and Future Applications of Contemporary Knowledge Representation: A Literature Review Dalkılıç A. O., Alkış-Bayhan N.	338
Interconnection of Smart City, Smart People and Stem Skills of People Damar E., Aydınkal M.	339
Investigating Urban Rail Transit System with District Based Socio-economic Parameters Çalışkan B., Atahan A. O., Güney C.	340
Multiple Criteria Decision-Making for Subcontractor Selection Using Fuzzy Analytic Hierarchy Process and TOPSIS Methods Ozbey A. U., Jabarjenad M.	342
Process Design of New Digital Payment Platform Altınbulak N., Çorum A.	343
Study of the Fatigue Behavior of Plate with a Central Crack Repaired with Composite Patches Abdelmadjid M., Djafar A. K., Abderahmane S.	344
The Method of Selecting Employees in the System of Visual Quality Control of Wood-Based Panels Wachowiak F.	345
TOPSISsort ile Scrum Takımlarının Performans Sınıflandırması Yeğen N., Gül S.	347
User Experience Evaluation of an Online University Library via User Test and Heuristic Evaluation Özer B., Köşker B., Yıldız M. G., Mert Y., Sivri Ç., Erdinç O.	349
Well-Being as an Effect of Shaping Parameters in Office Space Rajewski J.	350
Promoting Team Collaboration in Engineering Teams through Mixed Reality Technology Akdere M., Jiang Y., Choi M.S., Azzam I., Breidi F., Mousas C.	351

FULL PAPERS

A Data Science Project Management Methodology: From Development to Production

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Abstract— Data Science needs to be managed well with trust and transparency to accelerate digital transformation, create individualized customer experiences, and make more data-oriented decisions. Companies utilize data science to empower their products and services with Artificial Intelligence (AI). There is a clear need to optimize business decisions with prescriptive analytics, accelerate time to value with analysis tools, and manage the project lifecycle with MLOps. Companies practicing data science projects may face challenges like developing and operationalizing Machine Learning (ML) models with unclear accuracy and difficult-to-audit predictions. The methods and new applications of data science have been studied in detail for a long time in the literature. When the studies in the literature are examined, it has been seen that many studies focus on developing analytical skills. There are limited studies on how this effort can be most effectively coordinated and managed. Despite well-developed literature on general project management methodologies, studies of specialized management tools for data science projects have been limited. This paper presents a customized project management methodology for data science and a much more useful way to govern AI applications. It aims to perform performance management with a dynamic project management approach. This method has been tested with AI/ML projects in the finance, automotive, manufacturing, and hospitality sectors. In addition to the project steps followed during the development of the applications, processes that are automated in the production environment are included in the methodology.

Keywords— Data Science; Project Management; Agile; AI Applications; MLOps

I. INTRODUCTION

Using data science projects to solve real-life problems has become widespread with success achieved by neural network models. A well-structured data science management guideline can accelerate AI-driven innovation in companies. Operationalized data science models may give high performed AI outcomes. The ability to run any model with flexible deployment and a simplified MLOps lifecycle can be achieved with a structured management methodology. While implementing an action plan to govern AI, the technical infrastructure should be prepared, the analytical needs of the business should be determined, and a road map should be developed to meet these needs. The plan should be able to respond to diversified needs with a functional structure. Effective coordination is crucial to performing a data strategy to meet all these requirements.

The changes in the analysis tools used to understand the current situation, the developments in predictive models, the increasing volume and diversity of data sources, and the high-performance storage and processing could be considered critical analytical needs [1]. The methodologies developed for executing data science projects should have a flexible, dynamic, and sustainable structure to solve these problems. However, research has shown that organizations do not use standardized processes but instead adapt them to meet their various requirements [2]. This study explains a systematic approach that can adapt to the dynamics of business problems with standard principles, not rules. At the same time, decision-makers make critical strategic decisions on behalf of their companies every day in the developing and growing world. Technology companies that produce various applications with software development processes must choose from many alternative sources [3]. Managing is as important as selecting the right resource to increase the benefit. Therefore, it has become necessary for technology companies to develop customized project management methodologies to succeed.

Continuous improvement needs to be managed in the scope of the projects because the primary source of the projects, data, is constantly transforming. Responding to progress in machine learning and artificial intelligence application development processes continue to be a need for management methodologies. One of the most critical issues in managing data science projects is how to keep up with transformation and improvements. Using software solutions as a support function in data science projects and the automation of training processes are significant tasks that need to be accomplished. We can examine the most critical developments in this subject under MLOps. MLOps is a discipline that combines ML, Development Operations (DevOps), and Data Engineering to deploy ML systems reliably and efficiently. MLOps is a relatively new phenomenon and there is not sufficient literature. As data management is becoming the new focus in ML-based systems, the area of MLOps emerged. MLOps can lower operational requirements by promoting the automation of all the steps involved in constructing an ML system from development to deployment [4].

This paper provides a holistic analysis and description of the principles for data science projects' experimental and production life cycles, intensive consideration of related roles and responsibilities. The approach presented in this study is implemented in four use cases. The results indicate that the methodology can deliver a helpful tool to help in data science projects' management, proper resource allocation, and AI/ML systems.

II. LITERATURE REVIEW

Studies on data science focus on data understanding, acquisition, cleaning, integration, extracting insights from data, and sharing the results with a task-oriented approach [5]. The data science team performs from defining a business problem to its solution with analytical capabilities and follows a method. When the literature is reviewed, it is seen that most studies focus on developing analytical skills or the benefits to the organization. There are limited studies on how this effort can be most effectively coordinated and managed to ensure organizational success [6].

Computer and Data Science

Computer science has traditionally been focused on algorithms, and data is a tool to activate the algorithms. Real science is data-driven, and an influential data scientist must first learn to think like a real scientist to understand the natural world. Data is analyzed to discover something about how the world works and data science is turning numbers into insight. However, software development is related to building systems, while data science tries to produce insights. The more engineers understand the entire data analysis pipeline, the more likely they will be able to create powerful tools capable of providing meaningful insights. Traditional hypothesis-driven science was based on asking specific questions about the world and then generating the specific data needed to confirm or deny it. Now, data-driven science focuses on generating data on a previously unheard-of scale or resolution, believing discoveries will come as soon as one can look at it [7].

Following ongoing software engineering practices, there has been an increasing interest in the rapid deployment of ML features, named MLOps. Organizations follow three steps. The first step is figuring out how to best use data. Then, they focus on building the first models and getting them to production. And finally, they are managing several models, their versions, and training datasets, as well as retraining and frequent deployment of retrained models. The first two steps focus on data and models. The third step is focusing on the benefits of MLOps when there is a need for frequent retraining and redeployment. When organizations are executing data science projects, they set up an MLOps pipeline as a natural step [8]. As an example, the results have been produced each day in the retraining for wind power prediction. The study has showed that retraining provides more accuracy, and a prediction automation process has been described phase [9].

The Need for an Improved Methodology

The lack of an empirically grounded data science methodology has been noticed when the literature has been reviewed. Most data science projects are managed at a low maturity level. The projects should focus on team, business, and technology, and it is noticed that the main challenge for data projects is coordination. Researchers address the need for data science project methodology via case studies, and more guidance is recognized. An improved process model would result in higher quality outcomes. Compared to software development, data science projects have an expanded focus on data, what data is required, and the data's availability, quality, and timeliness. Data science projects were similar to other information systems projects. There is a current lack of adoption of mature management methodologies for data science projects [5]. Customer-centric organizations

increase the satisfaction level and achieve the desired objectives. The analyses provide the opportunity to define customers. Manual data processing approaches are lacking in analysis. The process automation need has been met with the development of analysis tools. Businesses can gain insight from the analyses and draw realistic future projections with data science projects. This situation reveals the need for more efficient use and correct management of resources in data science projects [10].

In-Demand Skills

A dynamic team is not limited to job descriptions, works agile and focuses on creating co-created value with team spirit. We can define three main roles as data science, data analysis, and data operations for AI/ML projects.

Data science related tasks are focused on the results of projects. Examining in detail how their methods work with real-world data, that is, whether they work accurately and quickly, is considered under this heading. They include:

- Identifies use cases, determines appropriate datasets and algorithms, experiments and builds AI/ML models
- Extracts meaning from data using statistical methods, applies ML and Deep Learning (DL) techniques on existing data sources
- Determines the optimum approach/model to solve the given business problem in the data science project using different advanced analytics methods

The tasks studied in the discovery and preprocessing of the data are evaluated under the heading of analysis. Analysis related tasks:

- Identifies customer needs and manage end-to-end ML/AI projects, ensures continuous feedback loop
- Makes the appropriate data available for data scientists; focuses on data quality and availability
- Performs the feasibility of ML/AI projects using available selected tools and platforms
- Sets benchmark performance criteria for ML projects by using Automated Machine Learning (AutoML) tools

Data operations cover data transformation and data analysis preparation in the development life cycle. It supports and improves the existing system and participates in some data science projects in the production life cycle [11]. The tasks:

- Designs and implements MLOps architecture, test and optimize end-to-end AI/ML models
- Develops "data pipeline" for different extraction operations to be used in AI/ML projects
- Deploys AI models through effective scaling and ensuring production readiness
- Monitors AI/ML projects life cycle

III. METHODOLOGY

A. Scope Management

Interaction is increased by carrying out the development and production processes of the project in cooperation with the end-user. A mechanism is established where the expectations are regularly and continuously re-approved by the end-user, and the ownership of the final product is shared. Requirements for business problems are often not detailed enough to be documented when starting a project. But, when the collaboration between stakeholders focuses on solving the business problem through active communication, a solution-oriented approach can overcome uncertainties.

B. Development Life Cycle

Proposing a hypothesis, experiment design, data preparation, data analysis, model building, evaluation, monitoring, and improvement steps are the main components of the data science projects' development phase. All steps should be documented, stored, and linked to ensure reproducibility. The continuous development, improvement, and delivery can be applied to ML pipelines [12].

1) Task 1 - Problem Definition: A discovery process is conducted for unclear project expectations by stakeholders. This stage starts with defining information requirements, the proposed solution for the business problem, and identifying the needed data sources. Also, the importance of the business problem in the data

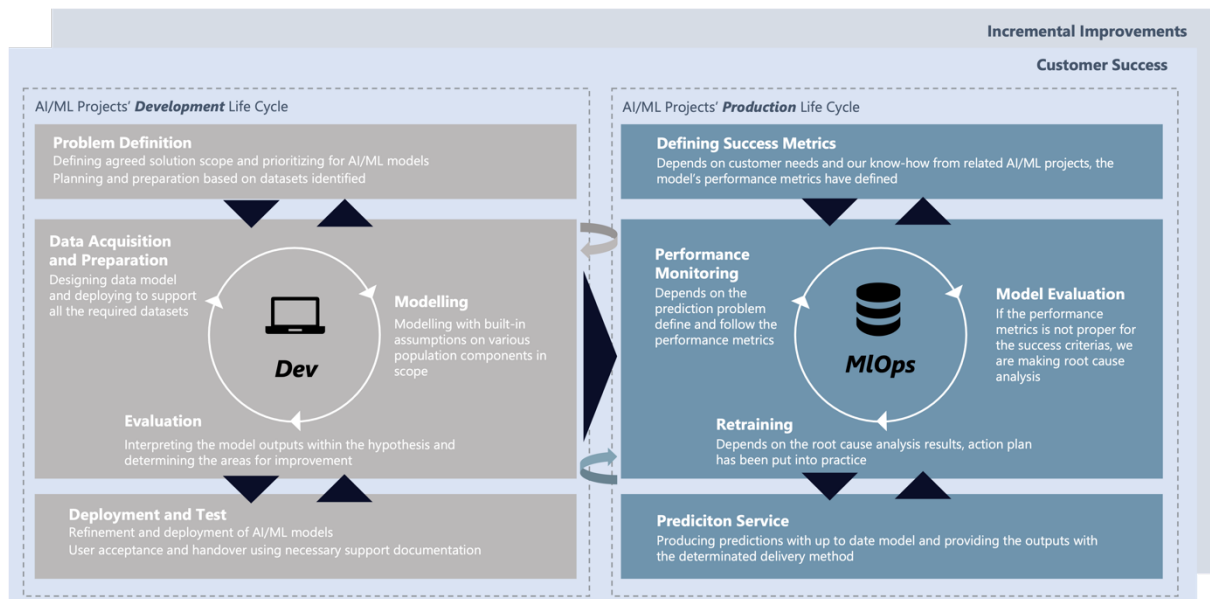
strategy is determined. Finally, project success criteria are specified, and the metrics that are tried to be reached at the end of the project set the common goal that will be followed as a guide by the project team.

2) *Task 2 - Data Acquisition and Preparation:* Teams with technical skills such as data science and software development work together to identify data sources for the extraction process. When a data scientist reaches a data source, processes a data set, or produces outputs, the scientist must constantly interact with all stakeholders to validate progress. Visualization tools may help create charts and diagrams to allow understanding of multiple data sources in different formats.

3) *Task 3 - Modelling:* The purpose of the development phase is to produce predictive/descriptive models that support the business with data science methods. Model development in data science projects can involve many different methods and algorithms. A variety of statistical and analytical techniques have been used to support the business function. The development scope focuses on extracting a meaningful output from the data to increase business value. The team should note that the model should be iterable and scalable when completing this task.

4) *Task 4 - Evaluation:* Evaluation is a control process to minimize the error obtained during the modeling phase. The phase includes to check for the quality of the model to be assessed and if it meets the business requirements. Also, the adequacy of the developed model is questioned, and the model parameters are optimized. If the model is not considered sufficient, the feedback is also prepared for improvements in this stage. For example, suppose there is insufficient data, or a data quality problem is detected. In that case, the step is where the decision is taken to return the development circle to include new data sources.

TABLE I
 DATA SCIENCE PROJECT MANAGEMENT FRAMEWORK



5) *Task 5 - Deployment and Test:* Data science projects involve many complex processes. One reason for the complexity is that the developed system has many independent components due to its integration with data sources. Another reason is that the system is affected by the constant change caused by dynamic data structures. Because of this complexity, the testing and deployment process plays a substantial role in confirming the completion of the development phase. The task's activities focus on stabilizing the model and maintaining the stability and sustainability of the system. The systems are like living organisms and need to be supported and revised according to environmental changes. The life cycle of an analytical model can be affected by numerous internal and external factors. As a result, analytical models may lose their applicability over time. In order to

prevent these risks, the model should be flexible and compatible with foreseeable risks. Feedback from users during system tests and the pilot is one of the most crucial inputs of this task.

C. Production Life Cycle

Upon completion of the development lifecycle, the outputs in this section are integrated into a professional IT infrastructure. Results produced as prototypes must be prepared and converted into an application for regular operations. The model scalability and applicability for the production environment are questioned. Configurations need to be completed so that the model can sustain itself without the continued support of data scientists. Event or time-based data streams must be created and aligned with the system. The compliance, security, and data privacy requirements need to be satisfied. Test management and service level agreements must be finalized when the project is intended to take on a strategic, long-term role. An agile, iterative, and incremental development model is operated to stable results. Converting a prototype to an application works in production takes a lot of effort [13]. So, the tasks present a methodology to make the production environment more traceable and manageable.

1) *Task 1 - Defining Success Metrics:* While importing the models used in data science projects into the production environment, the roles related to each part of the line are defined, and tools are selected for the MLOps cycle. Comparisons are made according to the tools' ability to work together and meet the MLOps requirements. The tools used in the MLOps cycle, the techniques used in the model development process, and the technological infrastructure are some factors that affect the performance in the live environment. Success metrics must be selected considering this and many other project-specific factors. By determining model performance metrics, the quality of system outputs is tried to be optimized.

2) *Task 2 - Performance Monitoring:* The purpose of this process is to monitor not only prediction quality but also system resources. Therefore, the necessary infrastructure is substantial, using a fully managed cloud platform, a local solution, or a hybrid approach. System performance could be tested with stress besides the model performance [14]. For example, a stress test tool can be configured to send continuous requests from multiple simultaneous threads, simulating high-demand scenarios.

3) *Task 3 - Model Evaluation:* Despite an ML system being like any other digital product running on top of the operating system, it has specific tasks that typically exist in data science projects, forming a pipeline. This pipeline is not always performed in a single direction, one step after another. To reevaluate some tasks to refine the overall results may be needed. This is more frequent during the experimental phase when the hyper parameters for the algorithm are being adjusted. It is also required when working on the production life cycle. In the evaluation phase, the system acts like a decision-maker to automate this process using performance metrics.

4) *Task 4 – Retraining:* The retraining task may be started by obtaining the data set from the source. After deciding how often the data set will be pulled from the data source, the jobs can be scheduled. There may also be a need for access to live data within the scope of the project. After the data acquisition process, the manipulations to be applied to the extracted data set should be automated to train the model. After the input to feed the model is prepared, the training process can be started. For example, to predict the value at time $t+1$, an autonomous model is trained retrospectively using the values from time $t-n$ to time t [9].

5) *Task 5 - Prediction Service:* Feedback loops is needed to keep the solution alive and relevant for a long time. Properly configuring the model in order to produce meaningful results in a fast and simple way is main purpose of the production life cycle [14].

D. Framework Fixed Features

1) *Customer Success:* Every step of the data science project focuses on the success of customers who meet their business needs with this project. The team clearly explains to the customer what needs the project might fail to meet and which product/service package would better meet their needs. So, customer success gives all stakeholders a competitive advantage and profit/benefit. Furthermore, as major barriers to implementing an effective customer satisfaction strategy are identified and overcome, data science projects would be better managed for long-term success [15]. Sustainable success is achieved when teams understand how each data science project impacts customers. In addition, the team should check the harmony between the project's

performance metrics and customer success at every stage. On the other hand, the relationship with key accounts that is unprofitable due to the cost of meeting extreme service demands for customer satisfaction needs to be rethought. Activity-based costing systems may be adopted, and whether the customer relationships are cost-effective should be questioned. Being a preferred supplier is only valuable when it provides profit.

2) *Incremental Improvements*: Agile methodologies [16], which are used in many application areas, must be understood, and presented as customized solutions for data science projects. Agility helps increase flexibility in data science projects to adapt to rapid change. For example, agile approaches may be used to adopt the pace of new technologies used in ML and AI applications. The approach focuses on acceleration, advanced discovery, and incremental iterations in various application areas. Thus, more interaction and collaboration are provided for discovery and insight.

IV. EXPERIMENTS

An unexpected requirement during the project lifecycles means a change affecting key project management aspects—time, resources, and budget. The traditional project management approach follows the plan and avoids changes. Traditionally, change is an obstacle that must be removed, not a rule as in agile methodology. The agile approach that removes bureaucracy from software development processes has met requirements for use cases in various sectors. So, when the methodology implemented the sectors, the changes has been evaluated and managed under the methodology. Contracts have been set the framework for project output with predetermined expectations, but at the same time, improvements and changes need to be allowed.

E. Implementation for Renewal Forecasting

Technology is used intensively in operational and business processes related to information management in companies providing financial services. There are various application areas of data science in financial companies, like customer lifecycle value analysis, market testing, price optimization, understanding advertising effects, and evaluating customers' preferences [17]. Besides, financial services include a broad range of more specific activities such as banking, investing, and insurance. Insurance is a significant subsector of the industry. Insurance services cover the protection against risks. The implementation predicts the likelihood of repeat purchases of customers who have previously purchased an insurance product. The model has been giving automatic responses with a web service. A specific study of commonly practiced antipatterns, solutions, and future directions of MLOps in financial analytics has been summarized [18]. A domain-specific approach can be designed by evaluating the study's prediction service and Muralidhar et al.'s continuous improvement structure.

1) *Development Life Cycle*: In the requirement analysis shows that the project aims to find who will renew their insurance. It covers both individual and corporate customers. The main business problem in this project is “Which of the customers will renew their insurance in the upcoming period?”. End of the project, the business unit try to increase insurance renewal rates. It is aimed to calculate the probability of renewing the motor and traffic insurances of our current customers and to identify the customers with the highest probability of renewal. The data is obtained from the database of the application in which the business unit carries out its processes. The data acquisition is completed from the database of the application in which the business unit carries out its processes. Light GBM was used in the modeling phase. Due to the case is a classification problem, the classical performance metrics (MAE, MAPE RMSE) has used to evaluate the model. f1 score is substantial, but at the same time, because of the customer needs we are looking for precision scores.

2) *Production Life Cycle*: The same success metrics has been defined in development part is used. Also, the confusion matrix values, and AUC is used to monitor the model effectively and threshold has been set as 0.75. All the confusion matrix values, and AUC scores are defined as success criterias, and they can be watched live with dashboards. Model performance was evaluated for 6 months. Afterwards, the application was configured to run the prediction service with API call. In the retraining phase, we continue to monitor the model and evaluate its performance. There was no need for retraining for more than 1 year. Features come to our servers with an API call in json format. The model generates a prediction and returns a response to the API call in the prediction service.

F. Implementation for Stock Management

The ecosystem of advanced analytics tools has snowballed in the last few years, offering companies new opportunities for data-driven solutions. Industry 4.0 represents a major application domain for data science and advanced analytics to use the vast amounts of data generated across the industrial value chain. Data-driven manufacturing refers explicitly to the application of data analytics in product manufacturing. The data science projects for the manufacturing sector involve various challenges beyond tools and data analytics technologies. The challenges are mainly about industrializing analytical solutions and defining holistic analytics governance to ensure the efficiency and effectiveness of the data science projects' outputs. Overcoming the challenges require further comprehensive research, especially for the specification of modular and reusable analytical services for analytics governance [19].

1) *Development Life Cycle*: The implementation has been carried out at the authorized service center of Turkey's leading automotive importer and one of the largest automotive distributors. The business problem to be evaluated within this project's scope aims to estimate the requests to the authorized service as close to reality as possible. Stock optimization has been contributed by keeping spare parts available in required quantities when needed. It is desired to ensure that the right part is available at the right time and to reduce the inventory cost. The parts to be estimated are examined in three groups according to the amount of demand: low-frequency parts (0-20), medium-frequency parts (20-200), and high-frequency parts (>200). The frequency-based segmentation process has been examined separately, showing different patterns during the modeling phase. Additional development has been made to determine the anomalies in the daily and monthly order quantity of spare parts due to the evaluations made based on the business problem and to revise the data in a way suitable for the data structure instead of outliers. The two data used in the study contain catalog information of each spare part and daily order quantity information. Outlier detection work consists of a combination of two studies resulting from monthly and daily calculations.

2) *Production Life Cycle*: Success Metrics has been defined as the average difference between each estimated mean and the observed outcome (MAPE) and the standard deviation of prediction errors (RMSE). Model performance was regularly reviewed while the project was in the experimental phase. Due to the nature of the business problem, it was decided to retrain it at regular intervals (once a week). The flow is applied once a week to retrain the model with the new extracted data set. The predictions shared with the users via FTP. Alternatively, the predictions are saved on a relational database to use in the future analytics projects.

G. Implementation for Customer Demand

ML is typically used for clustering, classification, and regression. In tourism and hospitality, ML has been applied for revenue management, operational analytics, and improving the customer experience. ML technology in hospitality aims to gather data, learn from it, and enhance self-capability without the involvement of humans and reprogramming. ML methods allow employees to be part of an automated management system. The team can predict the future business conditions and complete all the preparation for the upcoming period. The ML is directed to the operation; furthermore, the businesses may gain insights into customer demand, behavior, and future tourism trend (Parvez, 2020).

1) *Development Life Cycle*: It is desired to estimate the total customer demand a restaurant chain will have to meet the next day. Therefore, the daily number of customers coming to over 70 restaurants was obtained as a restaurant-based time series. In addition, religious, national holidays, and weekends showing different patterns in the time series are marked. The DeepAR forecasting algorithm, a supervised learning method for forecasting one-dimensional time series using recurrent neural networks (RNN), has been used.

2) *Production Life Cycle*: Depends on the business needs, the performance has been measured with a customized metric based on MAPE. Model performance was reviewed automatically to detect when the model is insufficient to meet the customer needs. Model success metrics compared with the defined threshold value for every iteration. When the model performance drops down below a defined level, model is retrained automatically. The predictions displayed on a dashboard and the related users can access and monitor the results.

H. Implementation for Workload Estimation

Workload estimation and capacity planning have utmost importance in many sectors. Maintenance, Repair, and Overhaul (MRO) organizations predict the amount and types of resources required to perform the maintenance interventions, particularly staffing differentiated by skills. Therefore, the prediction of workload approaches has been proposed to be used in industrial practice. For example, a tool to support the capacity planning process of complex product systems maintenance organizations using predictive analytics has been developed. The motivation for developing these kinds of tools is mainly the inability of current approaches to accurately forecast the workload of future maintenance interventions and plan an adequate capacity to face that expected workload. The tool includes a forecasting module that predicts future and unprecedented maintenance workloads from historical data. And also, it is powered by a simulation function to combine the simulated workloads with historical data through probabilistic inference. A linear programming model is also developed to improve the efficiency of the decision-making process supported by Bayesian networks by using real industrial data [21].

1) *Development Life Cycle*: The daily tasks and work types in an automotive company's warehouse are taken as input for the implementation. The prediction of daily workload at each station and the optimized staff assignments have been completed within this project's scope. To increase the efficiency of the human resources used in warehouse operations is aimed. The works carried out in this warehouse are examined under two main categories: entry and exit operations. The model estimates the workforce required in warehouse entry and exit operations. Before using the model, workload estimation and station staff assignments have been made using manager experiences and past trends. This situation caused staff shortages, delays in deliveries, and disruptions in activities. During the analysis, the examined features are the number of parts, the types of work, and the processing times. They have been evaluated based on hour-day-month periods and stations. The three-year daily transactions, which warehouse managers use for manual workload estimation, have been extracted. The final data set contained 783,792 transactions and 9 features. Various models have been tested with the prepared time series data. LSTM, DeepAR, and classical time series methods ARIMA, ARIMAX, and SARIMAX have been applied, and model performances have been compared using MAPE and RMSE metrics. Finally, the production life cycle is started with the SARIMAX model, which gives the best results.

2) *Production Life Cycle*: The average of the absolute differences between prediction and actual observation (MAE) is used to evaluate performance of the model. Models were evaluated according to success metrics. The selected model's performance in the live environment is monitored. The model that gives the best results has been deployed and its performance in the live environment is regularly reviewed. No need for retraining has been observed. A daily scheduled job extracts the data set from the relevant database. The predictions are made, and the results are shared with the users via mail.

V. FINDINGS AND CONCLUSION

Problems solved in data science projects are often dynamic, and in real-life problems, even minor changes in the data source may require model retraining [22]. Using the development lifecycle to meet the retraining needs of models increases project costs. Automated production environment lifecycles can quickly retrain machine learning models when minor changes occur to the training dataset. Retraining the algorithm may take more time than a fixed training step. However, it allows us to improve the forecast as more data is collected. Contrary to most studies that use a fixed learning dataset, this study proposes continuous learning using the latest available information.

The data handling, modeling, evaluation phases in the development life cycle and performance monitoring, evaluation and retraining in the production life cycle benefit from iterative processes, stakeholder collaboration, small time-boxed increments, and co-located resources. The project management methodology designed within this study provides an end-to-end roadmap for a data science project, from the definition of the problem identified to the development and continuous implementation of the solution to that problem. This methodology has been followed in data science projects developed for various sectors as the reference guide of a technology company.

Data science is agile since it follows iterations, requires cooperation between business subject matter experts and technical resources, and uses small teams. Besides, the experimental design in data science projects aims to ensure that all organizations may achieve resilience in their strategy, operations, and emergency response

[23]. This paper has compiled research and experience-based data science delivery framework that synthesizes agile applications with analytical delivery applications.

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A Digital Business Model Framework for Public Bus Transportation: Istanbul Case Study

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Abstract—With the rapid advent of technology in connectivity, specifically in autonomous driving, vehicle-to-vehicle interoperability, and the diffusion of the Internet of Things (IoT), digital transformation seems to become indispensable in the public transportation domain as well. These transformations require public transportation authorities to innovate their existing resource and capability sets, which are rather built on tangible resources and bureaucratic processes. As an obvious misfit exists among the current resource&capability sets of Public Transport Authorities (PTAs) and those that are required by the digital transformation, a digital business model framework is proposed for the public transportation domain. Blocks of the proposed transportation business model are analyzed step by step regarding the digitalization enablements of each block. The proposed model is applied to Istanbul public transportation as a case study. Results show that the public transportation business model in Istanbul, although requiring major transformations to face future challenges of digital transformation, is ready to absorb and implement major components of the digital business model. This study will be a guide for both academicians and managers to provide a toolkit for digital business model transformation in public transportation.

Keywords—Digital Transformation, Business Model, Design, Innovation, Public Bus Transportation

I. INTRODUCTION

With the development of technology, digital transformation is applied in many business areas such as education, banking, communication, mining, shopping, and transportation. Digital transformation is preferred to increase productivity, value creation, and social welfare [1]. Also, digital transformation contributes to both the social and economic sides. From a social perspective, it fosters innovation, accessibility, affordability, transparency, and quality of service. On the economic side, it provides to implement the new business model and improve technical standards regarding regulatory framework [1].

Although there is no consensus definition of digital transformation, it will be categorized as technological, organizational, and social [2]. While the technological side includes new digital technologies such as connected devices, autonomous devices, and social media, the organizational one consists of the creation of new business model and the transformation of business processes. On the social side, it contains service excellence and improving customer experience.

According to Mergel et al. [3], digital transformation is handled with three main titles that are using technology for transforming service delivery, using technology for transforming organizational culture and relationship with citizens, and using technology for transforming value creation. Service delivery is provided by platforms such as software. When Uber can be an example to satisfy travel demand for the private sector, and e-government is a sample for the public sector delivering services. Transforming organizational culture includes new partners, new rules and flows, and transforming organizational structure regarding citizens'/customers' needs. Value creation is a core issue for differentiation. Using digital transformation products and services will be improved. To sustain digital transformation three fundamental keys are presented by Boston Consulting Group (BCG) which are developing a new business model, digitalizing core operations, and building a robust internal digital foundation [4].

In the transportation sector, a digital transformation affected business models from infrastructure to customers/passengers. From the activity side of the business model, key partners can be varied, key resources

can be changed regarding tangible ones, and key activities are diversified. For the value side, proposing value can be transformed with digitalization, customer segments are changed, and customer relationship and distribution channels are digitized. On the monetary side revenue and cost, items can be varied due to digitized service. Despite the digital transformation term being adapted from the private sector [3], it is used effectively in the public sector.

Although there are lots of studies about digital transformation in the literature, there is a lack of public transportation business model studies in the digital era. This study will be an example of this situation by presenting a digital business model framework for public bus transportation. Also, the proposed framework is applied to Istanbul as a case study. The study not only fills the gap in the literature but also gives a guide to decision-makers.

In the next section, the literature reviewed is analyzed regarding digitalization's effect on transportation and business models. In the third section, a methodology which is business model innovation is proposed regarding digitalization for public transportation. An application is presented as a digital business model framework for Istanbul public bus transportation in the fourth section. Discussions are represented in three main parts which are theoretical and managerial implications in the fifth section. Lastly, the conclusion is presented as the sixth section of the study.

II. LITERATURE REVIEW

The effect of digitalization on transportation and business model is taken into account for literature studies. In the first subsection, digital transportation systems are analyzed such as IoT, connected vehicles, autonomous vehicles, and smart transportation systems. In the second subsection, how business model transforms in the digital era is examined as an innovation in the literature.

A. Digital Transport Systems

Related to IoT, Forell et al. [5] indicated that using micro-navigation for urban bus passengers improves the public transport experience. They indicated that using the IoT removes barriers to public transport usage. Handte et al. represented navigation systems as an IoT for urban bus riders. The system provides both micro-navigation and crowd-route recommendations. The technical system was applied in Madrid and shown that how people feel about public transportation journeys [6].

When we look at connected vehicle studies for transportation, Uhlemann applied a survey for self-driving vehicles. The author conducted interviews with more than 20 city policymakers and transport authorities who were from Dubai, Helsinki, New York, Amsterdam, Singapore, and Toronto about their experiences. Results show that decision makers found that applications will have the potential to be the last-mile solution for public transport. Also, the author added that Singapore and Gothenburg prepared for the introduction of self-driving cars [7].

In terms of autonomous vehicle use on the transportation side, Pakusch and Bossauer applied a survey to understand the intention to use fully automated public transport in the future. Results showed that consumers were familiar with fully autonomous vehicles and eager to experience them [8].

For smart transportation systems, Barabino analyzed data collection from smart vehicle concepts such as defining low-quality vehicles and bus stops in bus services. Using collecting data, there was an aim to increase bus services. The proposed framework was applied in the Italian case [9]. Birr et al. wanted to estimate the travel time of public transport vehicles estimation. With Automatic Vehicle Location (AVL) system, the travel time of public transport vehicles was measured in the main streets of the Tri-City Agglomeration (Gdansk, Sopot, Gdynia). The results will be guided for macroscopic transport models [10].

B. Business Model Innovation

The business model is frequently applied in different transportation domains such as shared mobility services [11]-[13], mobility as a service (MaaS) [14]-[16], green transportation [17], [18], and digital transportation [19]-[21].

For the innovation side, there are many studies about business model innovation regarding digitalization in the literature. Some of these studies are summarized in this section as follows. Adhiatma [22] proposed a business model taxonomy for a new product-service system. They handled the business model with value

perception. They split the value into three categories that are value creation, value capture, and value delivery. The authors indicated future research will build the proposed taxonomy in the paper.

When the innovation process is analyzed in the literature, Bucherer et al. formed the innovation process in their study. The first step is to define sources of innovation. The innovation triggers organizational issues such as innovation process and implementation. The last step is to measure the degree of innovativeness regarding the study [23].

Garzella et al. studied business model innovation in small and medium-sized enterprises (SMEs) during the digital era. The Structural Equation Modelling method was applied with a survey of 250 Italian experts. The study aimed to show how digitalization affects a firm’s boundaries. According to the study, managers should give more attention to the boundary management of SMEs to support business model innovation [24].

III. METHODOLOGY

The business model canvas framework helps to visualize the business including activities, value creation, distribution channels, customer segments, and monetary side with a holistic view [25]. Also, it reduces business failure risk regarding changing business conditions [26].

Once the business model is structured, there is a need for improvement and transformation regarding changing conditions in a business environment. Vial [27] stated that when technological factors affect the company, there is a misfit between the company and its environment. At that time there is a need for company alignment with business model transformation. According to Vial’s study, we developed a business model innovation conceptual framework within five steps that are presented in Figure 1 below. Digital technologies are defined as fuel for disruptions. Disruptions are sorted consumer behavior, technological developments, and availability of data. The disruptions are called triggers for strategic responses. Strategic responses make a movement to change the current blocks of the business model. On the other hand, changes in elements of the business model have adhered to organizational structure. The endpoint is to get a digital business model.

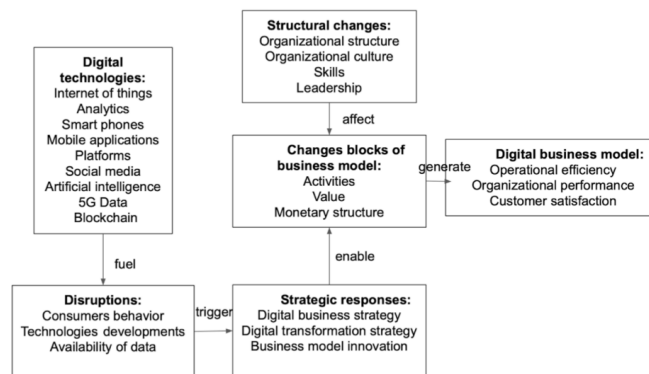


FIGURE 1
 DEVELOPED BUSINESS MODEL INNOVATION CONCEPTUAL FRAMEWORK REGARDING VIAL’S STUDY [27]

IV. APPLICATION: PUBLIC TRANSPORTATION DIGITAL BUSINESS MODEL FRAMEWORK FOR ISTANBUL PUBLIC BUS TRANSPORTATION SYSTEM

Although there are lots of studies about the business model, there is a lack of study of the public transportation business model framework in the literature [28]. Public transportation not only is a service but also contributes to social and environmental impact. Taking into account impact factors, Buran and Erçek proposed a business model framework for public transportation [28]. According to the rapid technological developments, there is a need to revise the proposed business model regarding business needs. In this process, where digitalization has accelerated, the proposed business model framework is reviewed with the developed business model innovation conceptual framework regarding Vial’s study which is presented in Figure 2 [27].

According to the proposed digital business model, digital solution partners, technology partners, and mobility service operators are added under the key partner's block of the business model to serve integrated digital transportation solutions respect with to changing passenger needs. When we look at key activities,

integration with other transport modes, optimization of network, management of the system, and data analysis to capture changing trends and passenger behaviors are taken part in the business model. For key resources, smart technologies such as intelligent transport systems, the IoT, and connected&autonomous vehicles are put in the framework. To develop and maintain the systems, there is a need for digital capacity and information technology (IT) specialists.

From a value perspective, value offerings are differentiated with digitalization. Using technology, a travel assistant will be developed to satisfy passenger travel demands with a holistic viewpoint regarding cost, comfort, time, and speed. With time, ticket, and physical integration, multi-modal and sustainable transportation will be served under MaaS [28]. Also, customized transportation options will be actualized such as Demand Response Transport (DRT) [29], [30]. For customer relationship mechanisms and channels, digital options that come to the fore are virtual channels, web site, applications, and social media. These options not only facilitate operations but also make them accessible. For customer segments, developers can be added to improve developed software.

When we look at the monetary side, with the digitization process, both revenue stream and cost structure vary from than previously presented framework. Due to the platform system, subscription fees and data sharing are addressed as new revenue types in the framework [31]. For cost structure, platform management cost and research development cost are attached to the model.

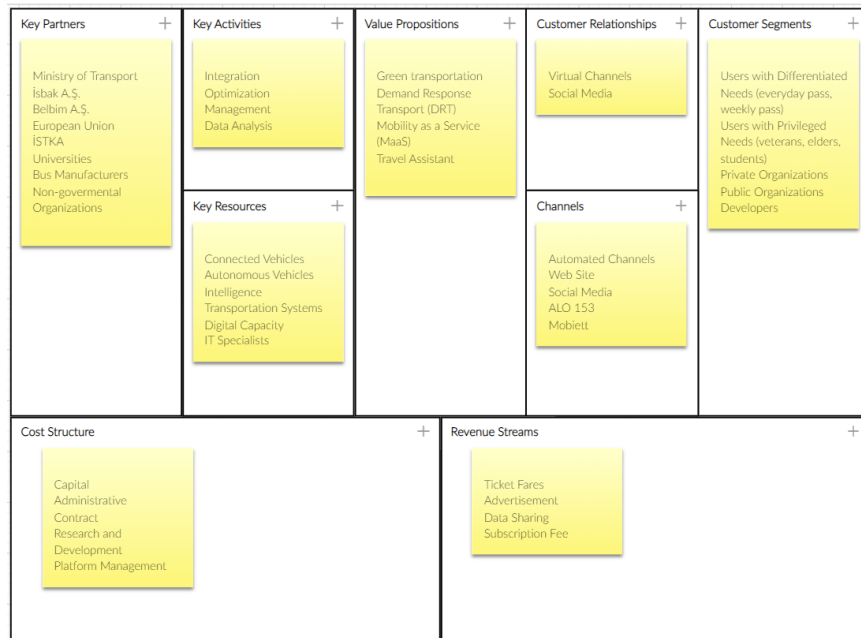


FIGURE 2
 DEVELOPED BUSINESS MODEL REGARDING DIGITAL TRANSFORMATION FOR İSTANBUL PUBLIC BUS TRANSPORT

V. DISCUSSION

C. Theoretical Implications

The business model provides a strategic tool to manage company direction according to the defined objectives [32]. In some situations, companies get away from goals due to changing both external and internal factors such as external side technological issues, and internal side organizational structure. According to Abd Ghani, while financial resources and a firm's management are seen as internal effect factors, legal issues are the most important factor for external factors [33]. At this point, there is a need to look at the transportation domain. Nouri and Mousavi indicated that cooperative management, organizational agility, and employee empowerment have critical importance for internal factors in the transportation industry [34]. Odeck found that mergers increase efficiency and productivity growth, respectively. Mergers that are defined under key partners

in the business model template are seen as important internal factors for transportation [35]. Rohani et al. indicated that bus service quality is affected by economic conditions, public policy, and demographic changes [36]. Political, economical, social, technological, environmental, and legal (PESTEL) analysis is applied to public transportation [28]. In the study, regulation, tax policy, and labor law are defined as political issues. For economical conditions, petrol price, private car ownership, exchange rate, and inflation rate are defined. From a social perspective, the growing population, aging population, and transport culture are taken into account. In the digital era, rapid development and innovation stand out as technological factors. Lastly, environmental protection and climate change are identified under the environmental cluster.

This study contributes literature about public transport business model innovation with a digital trigger. Using the proposed template, the digital transformation of public transportation can be monitored.

D. Managerial Implications

Digital technologies are seen as an enabler for innovation including process and product [37]. While process innovation includes new methods, procedures, or responsibilities, product innovation provides to enter a new market. To adapt to new technologies, there is a need digital roadmap which can be called a digital strategy. Using dynamic capabilities and capacity, the managerial role plays an important role to sense changes, seize opportunities, and transforming the firm [38]. For cities, mayors of municipalities define strategies related to what they serve citizens. For example in London, the mayor declared a roadmap to transform London into the smartest city in the world. According to the roadmap, five missions were delivered which were more user-designed services, striking a new deal for city data, world-class connectivity, and smarter streets, enhancing digital leadership and skills, and improving city-wide collaboration [39].

In New York, the transportation plan for 2030 was released by the government. Regarding the proposed plan, the main goal was defined as using advanced technologies, to meet customer expectations for mobility and reliability [40]. Also, the government developed Intelligent Transportation Systems (ITS) strategies with three main timelines that are short, medium, and long-range.

In summary, governments and municipalities declared digital strategies for public transportation in the world. If the governments allocate specific budgets for digitalization with a road map, municipalities take responsibility as practitioners to realize defined smart goals. Thus, the critical success point is to provide a good relationship between the government and the municipality.

VI. CONCLUSION

The business model provides the understanding of who is the target customer, what is value offered to them, how is the value proposition is created, which channels and relationships are used to reach customers, and why is the business profitable. A business model is a crucial point in how the company creates and captures value. The business model is widely used in both literature and practical domains. It is applied in many different business areas such as health care, education, banking, agriculture, and transportation. Although there are lots of studies about transport business models in the literature, there is a lack of work on public transportation business models [28]. In this study, the public transportation business model framework is handled in the digital area with an innovation process. A digital business model framework for public transportation is proposed with five main steps that are fuel, trigger, enable, affect, and generate. Items of each step are defined for the public transportation domain regarding literature studies. Also, an application is proposed for the Istanbul bus transportation system.

In some cases, the public sector has trouble keeping up with changing conditions due to its structure, legal issues, and lack of funds. For technological developments, there are some barriers such as high investment costs, rapidly evolving innovations, lack of digital capability resources, political, and legal issues. At this point, the government should support public establishments to adapt to evolving conditions. Digital government strategy can be an example to align public authorities according to digitalization. In the business environment, the compliance of the public sector is as important as the compliance of private companies with technology. The best results will be achieved with private and public integration. Outputs of digital transformation are asserted as cost-saving, improved productivity, increased agility, more resiliency, better resource management, improved customer, and engagement and satisfaction [41].

This study will be a guide for both academicians and practitioners to adjust business models regarding changing conditions. Also, the study shed on lights the impact of digitalization on the business model. How other external or internal factors affect business models will be studied separately in the future.

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A New Perspective to Innovation Competitions: IdeaSprint

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Abstract— Increasing digitalization, information becoming so widespread and agile ways of doing business have revealed the need for a change in the closed innovation approach, where solutions can usually emerge from existing internal sources and which is heavily based on R&D investments[1]. In this context, it has been realized that it is now very restrictive for institutions to conduct their own research with their internal resources and innovative ideas can be implemented faster and with more added value by sharing risks and gains within the scope of open innovation. Innovation competitions, which have become more popular in recent years, are seen in many organizations as the first stage of new product, service, business model or process development. In addition, in order to compete in the increasingly competitive world, organizations need human resources with the skill of innovative thinking. In this context, innovation competitions are an important resource for the innovative human resource needs of organizations.

Various fictions such as ideathon, hackathon and make-a-thon, which are widely used as innovation competition subheadings in the literature, have problems in converting outputs into value and producing commercial outputs due to their different disadvantages [2]. This scope of work; the strengths and weaknesses of the idea competitions in the literature and the “Design Sprint” methodology [3] developed by Google Ventures have been analyzed. By inspiring this competition and methodology, a new program called “IdeaSprint” that companies can implement within the scope of both open innovation and intrapreneurship programs, is proposed in this study. With this developed program, it is aimed to eliminate the disadvantages of the existing idea competitions in the literature, and to develop a new competition methodology that can be flexible and can create added value and output as a result of the program, which can be designed according to the internal processes of each institution.

Keywords— Innovation, Open Innovation, Innovation Strategies, Innovation Competitions, Innovative Human Resource

I. INTRODUCTION

Innovation competitions can be defined as time-limited competitions by a business that appeal to the public or a specific target group [1]. They encourage participants to find solutions and/or develop innovative products. In this context, the outputs obtained from innovation competitions that organizations can implement in line with their needs and strategy will play an active role in adding value to the organization.

Innovation competitions are important models in developing fast and effective ideas, so they are becoming more and more common. In order for organizations to compete in today's competitive environment, innovative ideas should be evaluated and supported through those competitions in interaction with both their own human resources and the open innovation ecosystem outside [2].

II. IDEATHON

One of the most common innovation competitions that used in organizations is ideathon. Ideathon is a competition or marathon where entrepreneurs come together in open innovation environments and form a team on specific or uncertain topics, come up with innovative ideas or projects in a very limited time [2]. Ideas or projects are evaluated and voted on by a jury.

Ideathon events can serve many different purposes. For this reason, the first thing that organizations should do is the result they want to achieve when the ideathon they plan to organize ends. It can be queried if it is desired to solve an existing problem. Or it can be thought if it is the proposal of a new business idea, the discovery of innovative people and recruiting them to the staff. After the framework is drawn, the event should be planned in detail, mentors and training steps should be determined.

Since it is an idea development marathon, ideathon is the scene of brainstorming. Dozens of ideas produced enable organizations to reach their intended output in a short time [4]. On the other hand, such an environment reveals the innovative aspects of the participants. Participants can announce their ideas and skills to large audiences. It provides cooperation between society and companies or organizations. It is important for the development of sectors and the country.

Ideathons generally last 24 consecutive hours, but you can arrange different time limits from 3 to 24 hours. Ideathon competitions are open to either individual or team applications. Teams are formed by the organization team. Team building can be done before or during the event. Ideathon can be easily adapted to any subject in terms of fiction. So that, ideathon competitions of organizations from different sectors can be seen frequently.

III. HACKATHON

Second example for one of the innovation competitions is hackathon [5]. Hackathon is a coding competition where programs are developed, not ideas. Hackathons are also competed as a team on a specific topic. The codes written at the beginning and at the end must be written in the environment determined by the host organization of the competition. Developed codes are voted on by a jury as the same method in ideathon. Hackathon is also called as hackfest, codecamp, hackday or codefast, but generally the name of hackathon is used in competitions.

Hackathon is a functional event and makes significant contributions to institutions and organizations. The main purpose of these events is never to make more income or to advertise [6]. The host organization's easy access to innovative projects on a determined subject is the most important benefits brought by hackathons. Hackathon is a great importance for the organization to assume new roles in the sector, to expand its application areas and to offer more usable outputs. Moreover, the hackathon creates the appropriate environment for the determination of new employees.

Hackathon is usually set up for 48 consecutive hours. After the development of ideas, a project is presented to the jury and the winning teams are determined. Hackathon is a setup suitable for competitors to compete both individually and as a team. However, the evaluation of the developed project from many perspectives and the combination of different talents will have a positive effect on the outcome of the competition.

IV. MAKE-A-THON

Make-a-thon is a creative competition which accelerates innovative ideas into physical and digital prototypes that promote positive social impact [7].

At other innovation competitions (for example hackathon) people are pitted inside an arena like setting where competition between the teams is at a high level. Mostly there are money prizes to be won for the first, second and third best idea which is decided by a jury. The emphasis is on the realization of an idea, not on the process itself. A make-a-thon has its focus on the process of making things together. It is more about the process than it is about the end results. The main drivers for a make-a-thon is having fun creating stuff, firstly. Creating something new is an exhilarating experience. Secondly is learning while attendees go. The best way to learn is to build something. Thirdly is that increasing attendees' network reach. Professional and non-professional friendships are easily formed in the right environment. During the make-a-thon highly skilled people are present to help attendees out with technical and non-technical matters. Attendees can actually ask them to build something for their team.

V. DESIGN SPRINT

Design Sprint [3], developed by Google Ventures (GV), is a five-day marathon to answer critical business questions through design, prototyping, and testing with its customers. GV applies the design sprint methodology to successfully and effectively test business ideas in companies they invest in and provide consultancy. Fig 1 shows the five-day Schedule of Design Sprint.

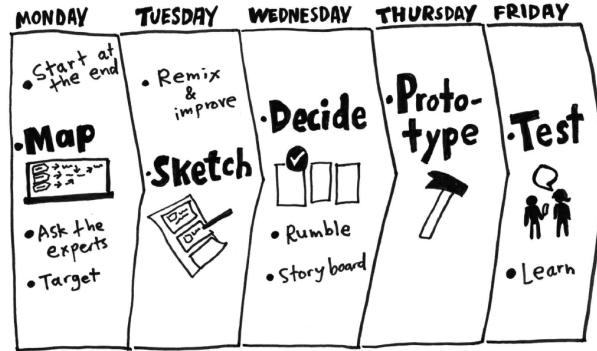


Figure 1 : Design Sprint 5-day Schedule [2]

Firstly, the sprint team, which ideally includes people from different departments directly related to the problem and have strong opinions to help find the right solution, need to clear a whole week on their calendars. The 5-day program of the Design Sprint program is described below:

- **Monday:** On the first day, the sprint team agrees to a long-term goal, interviews experts, map out the problem, and choose a focus for the sprint.
- **Tuesday:** Team members do a literature review and current solutions for a problem and sketch solutions on paper.
- **Wednesday:** The team choose the best solutions and plan for the prototype.
- **Thursday:** The team develops realistic prototypes based on the solution/solutions and requirements they decided on the day before for Friday's live test.
- **Friday:** Test idea, prototype, and features with customers.

The Design Sprint methodology provides great benefits in terms of producing solutions to existing business problems with a diverse team, prototyping quickly, and testing with real customers. Besides the advantages mentioned, the methodology has several shortcomings such as requiring five days of dedicated time, limited time for prototyping, and not being suitable for every institution. Although the Design Sprint is not an idea competition, its methodology and process for developing and testing solutions to business problems inspire us to develop a successful and effective idea competition model.

VI. EXAMINING SWOT ANALYSES

SWOT Analysis is a tool used in strategy management that addresses the strengths and weaknesses of a project, an idea or an organization, as well as gathers opportunities and threats that may arise outside the organization.

- **Strengths:** Features of the project, idea or organization that give it an advantage over others
- **Weaknesses:** Features that put the project, idea or organization at a disadvantage compared to others
- **Opportunities:** Elements in the environment that the project, idea or organization can use to their advantage
- **Threats:** Elements in the environment that may cause problems for the project, idea or organization

When the innovation competitions in the literature are examined, it has been determined that the most common setups are Ideathon, Make-a-thon, Hackathon and Design-a-thon. As the explanations, contents and application areas are given below the most common models, were examined in detail under the conditions in Turkey [8] in Table I with the SWOT Analysis method.

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TABLE I
 SWOT ANALYSES FOR COMPETITIONS

Ideathon		Make-a-thon	
Strengths	Weaknesses	Strengths	Weaknesses
<ul style="list-style-type: none"> ○ Subject flexibility ○ Completion in a short time ○ Team work ○ Both team and individual applications ○ Technical infrastructure 	<ul style="list-style-type: none"> ○ Explaining the subject of the competition during the competition ○ No prototyping ○ Lack of interdisciplinary structure ○ Not working with a mentor ○ Having new teams to meet ○ No opportunity to test with the customer 	<ul style="list-style-type: none"> ○ Prototyping / Production Area / Physical Output ○ Initiative support for teams ○ Interdisciplinary teams ○ Mentor support throughout the competition ○ Both team and individual application ○ Human resources in various specialties ○ Technical infrastructure 	<ul style="list-style-type: none"> ○ Loss of motivation/fatigue in the participants as it is an ongoing fiction. ○ Need for expensive equipment ○ No opportunity to test with the customer ○ Mentor-team mismatch ○ Having new teams to meet
Opportunities	Threats	Opportunities	Threats
<ul style="list-style-type: none"> ○ Opportunity to perform online ○ Spread of entrepreneurship culture in universities ○ Increasing awareness of innovation competitions ○ Using innovation competitions as a means of employment 	<ul style="list-style-type: none"> ○ COVID-19 Precautions ○ Similar setups of different companies 	<ul style="list-style-type: none"> ○ Developing prototyping technologies ○ Spread of entrepreneurship culture in universities ○ Increasing awareness of innovation competitions ○ Using innovation competitions as a means of employment 	<ul style="list-style-type: none"> ○ COVID-19 Precautions ○ Presence of competitions completed in a shorter time with less effort
Hackathon		DesignSprint	
Strengths	Weaknesses	Strengths	Weaknesses
<ul style="list-style-type: none"> ○ Team work ○ Mentor support throughout the competition ○ Training sessions ○ Both team and individual applications ○ Applicable for any institutions 	<ul style="list-style-type: none"> ○ Short time schedule (nonstop 48 hours) ○ No opportunity to test with the customer ○ Limited scope of work 	<ul style="list-style-type: none"> ○ Providing quick solutions to processes ○ Enabling innovation faster ○ A focused and short calendar 	<ul style="list-style-type: none"> ○ Having to use always the same methods, in a specific order ○ Being not suitable/applicable for every institution (early stage ins.) ○ Focusing only successful processes ○ Lackness of the content (training, customer parts) ○ Requires 5 days of dedicated time
Opportunities	Threats	Opportunities	Threats
<ul style="list-style-type: none"> ○ Seeing innovation competitions as an employment tool ○ New work roles for institution 	<ul style="list-style-type: none"> ○ COVID-19 Precautions ○ Lackness of the place (technique) ○ Not suitable for online 	<ul style="list-style-type: none"> ○ Increasing prevalence by trusted format in many large companies 	<ul style="list-style-type: none"> ○ Innovation competitions of other organizations ○ Covid-19 Precautions

VII. IDEASPRINT

As explained above, although the Design Sprint model is used effectively by one of the global technology giants, it has its own shortcomings. The primary factor that institutions should pay attention to when constructing open innovation competitions is their internal dynamics. In this context, the new model proposed in this study is an open innovation competition setup blended with the needs and expectations of especially large scale companies. The relevant methodology will be referred to as "IdeaSprint". IdeaSprint is a new and improved program model, inspired by both the Design Sprint and other methodologies currently implemented in the ecosystem, and by eliminating the shortcomings of the existing models mentioned in the SWOT analyzes above.

Within the scope of this study, the innovation competitions of other corporate companies and the models in the literature such as ideathon, hackathon, Make-a-thon were examined and the "IdeaSprint" model was developed as an open innovation competition setup to be applied. The process flow of the IdeaSprint model is as follows.

DAY 1:

- Opening Ceremony – Greetings and program plan announcement to the participants
- Study subject reveal of the previously announced theme
- Speed Networking Session – Creation of teams for the individual participants
- Role sharing within the teams
- Brainstorming Session 1 - Identifying the target audience
- Brainstorming Session 2 - Identifying customer problem (needs and expectations)

DAY 2:

- Literature review on the problem
- Benchmarking for existing solutions
- Guidance Session - Working with mentors
- Customer empathy map / Value proposition canvas / Business model canvas filling
- Solution development/idea generation sessions as a team

DAY 3:

- Prototyping - MVP/Landing page preparation
- Customer interview questions preparation
- Guidance Session - Working with mentors

DAY 4:

- Conducting customer interviews (If not possible, can be simulated using customer empathy map)
- Pivoting Sessions
 - Individual pivot idea generation session
 - Mixer Stage - Selection of a pivot idea as a team among individual ideas
- Post pivot updates – Revision of business model canvas and MVP

DAY 5:

- Preparation of pitch decks
- Elevator Speech Rehearsals
- Jury Presentation – Selection of the Best / Most Open to Development / Most Unsuccessful pivot projects
- Closing Ceremony – Presenting the awards to those selected in the relevant categories and receiving feedback about the program

The target audience of IdeaSprint is all entrepreneurs who have a solution idea for the given theme, especially students (as participation in these competitions usually comes from young people). Participants can apply individually or in teams of up to 5 people.

Just like all other open innovation competition models, the main purpose of IdeaSprint is for teams to come up with innovative ideas within a limited time frame within a given theme. However, there are some innovative points where IdeaSprint sets it apart from all other models.

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 İstanbul Technical University & Bahçeşehir University

1. Relevant entrepreneurship trainings are given by video during the application. Participants who do not watch videos containing basic short trainings such as preparing a business model canvas and filling in a customer empathy map will not be able complete the application form. In this way, time will not be lost with training in the productization process of ideas that come together physically, and when it comes to the implementation, everyone's level of knowledge on the technical details of the subject will be equal, so it can be put into practice directly.

2. The section referred to as “Mixer” in the model will develop different competencies of the participants, thanks to its setup on working individually and then in teams. It is true that a successful entrepreneur should be able to freely express his or her own opinion and stand behind it; however, they should also be able to adapt to teamwork, be a good team player, be able to approach a good idea objectively no matter who it comes from, be able to criticize their own ideas and not always see their own work as the best. The Mixer stage contributes to the development of these competencies.

3. The necessity of pivoting to the first solutions developed in the program is a very useful practice for entrepreneurs for real-life scenarios. Most successful startups on the market today are at a very different point than they were in their first versions. This again proves the necessity and inevitability of the concept of “pivoting”. IdeaSprint obliges participants to pivot their ideas, that is, partially or completely revise them, by taking advantage of the feedback they receive after customer interviews. The aim here is to simulate one of the real life problems and prepare the person for the real entrepreneurial journey, as well as to teach how to avoid the mistakes of being fixed-minded and falling in love with his/her own idea, which is one of the most common mistakes entrepreneurs make.

4. At the end of the program, not only the best project is awarded by the jury, but also the “most open to development” and “most unsuccessful” projects will be selected. Giving feedback to the competitors in these categories and giving them a voice is one of the best ways to explain to entrepreneurs that failure is the best way to learn and encourage them not to be afraid of making mistakes.

TABLE II
 SWOT ANALYSIS FOR IDEASPRINT

Strengths (Positive & Internal)	Weaknesses (Negative & Internal)
<ul style="list-style-type: none"> ○ Progress depending on the methodology ○ Providing expert opinion ○ Education series ○ Team work ○ Customer view ○ Direct application after training ○ Pivot opportunities Awarding unsuccessful projects methodology	<ul style="list-style-type: none"> ○ A busy and long calendar
Opportunities (Positive & External)	Threats (Negative & External)
<ul style="list-style-type: none"> ○ Spread of entrepreneurship culture in universities ○ Increasing awareness of innovation competitions ○ Seeing innovation competitions as an employment tool 	<ul style="list-style-type: none"> ○ Innovation competitions of other organizations ○ Academic calendar arrangements (for student-programs) ○ Covid-19 Precautions

There are some important criteria used when comparing open innovation models. The benchmark chart of open innovation methodologies, including IdeaSprint, which is the model we proposed on the basis of these criteria, is stated in Figure 2.

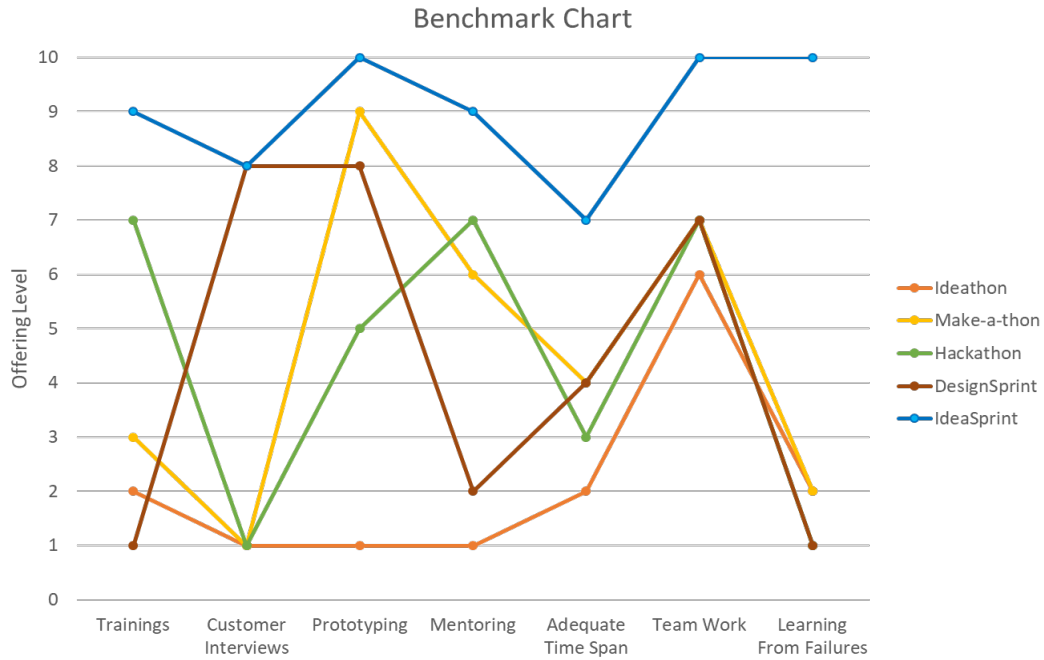


Figure 2. Benchmark Chart

VIII. CONCLUSION

In this study, first of all, ideathon, hackathon, make-a-thon, open innovation models are examined in detail. Then, the Design Sprint setup was evaluated. SWOT analysis studies were carried out for all these models and their strengths and weaknesses were determined. Based on the identified deficiencies and considering the unique needs of especially large scale companies, a new open innovation model was created and this new model proposal was named "IdeaSprint". Finally, a comparison chart of IdeaSprint and other models in question is presented. In the evaluation, it was seen that IdeaSprint showed the highest performance in the criteria determined for the efficiency of open innovation programs. After this study, it is aimed that the IdeaSprint design model will contribute to the literature and create benefits for the entire entrepreneurship ecosystem with its multiplier effect.

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A Supervised Machine Learning Approach for Stock Transfer between Stores

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Abstract—Providing resale process of products has become a challenging issue for retail companies. Due to the logistics of delivery, this procedure causes retail businesses to suffer significant losses. This study focuses on the establishment of an intelligent system as an enabler of Artificial Intelligence in footwear retailing to reduce costs and create more value for customers. As a matter of fact, primary growth determinants for the footwear market include customer’s demand along with customer experience. In shoe retail, somehow one part of the shoe which is called “one loose shoe” could be lost in the store. Lost shoes cause annual loss. To solve this problem, a hybrid “match maker” system for transferring the stocks with high possibility of sale between stores has been proposed. Proposed system consists of three main submodules. Each module is built by further examining the feature contribution of the score. First submodule; “Matching Error” is based on a machine learning algorithm; second submodule “Sales probability” is based on statistical calculation and last submodule “Shipping Cost” is based on logistics of delivery cost. The results showed that CatBoost Algorithm is the best applicable model since data consist of categorical data with accuracy 93%. The performance of the model is achieved as follows: recall is 94%, F1-Score is 97%, precision is 99.0%, and AUC value is 70.0%, respectively.

Keywords— Machine Learning, Supervised Learning, Artificial Intelligence, Retail, Stock Transfer

I. INTRODUCTION

Retail along with logistics sectors are exploiting artificial intelligence (AI) and gaining tremendous benefits. Utilization of AI integrated systems have advantages like reducing costs, increasing revenue, and enhancing asset utilization. AI leads businesses to forecast customer demand accurately, optimize R&D, increase manufacturing with lower cost and higher quality, provide better customer experience along with higher employee work performance and gain competitive advantage [1].

In this study the main goal of the dataset is to predict the probability score the store sends which is a regression problem. Machine Learning (ML) is a subset of AI in which identification and learning of patterns and utilization of insights are executed for making decisions without human interaction. Nowadays, ML has become one of the most rapidly growing technical fields in the intersection of computer science and statistics, and at the core of AI and data science. The adoption of data intensive ML methods have been found throughout science, technology, and commerce, allowing more evidence-based decision-making processes (Jordan et al., 2015) [2]. One of the sectors that benefit most from ML is retail sector. ML algorithms have wide utilization in different retail areas such as price management, forecasting, store layout, location selection, assortment planning, market optimization (Weber et al., 2019) [3]. It has also again been emphasized that AI has had a significant impact in the retail sector in the last decade (Pooranam et al., 2019) [4]. It is in the focal point of footwear which is

one of the challenging markets for competitive fashion industries that have experienced rapid progresses in recent years. As the world's population grows, demand for footwear has increased. From these standpoints, consideration of Implementations of AI and ML for footwear retailing processes becomes inevitable since the footwear retail industry is expanding and modernizing. In the footwear market, automation, hyper-personalization, complementarity, and innovation are currently hot topic areas of AI (Cao, 2021) [5]

An image-based shoe recommendation system with accuracy of over 84% was performed using Machine Learning using feature extraction techniques on the attributes of the shape, color, and texture (Saxena 2013) [6]. Another specific research for the “footwear market” is comparing several ML algorithms which are Support Vector Machine (SVM), Linear Regression, K-Nearest Neighbors (KNN) in predicting sneaker prices (Raditya et al., 2021) [7]. Evaluation of machine learning algorithms for designing shoes in an accurate fashion with linear regression has also been studied. Booth et al. (2019) [8].

This study handles the dataset of the one of the biggest Shoe retailing companies in Turkey in which facing problems with respect to “one loss shoe” which means “losing one of the pair of shoes” arisen from customers trials during shopping. That is to say, one piece of pair can be lost in the stores. Thousands of “one loss shoes” cause great financial losses in chain markets with large sales volumes. Labour force and work loss cannot be efficiently and effectively utilized within the companies due to rework processes of “one loss shoes” which causes extra costs.

To address this issue and understand how Using autonomous system, an efficient AI based recommendation system which matches the “one loss shoe” with similar another “one loss shoe” with respect to electronic data record of stores in footwear retailing. Failures arisen from the human influence on the goods are aimed to be reduced by adapting ML techniques in shoe retailing. Image processing is not considered for this study. To the best of our knowledge, it has not been handled in the literature yet. In this regard, we believe that this study will be a pioneer study in the sector for practitioners as well as a guideline for researchers in the literature. Footwear industry can benefit from this research by developing a strategy for selling one loss shoe in another store by stock transferring based on AI and statistical calculation.

The rest of the study is organized as follows: Section 2 describes the theoretical background about the CatBoost algorithm which is used to design Match Maker System. Section 3 introduces methodology used in the design of CatBoost algorithm and evaluated performance metrics. in section 4 , problem definition , data collection stage for case study and results are provided. Section 5 presents conclusions and recommendations for further directions.

II. THEORETICAL BACKGROUND

Machine learning algorithms used in practice include support vector machine, logistic regression, CatBoost, random forest, decision tree, AdaBoost, extreme gradient boosting, gradient boosting, naive Bayes, K-nearest neighbor, etc [9]. This study handles CatBoost algorithm. For this reason, in this section the theoretical background of CatBoost which is based on gradient boosting is given.

The variations of gradient boosting algorithms have advanced quickly in recent years [10]. Three key implements have evolved within the gradient boosting decision tree (GBDT) framework: Extreme Gradient Boosting (XGBoost), Light Gradient Boosting Machine (LightGBM), and CatBoost[11]. In this section, conceptual explanations would be provided for methodology executed for the proposed system including gradient boosting and CatBoost.

Boosting is a term researchers come across while studying machine learning which is the term misunderstood frequently. The basic idea behind boosting methods is that after creating a model by using the training dataset, a second model is created to fix any mistakes in the original one. It is essential to realize that boosting is an algorithm rather than a particular model and it is improved by a weak model [12].

Gradient boosting is a robust machine learning method that has been successfully used for a variety of commercial difficulties, including fraud detection, product recommendations, and forecasting. In contrast to other models, which must learn from a vast quantity of data, it can also produce extremely good results with relatively limited data. It is also powerful for learning problems with heterogeneous features, noisy data, and complex dependencies along with recommendation systems, etc. Decision trees are used as the primary predictors in most gradient boosting implementations. Although it is practical to utilize decision trees for numerical variables, many datasets also contain categorical elements that are crucial for prediction. Categorical

features are discrete sets of values that are not always comparable to one another. The method of transforming categorical features to numbers prior to training is the one that is most frequently used.

CaTBoost is a gradient boosting library which can deal with categorical data. It effectively handles categorical features and benefits from handling them during training rather than pre-processing time. CatBoost does not utilize binary substitution of categorical values. Instead, it performs a random permutation of the dataset and evaluates mean label value for the example with the same category value placed before the given one in the permutation. [13]. CatBoost is also an open source sequential machine learning technique in which several models are added to the overall model performance iteratively to enhance. The algorithm has been developed by Yandex to improve the performance of Gradient Boosting algorithm with high learning speed, ability to work with both numerical, categorical and text data [14]. CatBoost classifiers have been widely utilized in supervised machine learning applications for both classification and regression issues such as fraud detection, spam email, loan prediction, and so on.

While training a model, the main aim is finding the model that best solves the given issue (regression, classification, or multi classification) for any input object based on a set of features. A training dataset, which is a collection of objects with known features and label values, is used to find this model. Gradient enhanced decision trees are the foundation of CatBoost. During training, a series of decision trees is constructed one after the other. Each succeeding tree is constructed with less loss than the prior trees [15].

III. METHODOLOGY

The steps of the algorithm for a single tree are as follows:

Step 1: Evaluation of splits

Step 2: Conversion of qualitative(categorical) features into quantitative features

Step 3: Selection of tree structure

Step 4: Evaluation of the leaf values.

In Step 1; Evaluation of splits is performed; each numerical attribute is quantified to split data into buckets and obtained data is utilized to determine the tree structure. The starting settings and the number of buckets is identified.

In Step 2; Conversion of qualitative(categorical) features into quantitative features is performed before each split is selected in the tree. The process is done in following order.

- In a random sequence, the set of input objects is determined based on permutation.
- The label value is converted from a floating point to an integer.
- Categorical features are converted into numerical features by the determination of starting attribute

Notably, conversion of text features into numerical features which include text pre-processing by tokenization and dictionary creation hasn't been applied in this study.

In Step 3; Selection of tree structure is performed. A randomized permutation of classified objects is conducted before every new tree is built. The structure of the next tree is selected using a measure that includes the direction for further enhancing the function.

In Step 4; Evaluation of the leaf values is performed. For each object, the value is calculated in a sequential manner. The randomized permutation gathered is used in the calculation before building the tree.

Performance Evaluation Metrics

Machine learning pipeline has performance measurements. They quantify the progress and represent the performance of models based on several evaluation metrics. The most common machine learning task may be divided into categories such as regression and classification [16]. Similar to the machine learning task categories, performance metrics are handled with respect to the task type which could be measured during training and testing. In this study, since the problem focuses on classification the below metrics were given below for model performance measures in Eqs. (1)–(4) where FN and TN stand for "false negative" and "true negative," respectively, and FP and TP stand for "false positive" and "true positive," respectively, PR stands for Precision

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$\text{Recall} = \frac{TP}{TP + FN} \quad (2)$$

$$\text{Precision} = \text{PR} = \text{TP} / (\text{TP} + \text{FP}) \quad (3)$$

$$\text{F1score} = 2 * \text{Precision} * \text{Recall} / (\text{Precision} + \text{Recall}) \quad (4)$$

IV. CASE STUDY AND RESULTS

A. Problem Definition

The main aim of the research is development of a decision mechanism based on Artificial Intelligence techniques where the products which are identified as one loss shoe are sold with highest efficiency in the stores. FLO has 621 stores, located in 11 different countries and every year approximately 150000 shoes are defined as “one loss shoe” and 60%of them are destroyed for the following reasons.

- Accidental damage to a shoe by the store personnel.
- Customers buying the right and left singles of the product with different numbers at the time of sale.
- Failure of only one of the products from suppliers.
- Lost/theft of single products.
- Finding one loss shoe in the store after a period.

A great inefficiency process arises when the cost of the disposal process and the loss of sales of the product are considered. In this research, design of the decision mechanism following cases were considered.

If the matching product is to be sent to store A, store stocks or current stock movements of the store also have been taken into account. If there is stock of the same product in the store, it is necessary to send the product to the other store. In case of multiple matching, the unit costs of the product and the cargo costs have been considered for the decision to keep the cost to a minimum. On a per-store basis, products should be sent to real saleable stores by estimating future sales using the relevant parameters.

B. Proposed “One Loss Shoe” System

Shoe retailing design has evolved from AI techniques. To develop an AI footwear recommendation system, it is necessary to analyse the current system and collect the original raw data from systems. In this research, the proposed Match Maker framework is presented. The overall system is designed based on three main subsystems which are, Matching Error Model: Sales probability Module and lastly Shipping Cost Module. The architecture of each subsystem is detailedly represented in Fig. 1 in subsequent order.

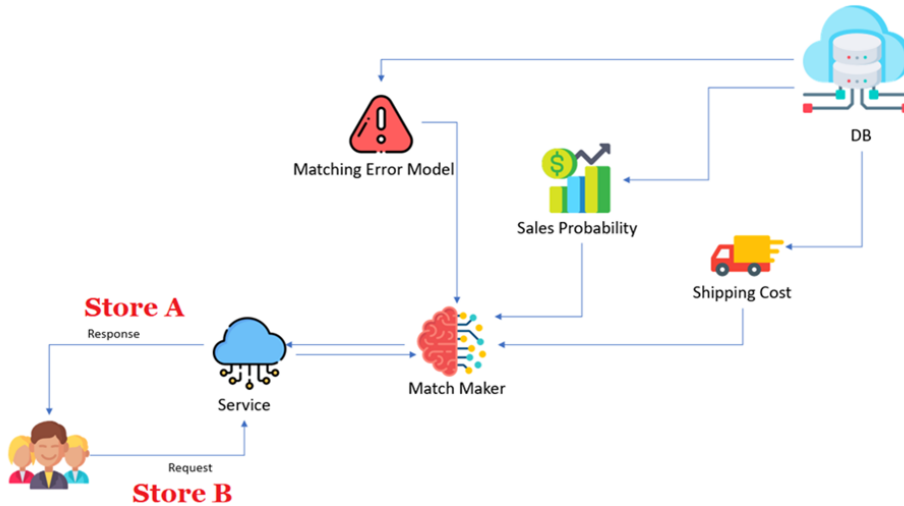


Figure II: Proposed “One Loss Shoe” System

As seen in Figure 1, when a user sends a request to service, the system checks the AI based “Match Maker” program, which makes the calculation that finds the maximum score including three main sub-modules as follows: First AI module “Matching Error Model” which calculates the probability of the store sending the wrong shoes based on faulty product survey and past match records. Second Module “Sales probability module”

which calculates the sales probability of the shoe to be sent in the relevant store based on shoe category sales amount, shoe sales amount history, stock data, sales amount for the next 3 months of the previous year. Third module “Shipping Cost” calculates the shipping costs and transportation time on the road based on stores geographical location by minimizing the time and shipping unit price. Finally, the proposed recommendation system calculates the following score using the below formula and modules in Table I.

$$\text{MAX} ((1-\text{error}) * [(\text{sales_prob} * (\text{sales_amount} - \text{cost} - (\text{shipping_cost} * \text{time}))] - (\text{time} * \text{shipping_cost} * 2 * \text{error}))$$

System is designed based on following modules:

TABLE II
MATCH MAKER MODULE LIST

Module	Explanation
Match maker	Performs the matching of shoe singles.
Sales prob	Calculates the probability of selling the product.
Matching error	Estimates the probability of incorrect transmission.
Profit	Performs the sales price-cost calculation.
Sales amount	Probability of sale
Cost	product cost

C. Data Collection

In this study, a dataset from 612 FLO stores is used from 2020 consisting of last 2 years shoe sales. In order to hide the private sales information of the company, only the number of records used in the artificial intelligence module is specified. General info about the tables have been used in the study are Sales, Past Matching Records, Shoe Price, Shoe Cost, Shoe Categories, Incorrect Shoe Matching, Store Info and Intercity Distance. In matching error, Survey_RESULT Table and ONELOSSSHOE_LOG tables have been used which contain 47597 records. All experiments were carried out using 10-fold cross validation. In this approach, the dataset is divided into 10 equal parts randomly and homogeneously. Each part is used for sequential testing, while the remaining parts are used for training. This process continues until each part is used for testing. Thus, each part is used for both testing and training which gives the spread 80% for training and 20% for testing.

D. Results

The proposed methodology could be applied for determination of probability of store sending wrong “one loss shoe”. The preliminary literature analysis showed that the CatBoost algorithm is the best when there exists categorical value on the dataset. The model was evaluated by using Standard performance indicators such as precision, AUC, and sensitivity (recall on positive and negative groups, respectively) for comparison. Results using performance measures generated from estimations acquired via 10-fold cross-validation are shown in Table II. Since the main of the model not to classify store whether sent wrong entry or not, aim of the study is to find probability of a shipment being wrong as a coefficient in the expression to maximize the whole score. So, AUC performance indicator also known as c-statistics which represents the summary of the ROC curve and measures a classifier's capacity to distinguish between classes has been used in the calculation formula. Figure 1b presents the PPV (positive predictive value) of a matching error against sensitivity, with AUC (area under the curve) of 0.70. The model's mean accuracy prediction for the prospective test set was 0.93. The feasible working points, based on predictions from the test set, are 99.00 percent precision and 94.00 percent recall and 97.00 percent F1-Score.

TABLE II

RESULTS OBTAINED FROM THE PROPOSED METHODS IN TERMS OF PROBABILITY OF WRONG SEND

Fold Number	Accuracy	Precision	Recall	F1	AUC
1	0.921849	0.025280	0.264705	0.046153	0.595641
2	0.917227	0.040609	0.5	0.075117	0.710025
3	0.927521	0.014925	0.25	0.028169	0.590190
4	0.921429	0.025069	0.272727	0.045918	0.599342
5	0.926471	0.029761	0.294117	0.054054	0.612569
6	0.922059	0.019283	0.318181	0.036363	0.621522
7	0.927941	0.030674	0.270270	0.055096	0.601682
8	0.925404	0.034883	0.342857	0.063324	0.636289
9	0.925615	0.023332	0.296296	0.043243	0.612751
10	0.931918	0.031847	0.333333	0.581395	0.634525

To confirm the success of our study, confusion matrix which is used to assess a classification model's performance of the model, where distribution is done between target classes can be seen in Figure Y. it has been observed that 8889 (TN) and 21(TP) class data points were correctly classified where 573(FP), and 36(FN) class data points were incorrectly classified as seen in figure II.

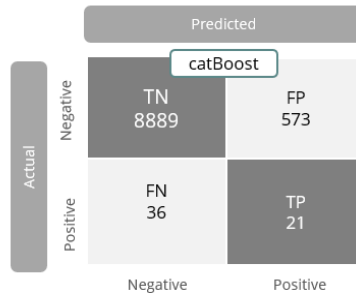


Figure III: Confusion matrix obtained from the proposed methods in terms of probability of store wrong send

V. CONCLUSIONS

The purpose of this research is to provide insight into how machine learning methods can support data driven decisions for a recommendation system designed for footwear retailing. This research handles the data set of matching the “one loss shoe” with similar another “one loss shoe” considering electronic data record of stores in footwear retailing through data science and machine learning.

It is possible to conclude that from knowledge driven modelling to data driven learning comes along with a tendency to see fuzzy systems with pure function approximators. For further directions, fuzzy set theory can be considered for decision making processes involving uncertainty, incomplete data since fuzzy set theory has potential contributions to machine learning along with data mining. Our analysis demonstrates that in the retail sector, AI-powered solutions could be implemented into their business processes in the management areas, significantly impact operations. The outcomes demonstrated that our proposed Match Maker system is a highly effective and accurate decision-support tool. The Match Maker will be evaluated in future study on a variety of instances using various larger datasets by extending for other retail companies not only shoes but also textile products

Future further research of some other classifiers with larger datasets may be applied.

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Agency Problem as a Barrier in Digitalization and Organizational Learning

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Abstract— Like many other fields, with the acceleration of digitalization organizations are experiencing the data and technology deluge, which is deeply affecting the whole functioning. While it seems possible to achieve the agility required by the age in organizations with digital transformation, it is important to make the learned information more permanent and organizational learning is needed more than ever in order to survive in the dynamic environment. However, despite the fact that the increasing importance of organizational learning is understood and many suggestions have been developed in theory and practice, there are challenges in reaching the desired levels of learning, which is expected to be accelerated with digitalization in organizations. Although various perspectives have been developed in the researches on the barriers to organizational learning, it is seen that the solution proposals remain at the general level instead of focusing on the problems one-to-one. Therefore, there is not enough aggregation other than general prescriptions in overcoming the disorders to learning. As a consequence, it will be possible to bring more functional solutions to the problem by directly examining certain problems. From this point of view, in our study, the problems arising from the agency relationship are discussed, considering that it is an obstacle to organizational learning in the digital transformation process. Top managers in organizations are expected to foster learning and guide strategies by providing a visionary perspective. Although many studies have emphasized the role of the management level in organizational learning, it has not received enough attention that the problems arising from the agency relationship between principals and agents are one of the main obstacles to learning. With this research, this gap in the literature is pointed out, and it is specified that agency problems prevent organizational learning, and the importance of boards of directors in achieving organizational learning by eliminating agency problems. In this context, the effect of goal differentiation, information asymmetry and risk attitude differentiation between principles, agents and employees on organizational learning and digital transformation strategies is discussed. Afterwards, the necessity of effective implementation of governance mechanisms throughout the organization in information and technology management is emphasized and suggestions are made for the board of directors, which is the most important component of corporate governance.

Keywords— *Organizational learning, Digital transformation, Barriers in digitalization, Agency problem, Board of directors*

I. INTRODUCTION

With today's increasing technology environment, digitalization has become a powerful phenomenon that is at the basis of every decision to be taken and every work carried out within the organization. So, with an effective technology management, it is possible to use an organization's resources effectively and efficiently and to obtain sustainable competitive advantage. Hence, an improper technology management; causing the organization to remain passive against external reactions and may be the main source of the failure of most of the work within the organization despite all kinds of efforts. However, despite the existence of the industrial revolution in our lives and the understanding of its importance, it is still not clear how the technology management that will lead to success is created. Because an inevitable and dynamic change is making the environment more complicated. The survival of organizations brings organizational learning phenomenon to the forefront for effective technology management by perceiving the changes in their environment and

activating their internal processes. Consequently; in the face of the changing environment, the mechanism of organizational learning attracts attention from the important dimensions of technology management and organizational learning emerges as a dynamic ability. Although various perspectives have been developed on the subject, a phenomenon that disturbs both researchers and practitioners is emerging in practice. Organizations cannot adapt at the desired level in the face of digital transformation as a result of technological advances that have taken place at a dizzying pace. In other words, while it is essential to keep up with digital transformation for an effective technology management that will provide agility and dynamism in competition today, organizations cannot perform the desired level of learning. Therefore, the question “How can the obstacles to organizational learning, which is an indispensable process in technology management, be overcome?” remains important to researchers and practitioners.

Barriers to organizational learning have been demonstrated in various researches. And it is mostly accepted that the attitudes of leaders and managers effective in organizational learning and they are in a way to encourage learning. It can be said that the same situation is experienced in digital transformation as well. However, leaders and managers in an organization may hesitate instead of leading organizational learning and digital transformation due to the avoidance of risks to be experienced in change, for reasons such as protecting their own position or income, and not losing control with digitalization. After all, the process may be quietly getting into a stalemate because they can't make it clear that they don't promote digitization and learning. It is thought that this situation may be mainly due to the agency relations, which do not receive enough attention in research on digitalization and organizational learning.

For this reason, in our study, while examining the barriers to learning and digitalization in the literature, the focus is on the agency problems, which is considered a problem at the general level and being ignored from close attentions. In this context, it is first modeled that optimization in digital transformation in organizations is a process that is influenced by stakeholders including the board of directors, top managers, shareholders and regulatory authorities, but can only be achieved through organizational learning. Then, the concept of organizational learning and researches that address the difficulties encountered in organizational learning are mentioned. In the next section, within the framework of the agency relationship, the effects of the differentiation of purpose, information asymmetry and risk attitude differentiation between principles and managers on organizational learning and digital transformation strategies are discussed. The necessity of effective implementation of governance mechanisms in the organization as a whole is emphasized, and recommendations are made for boards of directors, which are the most important component of corporate governance.

II. DIGITAL TRANSFORMATION AND ORGANIZATIONAL LEARNING OPTIMIZATION MODEL IN ORGANIZATIONS

Optimizing digital transformation in organizations is a challenging process made possible by organizational learning influenced by stakeholders, including the board of directors, directors, shareholders and regulatory authorities. In the digital transformation process, it is very difficult to make learning continuous and to move towards optimization. In achieving optimization in stakeholder-based digitalization, it is necessary to consider the possible restricting effects of boards of directors and top managers (especially CEO), which are at the center of corporate governance. This possible limiting effect is illustrated by dashed lines in Figure 1.

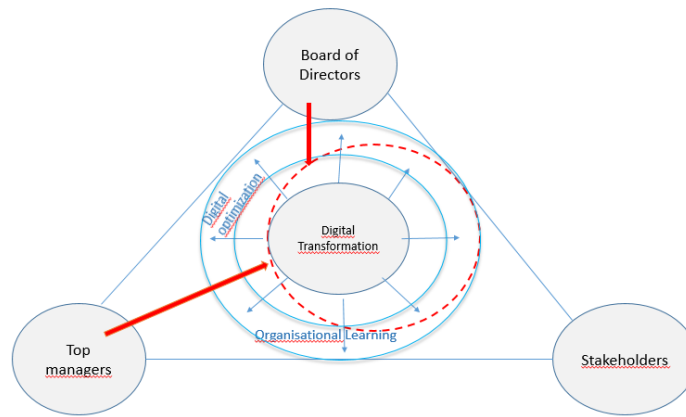


FIGURE 1
 LIMITING EFFECTS ON OPTIMIZATION IN DIGITAL TRANSFORMATION AND ORGANIZATIONAL LEARNING.

Starting with a brief literature review on organizational learning to assess why senior executives might prevent digital optimization by choosing not to engage in organizational learning, and how boards of directors support this limitation, will make easier to see the gaps.

III. BARRIERS TO ORGANIZATIONAL LEARNING

With the introduction of the concept of limited rationality by Simon [1], it became clear that organizations could not manage all variables with the same rationality. At this point, it would not be wrong to look for the source of organizational learning in understanding the fact that organizations cannot perform all kinds of information and management processes in a mechanical way. Because, as revealed by various researchers, the environment is becoming more complex. So, it is becoming more difficult for organizations to provide predictions with the increase in data and technology. As Mintzberg [2] states, although planning processes in advance, organizations need to manage emerging phenomena strategically in order to be ready for changes. This seems to be possible with the learning of organizations.

In the studies on how an effective learning process should be; it is stated that learning occurs at the individual, group and organizational level and that the expected behavioral change is in the culture, routines, structure and policies of the organization [3], [4], [5]. Regarding organizational learning by researchers; Many models have been developed such as single-loop/double-loop and second learning [3], organizational learning cycle [7] and 4I model (intuiting, interpreting, integrating, institutionalizing) [8]. While listing the barriers to organizational learning, which are defined as the systems or behaviors that prevent organizations from adapting in the main decision-making processes and processes they encounter, studies have mostly been carried out on the same models. It is stated that the studies on the barriers to organizational learning are more limited than the learning literature [9], and some prominent researches are seen in TABLE I.

TABLE I
 RESEARCHES TO BARRIERS TO ORGANIZATIONAL LEARNING

Author	Barriers To Organizational Learning
Senge (2022)	“I am my position”, focus only on position “The enemy is out there”, assigning blame on others The illusion of taking charge. The parable of boiling frog. The delusion of learning from experience The myth of management team.
Argyris (1996)	The defensive behavior inherent in the innate personality of the individual leads to limited learning of the organization.
Snyder ve Cummings (1998) [6]	“blindness” and “projection.” “simplemindedness” and “multiple-personality disorder”

	“paralysis” and “alien-hand syndrome.” “amnesia” and “superstition.”
Chief Executives (1995)	Imperfect mental models Incorrect analysis Insufficient dedication Blocked consciousness
McGill and Slocum (1994)	Barriers to learning culture Barriers based on ongoing experience Barriers based on the confidentiality of network assemblies Barriers based on information systems Barriers based on reward systems Barriers based on HR applications Barriers based on leader’ orders.
Schilling and Kluge (2008)	Barriers categorised as 4I model under below levels: Individual Structural Environmental
D. Fischbacher-Smith, M. Fischbacher-Smith (2012), [14]	Barriers to organizational learning can also arise from the processes of identifying and adopting new behaviors and practices in light of successes and failures.
Ganz (2015), [15]	Even in organizations where actors are rational and where there are no difficulties in aggregating information, organizational leaders may still choose not to learn, because leaders can attain better organizational outcomes (for themselves) if they do not collect information than if they do.

When the Table I is examined; it stands out that the lack of organizational learning begins at the individual level and continues with organizational level. Considering that the process, started with individual learning turns into organizational learning with appropriate strategy, vision, structure and culture. It is commonly emphasized by the researchers that various learning problems arise due to both individual and cultural, structural and leadership problems in the processes. Senge [4] collects the barriers to organizational learning under seven headings and draws attention to avoiding individual responsibility, being structurally over division of labor, being quick and incomplete in creating visions, protective behaviors throughout the organization and the "we said what I said" practices of leaders. Argyris [11], on the other hand, emphasizes especially defensive behaviors as a learning disability since it treats organizational learning as it does individual learning. Other researchers in Table I emphasize similar points and in general; they address the neglect of the lessons learned, important for the learning of the organization, the climatic and structural problems experienced in the circulation of information, the inadequate reward and incentive systems for information sharing and production, the key position of individuals in organizational learning, and the obstacles created by HRM practices within the organization [10], [12], [13], [6]. In addition to the general requirements, Ganz [15] draws attention to leaders and reveals that they may choose not to learn in order to achieve better results for themselves.

Since managers' preference for non-organizational learning limits both the organizational goal-setting process and the ability to achieve goals [15], it is necessary to focus on managers as one of the barriers to organizational learning and digitalization. Since in the digital transformation process, which is challenging for organizations, managers who are expected to make appropriate decisions and take ownership of the implementation of decisions can really become the most important barrier when they have different goals, do not share information and do not adopt appropriate risk attitudes. As mentioned earlier, this problem is thought to be based on agency relationships. Due to this reason, in the following part of the study, the answers will be sought in the light of the assumptions of the Agency Theory that the questions of what may be the manager-related problems in the digitalization process and organizational learning.

IV. AGENCY PROBLEMS IN ORGANISATIONS

In companies where the owners of capital are also managers, the shareholders can manage the company according to their own interests. However, as a result of the separation of ownership and control due to reasons such as the change in the capital structure of the firms and becoming multi-partner, their growth and the

complexity of the affairs, the capital owners leave the management to professional managers [16]. Where one or more persons (principles) appoint another person (agent) to make certain decisions on their behalf, the agent cannot always be expected to act in the best interest of the principle [17], [18]. The reasons and consequences of different or differentiated goals and interests are generally discussed within the framework of Agency Theory. In Agency Theory, it is assumed that people are bounded rational, utilitarian, self-interested actors who tend to be opportunistic [19].

According to the Theory, there are three main problems that can arise in the principle-agent relations between professional managers and shareholders [20]. The first is due to the fact that the purposes of the principle and the agent are different. While the manager wants to minimize his effort and maximize his income, the shareholder wants to maximize his profit by increasing the effort of the agent [17],[18]. The second is information asymmetry problem, which arises when the desires or goals of the principal and the agent are in conflict, when it is difficult or costly for the principle to verify what the agent actually did, whether he acted appropriately or not. It is the case that the principle cannot monitor the intentions, abilities, knowledge and actions of the agent, or only monitor them at high costs. The principal also needs information about the environmental factors or processes that affect the surrogate's business performance. In summary, in Agency Theory, it is assumed that there is asymmetric information in favor of the agent [21]. The third is the problem of risk sharing, which arises when the shareholder and manager have different attitudes towards risk. It is when the principle and the agent may choose different actions due to different risk attitudes [22]. In Agency Theory, it is assumed that managers avoid risk. Compared to principles, the possibility of a decrease in the income of the agent who has a low income and does not have the opportunity to diversify his income causes him to avoid risk [20]. There are numerous empirical studies that provide evidence that agent conflicts and the costs of power of attorney that they entail significantly adversely affect financial decisions, investment decisions and therefore firm value [23].

A. The impact of goal differentiation on digitalization strategy and organizational learning

The management of technological innovations is part of the strategic development of organizations. However, “technological myopia” can prevent the selection of a strategy that will positively affect the future success of companies [24]. This is often the result of managers focusing on short-term operational goals. For managers, long-term goals may seem far-reaching, sometimes even unattainable in the context of the manager's own possible tenure. In a study conducted by Bennett et al. [25], which included 974 companies, it was concluded that it may be important for managers to reach their compensation targets in case of a jump in wages when the performance target is exceeded or penalties such as dismissal when the target is not met. However, another remarkable result was reached in this study. It has been revealed that firms that exceed the earnings per share target have higher abnormal income accruals and lower R&D expenditures compared to firms that fail to meet this target [25]. From this point of view, using the assumption of the agency theory, it can be argued that CEOs may not be willing to make investment decisions that reduce profitability in the short term and aim at long-term profitability and sustainability by creating significant transformations, therefore, CEOs may tend to short-term goals by keeping the risk appetite of the institution low. Considering the intense R&D activities and expenditures required by digital transformation, it can be argued that the probability of making transformative digitalization decisions and organizational learning decreases when shareholders prioritize sustainability and managers focus on short-term profit targets. In Figure 2, there are predictions regarding the positioning tendency of manager decisions and shareholder expectations in a decision area affected by the agency problem. Considering the intense R&D activities and expenditures required by digital transformation, we can make the following proposition.

Proposition 1: When shareholders prioritize sustainability and managers focus on short-term profit goals, the likelihood of making transformative digitalization decisions and organizational learning is reduced.

In line with our proposal, in Figure 2, we present our predictions regarding the positioning tendency of manager decisions and shareholder expectations in a decision area under the influence of the agency problem.



FIGURE 2

DECISION AREA INFLUENCED BY THE AGENCY PROBLEM

B. The impact of information asymmetry on digitalization strategy and organizational learning

In large organizations where ownership and management control are separated, owners must depend on managers for information about the business. This situation causes the capital owners to be unable to monitor whether the managers they authorize behave appropriately [26]. When information asymmetry occurs in favor of the manager in the agency relationship, moral hazard may accompany it. 2022 “Report to the Nations” prepared by the International Association of Fraud Investigators revealed that companies lose 5% of their revenues every year due to fraud, 23% of fraud cases are committed by those with senior powers and the biggest losses occur resulting managers abuses [27].

On the other hand, thanks to digitalization elements such as the internet of things, artificial intelligence, cyber security, big data, autonomous robots, cloud computing, which are in our field of interest with Industry 4.0, it has become possible to instantly access data that could not be accessed before, and to produce new information that could not be created before. Digitalization has made significant contributions to the processes of processing, control and reporting of information. These developments have also increased the efforts of organizations to make data suitable for technology and have made information valuable. Information systems have been established that improve the planning, control, coordination, analysis and decision-making functions of the management. Information systems provided full and timely access to reliable and unbiased information required at all levels. For example, digital technologies have transformed periodic accounting reports into real-time reports [28]. The negative effects of information asymmetry can also be mitigated when digital technologies are equipped with the advanced monitoring capabilities needed to address agency issues and thus reduce performance volatility. Automated control systems such as artificial intelligence applications that learn about patterns of irregularity and fraud and alert when faced with such typicality [29] can play an important role in preventing irregularity and fraud at all levels within the organization. Digitization helps harmonize executive decisions with shareholder expectations by reducing information asymmetry. In this context, we can make the following proposition.

Proposition 2: Since digitalization has a reducing effect on information asymmetry, this effect will have a positive effect on reconciling managerial decisions with shareholder expectations.



FIGURE 3

THE EFFECT OF DIGITAL TRANSFORMATION ON REDUCING INFORMATION ASYMMETRY

However, when we consider the basic assumptions of agency theory; It would not be wrong to think that managers will be reluctant to invest in digitalization/digital transformation strategies based on the argument that they will resist systems that will enable stakeholders to access information easily. In cases where managers want to restrict access to information, they may resist digitalization and organizational learning strategies that will ensure responsibility, accountability and transparency. So we can make the following proposition:

Proposition 3: In cases where managers want to restrict access to information, their tendency to resist digitalization and organizational learning strategies that will ensure responsibility, accountability and transparency will increase.

C. The effect of risk attitude on digitalization strategy and organizational learning

Digital transformation strategies are challenging organizational learning processes that require important investment decisions. Many companies experience difficulties and tensions in the digital transformation process, and as a result, transformation efforts are limited to gradual optimizations in existing business operations and production processes. Because digitalization initiatives involve great uncertainty, managers have a hard time developing their strategies for how to approach new business models for their organizations [30]. Uncertainty naturally brings with strategic, financial, operational and compliance risks.

The attitude of shareholders and directors to risk can be opposites. For example, while capital owners want to take risks related to investments that they think will return to be high, managers who are trying to protect their own income and position may develop an attitude towards risk aversion [26]. Indeed, Agency Theory assumes that agents whose job security and income are inextricably tied to a single firm tend to avoid risk in decisions about the firm in order to reduce the risk to their own income [31]. Therefore, while the opportunity potential offered by digital transformation increases the risk appetite of shareholders, managers who take into account the long-term positive effects of digital transformation projects, which are a high-cost, long-time, collaborative and specialized learning process that challenges current practices, and previous failures, will not want to make risky decisions that threaten the remuneration and similar payments they hope for the future. As a result, when shareholders want to seize opportunities while managers avoid risk, managers may show a tendency not to make digital transformation decisions.

However, because managers are more sensitive to losses than risks, they can also make high-risk digital transformation decisions as long as they feel they are avoiding loss, that is, as long as they are not affected by the financial consequences of risk. Risk-taking activities can often increase managers' ability to achieve better career outcomes, even if those activities hurt shareholders' financial results. For example, although risky acquisitions result in lower returns for shareholders, such bold strategic actions are considered an indicator of risk-taking ability that can open up a lucrative career path for managers. This can help managers achieve positive career outcomes for themselves. Therefore, managers may undertake such actions to build their reputations and careers in the labor market [32]. Therefore, we can make the following proposition.

Proposition 4: Since managers are more sensitive to losses than risk, their tendency to make high-risk digital transformation decisions will increase as long as they think that they are avoiding loss.

In the following section, it will be discussed how the agency problems can be reduced by increasing the maturity level of corporate governance by putting the board of directors at the center.

V. THE ROLE OF BOARDS OF DIRECTORS IN REDUCING AGENCY PROBLEMS

Leaving the necessary analyses and evaluations incomplete before large investments aimed at the digital transformation of the company's activities results in erroneous strategy formulations. In practice, it is often seen that the focus is on the risks that affect the feasibility of this current strategy after the strategy has been chosen. Therefore, the board of directors needs to determine whether the strategy is aligned with the organization's risk appetite and how it will help the organization set goals and ultimately allocate resources efficiently. Enterprise risk management considers the possibility that the strategy may not align with the mission and vision of the organization, and helps the organization identify, evaluate, and manage risks to the strategy [33].

The corporate governance approach, which refers to a system of rules and policies in a heterarchical interaction to direct and control the operations of a business, will be able to help unify interests in enterprises and help all members share risks. Corporate governance mechanisms include employees at all levels in the organization, especially board members, senior managers, those who perform internal control and internal audit functions [34]. According to Fama and Jensen [35], the board of directors is an effective tool that shareholders in large corporations can use to control the decisions and monitor opportunism of senior executives who have management control. Conceptualization and experimental researches addressing the problem of the independence of the board of directors within the scope of Agency Theory focused on two elements of the structure of the board. One of them is the composition of the board, especially the measure by which the board of directors is made up of members who may be reasonably independent of the firms' CEOs. The second is the leadership structure of the board of directors [36].

To take advantage of the opportunities provided by technological changes, companies need to make significant adjustments to their governance systems. For example, governance innovations at the board level may involve a shift to strategic controls rather than financial controls within the firm's governance mechanism. Less concerned with short-term financial performance, these strategic controls may focus on issues related to long-term sustainability, market share growth, stakeholder support and risk assessment. Today, apart from formal, highly centralized accountability and reporting systems based on financial indicators, governance systems are being developed that focus on broader risk definitions, including strategic controls, more informal communication systems between managers and stakeholders, and risks that create broader intangible effects [29].

Proposition 5: As the maturity of corporate governance increases and the board of directors gets stronger, their support for the optimization of digitalization strategies will increase.

On the other hand, the monitoring effectiveness of the board of directors depends not only on the incentives of the board members to monitor senior management, but also on their ability to do so [37]. Therefore, it is expected that the boards of directors of companies with scattered ownership will have board members with more monitoring skills compared to companies with dominant shareholders. For this reason, the members of the board of directors should be appointed taking into account the talents and resources they can bring to the board of directors [37].

Today, boards of directors need to focus on the dynamic agenda in a way that creates value for the organization as much as the tasks for approval and compliance [38]. Dynamic agendas make it almost mandatory for boards of directors to have members of the board of directors who are knowledgeable in the field of information technology and committees within or affiliated to the board of directors. For digital transformation, CIO/CTO (Chief Information Officer / Chief Technology Officer) positions are being created as well as C-level positions (Chief Digital Officer - CDO) responsible for digital change [39].

Bankewitz et al. [38] predict that boards could become virtual boards of talented people, with a fixed number of boards today comprising a network of talented people called to the board of directors in the future based on their competencies that match the organization. It is considered that this estimate should be considered as a recommendation.

The survey conducted by Wu David and Farzan [40] of 800 global board executives to identify common trends in how their boards are approaching the challenges of the Covid-19 pandemic showed that the lack of digital knowledge and training is the main reason for the deficiencies (in both the operations and cybersecurity of companies). The survey results reveal that companies need board members who are more than ever digitally competent and understand new technologies that influence their business decisions. This means both hiring the right directors and investing in ongoing training for existing directors. "Ongoing board training" appears essential for these trainings to provide new skills and up-to-date expertise in key areas such as stakeholder engagement, compliance, audits, diversity, sustainability, cyber security and risk management [40].

Managerial myopia, which results in non-optimal investment strategies that harm companies' long-term value maximization, is more common in firms with weaker corporate governance mechanisms [41]. It may not be possible for the board of directors, which does not have the necessary competence, to harmonize the strategic objectives of the organization with the objectives of digitalization. In this context, one of the most damaging consequences for the organization is that boards of directors support inappropriate or failed digitalization strategies. It is conceivable that without operating other governance mechanisms that can help reduce the

expected costs and their negative impact on firm value, the idea that only managerial ownership can align the interests of directors and shareholders can also be effective in this. Optimization and organizational learning in digital transformation are jeopardized when the board lacks the ability to monitor and discipline management, lacks to make strategic recommendations [37] and is only the approval authority.

Proposition 6: As corporate governance and the board weaken, the possibility of failure of managers' digitalization strategies will increase.

VI. CONCLUSION

Today, institutions that cannot benefited from the advantages of digitalization, lose their competitive power. On the one hand, successful digitalization or digital transformation projects increase the monitoring costs in the beginning due to the expensive investments, but when they are successfully implemented, they reduce these costs to minimum levels and provide much more effective monitoring opportunities. As a result, reaching an institutional status that creates sustainable added value with long-term strategies with the support of digitalization strategies can be achieved through an institutionalization process based on the establishment and development of institutional structures and procedures within the organization [42]. Optimization in digital transformation, which is an intensive organizational learning process, is possible by increasing the maturity level of governance, internal control and risk management systems. In this context, it is indisputable that an optimal corporate governance structure should be one that will minimize the institutional costs arising from the conflict of different interests [43]. In this study, the effect of purpose differentiation, information asymmetry and risk attitude differentiation between principals and agents on digitalization strategies and organizational learning are discussed. Six propositions were made by focusing on the top managers and board that the most important element of corporate governance regarding eliminating agency problems.

Finally, it would be appropriate to repeat some suggestions for practitioners in the context of the role of boards in the process of reducing agency problems in the digital transformation process and realizing organizational learning. The most repeated suggestions are that the board consists of members who can be reasonably independent from their CEO, and that the CEO is not the chairman of the board. In addition, boards of directors should support the organization in identifying, assessing and managing strategic risks, assessing whether digitalization strategies are compatible with the organization's risk appetite and the appropriateness of resource allocations. As the representatives of the shareholders, the board of directors should have the competence to actively fulfill the oversight role in order to control the decisions of top managers and monitor their opportunism, and should support the establishment of an appropriate information system. The skills and resources that the members of the board of directors can bring to the organization should be adequately discussed at the general assembly. The presence of board members knowledgeable in the field of information technologies should be mandatory in the boards of directors. Positions such as Chief Information Officer responsible for digital transformation, Chief Technology Officer, Chief Digital Officer responsible for digital transformation should be created and they should work closely with the board of directors and especially with the competent board member. The structure of the boards of directors should be made flexible by creating a "network of talented people" according to the competencies required by the organization. It should be kept in mind that there will be completely virtual boards of directors in the future. In order to have digitally competent board members of companies and to develop these competencies, appropriate methods for "continuous board training" should be developed.

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An Overview to Stochastic Modelling for Industrial Engineering Considering Utilization of Artificial Intelligence and Learning Systems

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Abstract— The aim of the study is to provide an overview to stochastic modelling used in industrial engineering focusing within the perspective of utilization of artificial intelligence and machine learning. The scope of the study involves comparisons of stochastic models and deterministic models.

Keywords—stochastic modelling, deterministic models, artificial intelligence, machine learning

I. INTRODUCTION

Stochastic modelling is a form of a mathematical model for estimating all potential results of scenarios by utilizing random variables. The focus is on the probability distribution of possible results. It's useful when you need to see a lot of different outcomes under a lot of different circumstances. It allows an asset inventor, for example, to make investment decisions based on statistical data in financial analysis. The study of stochastic modelling is related to research targeted at modelling and problem-solving. The stochastic model concentrates on decision making in complex, dynamic systems under uncertainty and emphasizes practical applicability in industrial engineering.

Using random input variables, a stochastic process creates a mathematical model to generate every conceivable result of specific scenario. The probability distribution of potential outcomes is the main subject. Stochastic processes are divided into Markov and non-Markov processes.



FIGURE 1

STOCHASTIC MODELS ADOPTED FROM A. MUBAYI, V. ARUNACHALAM, 2019.

The aim of this study is to provide an overview to stochastic modelling used in industrial engineering focusing within the perspective of utilization of artificial intelligence and machine learning. The scope of the study involves comparisons of stochastic models and deterministic models. The rest of the study is organized as follows: Section 2 briefly presents deterministic and stochastic models. Section 3 gives utilization of artificial intelligence for stochastic industrial engineering applications. Section 4 briefly explains learning systems within the perspective of machine learning concepts. Section 5 provides conclusion and recommendations for further directions.

II. STOCHASTIC MODELLING AND DETERMINISTIC MODELLING

A. Deterministic Model

Deterministic model is a mathematical model in which the outcome is solely defined by the input data values and initial conditions. . The deterministic model considers input components as well as the dependency of mean values over time periods ([Yu, Tan, Mathew, Andjelkovich, Levine, 1990](#)). In all respects, a deterministic model requires certainty. In Deterministic Models are the best option when the system structure and the system boundaries is clear. When the system structure and limits are unclear, the stochastic model are more appropriate than deterministic models.

B. Stochastic Model

Random variables are used in formulas for modelling problem and its include random objective functions or random constraints. Optimization approaches use random variables that can be considered as stochastic optimization. Random iterate approaches are also involved in stochastic optimization. In other words, stochastic optimization approaches merge definitions of stochastic optimization by using random iterates for stochastic issue. According to [Zhang, Guoi, Ruani, Wang and Zhou \(2022\)](#), stochastic optimizations influence fairly the efficiency of operations and solve stochastic order allocation problems. In terms of optimization efficiency and ability, improved strategies guide the stochastic optimization method.

A stochastic simulation is system model in which variables vary randomly according to individual probability. Stochastic simulation is a founded system model for the spreading and study of uncertain model estimation ([Song, Valdebenito, Wei, Beer and Lu, 2020](#)).

In order to comprehend and forecast the behavior of complex systems in company, spatial stochastic models are useful. Importance in Spatial models, Limited number of factors pertaining to spatial interactions between places must be explicitly known. Comprehending and forecasting behavior of sophisticated systems depends heavily on spatial stochastic models, The knowledge that the spatial pattern noticed in environment is merely one expression of a random process is one of the most significant effects of being aware of the significance of stochastic processes ([Fortin, Boots., Csillag and Rimmel, 2003](#)). According to [Fusco and Vidoli \(2013\)](#), When data are spatially auto-correlated and statistical inference is unbalanced, the assumption is failed. As a result, the model or failure concept need to tend models that enable for heterogeneity management, showing contextual aspects linked to inefficiency.

III. UTILIZATION OF ARTIFICIAL INTELLIGENCE FOR STOCHASTIC INDUSTRIAL ENGINEERING APPLICATIONS

Nowadays, there has been a lot of interest in a more data-based approaches in industrial engineering with stochastic modelling. A stochastic model is a reflection model of the real system that creates the observed data ([Dietterich, 1997](#)).

Data mining along with machine learning, artificial intelligence research have made significant advances in a variety of areas.

Inference for processes involving stochasticity or incomplete information have been used for modelling in biology, medicine, economics, and etc. Having incremental computational advances have enabled practitioners

and theoreticians to have statistical inferences for more complex, and arguably, thus, more realistic stochastic processes, leading to significant advancements in many areas.

Especially, researchers focus on Bayes' Theorem, which is one of the important concepts in statistics, machine learning and artificial intelligence, is used for calculating conditional probabilities given the set of hypothesis. Bayes' theorem is adapted with different machine learning models and many algorithms. It can be used to solve complex data science and data analytics problems having adoptions within various machine Learning models and algorithms. Some industrial applications of Bayesian method shows with machine learning are facial recognition, Netflix recommendations, stock trading systems, Google page ranking, fraud detection and etc ([Alzubi, Nayyar and Kumar, 2019](#)).

Machine learning makes computers to imitate and adapt human like behavior. The system can learn from interactions, actions and use as experience for the next time via machine learning. Data science along with artificial intelligence as well as machine learning are inevitable for modelling. From theoretical aspects, behavior and performance of many machine learning algorithms are known as stochastic that refers to a variable process in which outcome contains randomness and uncertainty.

IV. LEARNING SYSTEMS

Learning system adjust behavior task or activities for developing performance. It includes architecture and algorithm with parameters. Learning systems are beneficial in a variety of industries such as control systems, system identification and computer science that are one of the most important areas.

In Stochastic Learning, numerous machine learning algorithms exhibit stochastic behavior and performance. Stochastic process is called variable process in which includes uncertain and unpredictability outcome. Some of researchers worked from a wide range areas which include control systems, operations research and computer science. Researchers have shown a great deal of interest in area of learning and optimization of stochastic systems ([Cao, 2008](#)).

There are Stochastic Learning Algorithms, more specifically Stochastic gradient descent algorithms are in the extend family of learning algorithms involving numerous well known algorithms such as Perceptrons, Adalines, K-means, Learning Vector Quantization and Multi-Layer Networks along with more ambitious learning systems such as Graph Transformer Networks. These algorithms have common convergence properties. Especially although, stochastic gradient descent algorithm is known as a very poor optimization algorithm, it is a very effective learning algorithm. According to [Merkel and Kudithipudi \(2014\)](#), Traditional algorithms rely on gradient descent that need equations. Researchers show a stochastic learning approach for neuromemristive systems.

In machine learning systems, Stochastic gradient descent is extensively applied and it is a machine learning optimization approach for identifying the variables that correlate to the best fit between expected and actual outputs. Another one of the most effective strategies for developing predictive models is gradient boosting. Subsample of the training data is randomly selected from training dataset at each cycle. Then, the randomly chosen subsample is utilized for adapting base learner rather than sample. Gradient Boosting generates prediction model from a collection of classification algorithm such as decision trees ([Kermani, Batelaan, Fadaee and Hinkelmann, 2021](#)). Advantages of boosting gradient method is easy to adapt in the memory and it is fast and accurate technique. According to [J. H. Friedman \(2002\)](#), At each iteration, gradient boosting generates additive regression models by adapting specified function to current "pseudo"-residuals using least squares.

Machine learning methods are stochastic since they rely on randomization or probabilistic data. On non-linear and sophisticated approaches utilized to classifier and regression predictive modelling situations, the behavior of machine learning algorithms is widely noticed. Machine learning approaches are wellfitted to the task of methodological tools. Some of the studies aim to describe animal behaviorists who are inexperienced with machine learning (ML) about the potential of approaches to analyze complicated behavioral data ([Valetta, Torney, Kings, Thornton and Madden, 2017](#)).

V. CONCLUSION

The aim of this study is to provide an overview to stochastic modelling used in industrial engineering focusing within the perspective of utilization of artificial intelligence and machine learning. The scope of the study involves comparisons of stochastic models and deterministic models.

Stochastic models, which allow for unpredictability in one or more inputs in time, are used to evaluate the likelihood of diverse results. Probability distributions are produced by the model and these are mathematical functions that indicate likelihood of diverse possibilities. Stochastic model application has recently focused on complex problems mostly in energy industry, health industry, economy, finance and trade industry, environmental science, agriculture, innovation and technology.

The stochastic nature of machine learning algorithms is very crucial. Stochastic modelling is necessary for understanding and interpreting the behavior of many predictive models. Many applications involve engineering systems that utilize stochastic processes as key tools for modelling and reasoning.

Machine learning and artificial intelligence have risen dramatically in recent years in the area of data analysis and technology, which enables the applications to perform intelligently. There have been many developments, and the relevant literature in machine learning has been growing rapidly and thus many industrial applications can have more benefits as more areas within artificial intelligence and machine learning methods for solving their problems.

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Analysis of the Innovation Performances of Turkish States According to the Global Innovation Index Data with the Entropy Weighted TOPSIS Method

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Abstract— Today, innovation has a great place in the economic development of countries. Innovation is considered as a sustainable growth tool, especially for businesses. With this awareness, many countries and businesses around the world have begun to show the necessary importance to the concept of innovation in the twenty-first century. It is seen that the countries that determine and implement innovation strategies are at the top or become the leader in many reports and indices published globally in different fields. For this purpose, the Global Innovation Index (GII) has been developed to help countries open to development in catching up with the changes existing in the changing and developing competitive and technological environment by determining the innovation performance of countries in detail. Thanks to the GII measurements, countries will be able to see which criteria they care about how much, which criteria they lack and which ones they have good performance, they will be able to decide what needs to be done to improve themselves and to be better. In this context, the aim of this study is; By using Entropy and TOPSIS methods from MCDM methods, Turkic States; It is the comparison of the innovation performances of six countries, including Turkey, Azerbaijan, Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan, according to the GII data, which is a global study published every year. In the study, the innovation indices of the countries were calculated by making evaluations on 7 basic criteria in total, 5 criteria belonging to the innovation input sub-index published in the GII 2021, 2 criteria belonging to the innovation output sub-index. In the analysis phase, the weights of 7 basic criteria were calculated by the Entropy method. “Creative outputs” criterion has been the most effective criterion in innovation performance. The criterion of “information and technology outputs” is the second most effective criterion, and the criterion of “business sophistication” is in the third place. The criterion that has the least effect on innovation performance is the criterion of “Market sophistication”. According to the results of the study, Turkey, which has a clear advantage among the Turkish states in the GII and TOPSIS rankings, is the country with the best innovation performance. Azerbaijan is in the second place, followed by Kazakhstan, Tajikistan, Uzbekistan and Kyrgyzstan in the sixth place.

Keywords— Turkish States, Global innovation index, Multi-Criteria Decision Making, Entropy, TOPSIS

I. INTRODUCTION

In today's world, thanks to globalization and technological developments, the borders of countries have almost disappeared. In addition, the economic development of countries has turned into an economic race where there is constant competition. Countries that want to be in this race must have a competitive strategy in order to maintain their existence and gain sustainable competitive advantage. Therefore, countries should prioritize the concepts of innovation and efficiency in order to survive in a competitive environment. Competition at the global level leads countries to different strategies, however, the concepts of innovation, knowledge and entrepreneurship are encountered more frequently. With the change in the understanding of competition, it is seen that gaining competitive advantage has become more challenging. For this reason, countries need to add this information to the economy by producing new information in order to ensure sustainability in every field. At this point, innovation is a very important factor to ensure continuity in information age societies.

Promoting innovation, which is the driving force of employment and economic development of countries, can provide economic developments throughout the country and can be an important factor in policy making at local, regional, national and global levels. Thanks to the political decisions taken, it will be possible to make innovative production and services permanent and develop them, and as a result, countries will be able to

provide sustainability and growth in the long run [1]. Innovation index is the summary indicators of innovation capacities of regions determined for businesses, institutions and researches [2]. The Global Innovation Index (GII) is an important tool used to evaluate the past, current situation and determine the future in order to determine international innovation [3].

The GII is used not only to compare the performances of the countries, but also to clearly reveal the weak and strong sides of the innovation policies and practices of the countries. Countries with GII measurements; They can find answers to questions such as which factors should be taken seriously, which factors are insufficient, which factors show good performance, what are the good aspects to be improved and how they can be improved. For this reason, the global innovation index is one of the indexes that countries can choose as a guide for themselves [4]. By using this index, countries will be able to develop strategies to increase their competitiveness with other countries by determining which criteria can improve their economies and how much these criteria will weigh.

In the study, the innovation performances of the countries participating in the Organization of Turkish States (TSC) were analyzed according to the GII 2021 data, and inter-country comparisons were made. Countries that are members of the Turkic Council; Turkey, Azerbaijan, Kazakhstan, Uzbekistan, Kyrgyzstan and these countries as well as Tajikistan were included in the study. The formation of the Turkic Council first emerged under the leadership of Turkey in the period after the collapse of the Soviet Union in 1991. In this context, "The Summit of Heads of State of Turkic Speaking Countries" was held in 1992 for the first time [5]. Ten summits have been held so far, and the Cooperation Council of Turkic Speaking States, also known as the Turkic Council, was officially established at the last summit held on September 16, 2010, on the basis of the Nakhchivan Agreement signed by Turkey, Azerbaijan, Kyrgyzstan and Kazakhstan on October 3, 2009, within the framework of the institutionalization of the formation. After the four founding countries, Uzbekistan became a full member in 2019 and the number of member countries increased to five. In addition, Turkmenistan and Hungary are observer members of the organization. The name of the Turkic Council, which aims to cooperate in many fields, was changed to "Organization of Turkic States" at the summit held in Istanbul in November 2021 [6].

In the study, innovation, which is one of the most important factors for countries to develop competitiveness both at local and international level, to increase productivity, to increase economic progress and development, and thus to increase welfare and quality of life, is discussed within the framework of the GII 2021 data. In the first part, the studies in the literature related to the global performance index were examined, then the innovation performance ranking of the 6 member countries of the Organization of Turkish States was made using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. The data used in the study were selected from the data of the world in the GII 2021 report published by WIPO, and the weights of the 7 criteria belonging to this index were calculated by the Entropy method and included in the study. Finally, the country rankings and weighted criterion weights tables were created and the findings obtained were discussed in the conclusion part and some suggestions were made for future studies.

II. LITERATURE REVIEW

In the literature review, firstly the studies on the innovation performance of countries and then the prominent ones from the researches on the GII are summarized and presented below.

In the study conducted by Şahinli and Kılınc [8], it was aimed to determine the effectiveness of the indicators used to measure the innovation capacity and performance of countries. As a result of the study, countries are listed on the basis of R&D expenditures, high technology exports, number of entrepreneurs and researchers, number of patents and registrations. As a result of the ranking obtained, they drew attention to the fact that Turkey lags far behind.

Stojanovska and Josifovska [11] aimed to analyze Macedonia's innovation capability for the period 2012-2015 in line with the GII data . According to the findings, they emphasized that Macedonia lags behind in infrastructure and R&D compared to the countries in the ranking. In the context of the results, they warned the managers to develop better strategies, policies and practices that will increase the innovation capacity for the future of Macedonia.

Jankowska & others [14] studied how the innovation input in countries can be transformed into output by using the data of the GII 2015 . Analysis was carried out using the clustering algorithm on a group of 228

countries in total. A more detailed analysis was carried out for Poland and Bulgaria. Poland's strongest criteria are institutions, human capital and research. While the human capital and research criteria on the Bulgarian side remained weak compared to Poland, it achieved a high sub-innovation output thanks to the information and technology criteria. In addition, by using the cross-comparison method, why and how national innovation systems succeed or fail in producing innovation output is examined.

Hancioğlu [15], in his study, examined the relationship between innovation components in the GII using multiple regression analysis. In the study, GII data of the OECD countries for the period 2011-2015 were used. As a result of the study, the criteria that most affect the innovation index are respectively; infrastructure, research and human capital, commercial development, market sophistication and institutions. Another of the obtained results is; The sub-criteria of the second variable that best explains the innovation input sub-index cluster is education, higher education and R&D criteria.

Turan [16] evaluated Turkey's innovation performance by focusing on the input and output sub-components of the PPI covering the period of 2011-2017. In the period of 2011-2017, the ranking of the countries was made again by using the performance values of 114 countries included in the index every year. According to the results obtained; It is stated that Turkey has a better rank in the ranking made according to the output sub-index compared to the ranking of the input sub-index, and in this context, it is possible that Turkey can rank higher in the rankings of the GII and all sub-components with the improvements to be made in the institutions, infrastructure and business development criteria in the input sub-index. has been defended.

Ayçin and Çakın [18], it was aimed to measure the values of the innovation components in the European Innovation Scorecard of the European Union countries and the innovation performance of the countries and the degree of importance of the innovation components. For this purpose, Entropy and MABAC methods are used in an integrated manner. As a result of the research, the innovation performance ranking is Switzerland, Sweden and Denmark. Considering the degree of importance of innovation components by country, it is seen that they are in the form of intellectual assets, innovation, financing and supports.

Gürtuna and Polat [19], it was aimed to make a cluster analysis for the innovation performances of the countries over the values of the innovation components of 126 countries with the GII 2018 data. As a result of the analysis, it was stated that the countries were distributed according to their innovation performance as low-medium-high, low-low, medium-medium-medium-high-high. As a result of the evaluation, countries were classified categorically and sequentially in a maximum of 5 different clusters. Therefore, it has been concluded that the innovation performances of countries are different from each other.

Aytekin & others [21], it is aimed to compare the global innovation performances of European Union member countries and candidate countries. In this context, the data of the 2020 GII report were used. Data Envelopment Analysis (DEA) and Input and Output Comparative Efficiency Analysis Technique (EATWIOS) were used for evaluation. According to the results obtained, the Netherlands, Germany and Sweden emerge as the most important countries in terms of global innovation performance. Lithuania, Greece and North Macedonia occupy the last three places. In addition, some suggestions have been made so that countries can produce innovation output.

III. ANALYSIS OF INNOVATION PERFORMANCES OF COUNTRIES

In this part of the study, firstly, explanations will be made about the research method and the data set used, then the process of calculating the criteria weights to be used in the analysis with the Entropy method will be explained, and then the process of analyzing the innovation performances of the countries with the TOPSIS method will be explained.

A. Method and Data Set Used in the Study

According to the data of the Global Innovation Index (GII-Global Innovation Index 2021), the performance analysis of 6 countries accepted as Turkish States will be made with TOPSIS and PROMETHEE methods, which are among the MCDM techniques that are frequently used and accepted in similar studies in the literature, and the innovation input sub-sections published in the 2021 Global Innovation Index will be performed. 5 criteria belonging to the index and 2 criteria belonging to the innovation output sub-index will be evaluated on a total of 7 basic criteria. Criteria headings to be used; institutions, human capital and research, infrastructure, market development, business sophistication, information and technology outputs and creative outputs. The data used in the study are taken from the Global Innovation Index (GII), which is prepared every year in

cooperation with the World Intellectual Property Organization (WIPO), Cornell University and INSEAD [22]. In the report, the data of the relevant countries were used in a tabular form. Table 1 shows the data related to the Turkic Republics 2021 GII 7 criteria.

According to the data specified in table 1; It is seen that Turkey has the highest score in all other titles except for institutions and market development. It is also seen that the scores of the countries under the heading of institutions are close to each other. In addition, it is observed that the scores of information and technology outputs are generally low.

TABLE I
 TURKIC REPUBLICS 2021 GLOBAL INNOVATION INDEX SCORES

Countries	Institutions	Human Cap. and Research	Infrastructur	Market Sophistication	Business Sophistication	Information and Tech. Outcomes	Creative Outputs
Azerbaijan	65.5	24.2	35.1	53.2	20.7	10.5	23.5
Kazakhstan	69.8	31.7	44.4	43.8	23.0	15.0	14.3
Kyrgyzstan	55.7	30.6	35.3	49.2	17.9	12.1	10.2
Uzbekistan	55.8	30.4	40.4	56.9	14.8	17.9	12.3
Tajikistan	47.7	25.2	21.7	52.5	13.2	16.6	14.8
Turkey	56.0	48.5	47.0	49.7	30.8	25.3	35.3

B. Calculation of Countries' Criterion Weights by Entropy Method

In the literature, objective or subjective weighting methods are generally used in the calculation of criteria weights. While the preferences or decisions of the decision makers come to the fore in the weighting process using subjective methods, mathematical models such as Entropy method or multi-objective programming are used without considering the preferences of the decision makers in objective methods [24-25]. Entropy is a measure of uncertainty in information formulated using probability theory. In the entropy method, the calculation of the objective weights of the criteria is directly based on the data and only the decision matrix is needed. Therefore, ignoring the personal judgments and thoughts of decision makers in this weighting method reveals the strong side of the method [26-27].

In this part of the study, the weights of 7 criteria in the 2021 GII data will be calculated. In the literature on the subject, in some of the examples [28-29], the weights are determined by giving equal weights to the criteria (1/number of criteria), while in others, they are determined by Entropy or AHP methods. In general, it is seen that these methods have been used successfully in many studies. Therefore, it was decided that it would be appropriate to weight the criteria in this study using the Entropy method.

According to the 2021 Global Innovation Index, the weight calculations of the 7 criteria of the Turkic Republics will be made by the Entropy method, and the weights (W_{ij}) of the criteria are calculated in four stages. The steps followed in determining the entropy measure and the objective weights of the criteria are shown below, respectively.

Step One: Normalization of the Decision Matrix

As seen in the bottom line of the decision matrix of the Turkic Republics $\sum_{i=1}^m a_{ij}$ created for the 7 criteria in the Global Innovation Index, the totals are taken ($\sum_{i=1}^m a_{ij}$) and the first step calculations of Entropy are made over the decision matrix by dividing by the a_{ij} values . While making the calculation, the normalization of the decision matrix (P_{ij}) was performed in the Excel environment according to equation 1.

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^m a_{ij}} ; \forall j \dots\dots\dots (1)$$

Second Step: Establishing Entropy Value and E_j Matrix

After normalization of the decision matrix, equation 2 given below is used to calculate the entropy and E_j value of the matrix.

$$E_j = \left(\frac{-1}{\ln(m)} \right) \sum_{i=1}^m [P_{ij} \ln P_{ij}] ; \forall j \dots\dots\dots (2)$$

The E_j matrix created for the scores of the Turkic Republics according to 7 criteria. In addition, the sums of criteria values are taken at the bottom line of the table ($\sum_{i=1}^m a_{ij}$). After this process, the third step was started for the weight calculations of the criteria with entropy.

Third Step: Determining e_j and d_j values

In the third step of the entropy weight calculation, equation 3 was used to calculate the e_j value. To calculate the total e_j value, the e_j value was determined by summing the seven criteria values.

$$e_j = -k \sum_{j=1}^m r_{ij} \ln(r_j) \dots\dots\dots (3)$$

After determining the e_j value, equation 4 was used to calculate the d_j value.

$$d_j = 1 - E_j ; \forall j \dots\dots\dots (4)$$

The values of each criterion were calculated with the help of the formula. After this stage, seven values were collected and the total d_j value was calculated.

Fourth Step: Calculating Weights of Criteria

At the last stage of the criterion weights calculation, the operations according to equation 5 were carried out in Excel and Table VI was created.

$$W_j = \frac{d_j}{\sum_{j=1}^n d_j} ; \forall j \dots\dots\dots (5)$$

TABLE II
 CALCULATION OF WEIGHT VALUES OF THE CRITERIA

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
w _j	0.031	0.118	0.106	0.013	0.164	0.167	0.401

When Table II is examined, it is seen that all weight values of the criteria are between 0 and 1. In addition, the sum of these values is equal to 1.00. With this result, it is seen that the calculations were made correctly. According to this result, the "creative outputs" criterion affects the innovation performances of the Turkic Republics the most. It is the criterion of "knowledge and technology outputs" that affects innovation performance in the second place. Among the criteria, the one that has the least effect on the innovation performance of the countries is the "Market development" criterion.

C. Innovation Performance Ranking of Turkic Republics by TOPSIS Method

TOPSIS is one of the multi-criteria decision making methods that sorts the preference according to the similarity to the ideal solution. TOPSIS tries to rank the alternatives by calculating their distances from the ideal solution and the negative ideal solution, and simultaneously selects the optimum alternative that should have the closest distance to the ideal solution and the longest distance to the negative ideal solution [30-32].

TOPSIS method consists of 6 steps. In the first step, decision matrices are created with the help of ratios, while the decision matrix is created, rows and columns express different concepts. While the rows show the decision points used to determine the advantages, the columns show the evaluation factors used to sort, make a selection and briefly make the final decision [33]. In the decision matrix shown below, the m rows represent the alternatives and the values in the columns represent the criteria [34].

The first step; consists of determining the objectives, defining the evaluation criteria and creating the decision matrix. Calculations are made using equation 6.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & a_{mn} \end{bmatrix}$$

(6)

Second step: The performance values in the decision matrix were obtained according to different criteria. Since it has different units or expresses different sizes, the decision matrix should be standardized before proceeding to the evaluation process. Formula 7 is used for the standardized operation of the decision matrix. Necessary calculations were made in Excel and r_{ij} The values indicated by are obtained. R standardized decision matrix consisting of standardized values was obtained as shown in equation 8.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^m a_{kj}^2}} \dots\dots\dots$$

(7)

At the end of the calculations, the Rij matrix, which consists of r_{ij} elements, is shown in the form of equation 8.

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} \dots & r_{1n} \\ r_{21} & r_{22} \dots & r_{2n} \\ \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} \dots & r_{mn} \end{bmatrix} \dots\dots\dots (8)$$

As a result of calculations made in Excel with formulas 7 and 8, a normalized decision matrix is obtained.

Third step: After the weight values of the seven criteria to be used in the analysis are found by calculating with Entropy, the weighted standard decision matrix is obtained by multiplying the weights with each value in the matrix as shown in equation 9.

$$V_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & w_n r_{2n} \\ \vdots & \vdots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & w_n r_{mn} \end{bmatrix} \dots\dots\dots (9)$$

Fourth step: This is the stage where the Ideal (A^*) and Negative Ideal (A^-) analyzes are made. The ideal solution (A^*) consists of the best performance values in the weighted normalized decision matrix, while the negative ideal solution (A^-) consists of the worst values in the matrix. For ideal solutions, calculations are made using equations 10. In both equations (number 10) , J represents the benefit (maximization), and J' represents the cost (minimization).

$$A^* = \left\{ (\max_i v_{ij} | j \in J), (\min_i v_{ij} | j \in J') \right\} \quad A^- = \left\{ (\min_i v_{ij} | j \in J), (\max_i v_{ij} | j \in J') \right\} \dots\dots\dots (10)$$

The ideal solution ranges, that is, the largest value in each criterion column, are taken from the values obtained in the previous step. For negative solution values, the results obtained by taking the smallest values in the solution are written.

Fifth step: While calculating the separation measures, the distance of the J alternative from the ideal solution, the ideal separation (S_i^*) and the distance from the negative ideal solution, the negative ideal separation (S_i^-), values are calculated with the help of the formula 11.

$$S_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2} \quad S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \dots\dots\dots (11)$$

While determining the distances to the ideal and negative ideal points, firstly, each value in the weighted decision matrix row is subtracted from its ideal and negative ideal values. In the second step, the extracted values were squared and in the third step, all the rows were summed, the square root of the summed values were calculated and the results of the operation were shown in Table III.

Sixth step: In this step, innovation performance scores (C) of Turkic Republics are found by means of discrimination measures. These scores vary between 0 and 1. Equation 12 is used to calculate C scores.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \quad 0 \leq C_i^* \leq 1 \quad i = 1 \dots n \quad \dots \dots \dots \quad (12)$$

After the decision matrix was obtained, six-step formulas were applied for the TOPSIS method. As a result, the performance ranking of the Turkic Republics according to the 2021 Global Innovation Index has been made and shown in Table XII.

TABLE III.
TOPSIS SCORES OF INNOVATION PERFORMANCE OF TURKISH REPUBLICS

No	Countries	Scores
1	Turkey	0.99
2	Azerbaijan	0.47
3	Kazakhstan	0.24
4	Tajikistan	0.20
5	Uzbekistan	0.17
6	Kyrgyzstan	0.10

As a result of the study, the ranking of the Turkic Republics according to their innovation performance was obtained by TOPSIS, by making use of the data of the Global Innovation Index covering the year 2021. If a general evaluation is made on the data and rankings;

Among the countries, Turkey achieved a high value and ranked first in the innovation performance ranking. Looking at the Global Innovation Index data, it is seen that Turkey has the highest scores in the "knowledge and technology outputs" and "creative outputs" criteria, which have the highest weights. Turkey is in the 4th place out of 6 countries only under the title of "Market Development".

Azerbaijan got a remarkable score compared to other countries and came in second in the ranking. When the Global Innovation Index data is analyzed, it ranks 2nd after Kazakhstan in the "institutions" criterion. As a remarkable data, the score in the criterion of "information and technology outputs", which is the second most important factor, is in the last place among 6 countries.

When the countries in the last four ranks are evaluated together, there is no significant difference between the ranking scores. Ranking third, Kazakhstan has the highest score in the category of "institutions" among the six countries. Tajikistan, which is fourth in the innovation performance ranking, ranks last among six countries in the "institutions" category, and ranks third after Turkey and Uzbekistan in the "information and technology outputs" category. Uzbekistan, which is fifth in the ranking, ranks first among the six countries in the title of "Market Development". In the "information and technology outputs" heading, it is the country with the highest score after Turkey. Kyrgyzstan, which is the result of the innovation performance ranking, is in the second place after Turkey in the title of "Human capital and research". It ranks last among the six countries in the category of "creative outputs" with the highest weight.

Table IV shows the ranking of alternative countries according to the weighted criteria weights and then the advantages and weaknesses of the countries in the ranking according to the criteria are interpreted.

TABLE IV.
RANKINGS BY WEIGHTED CRITERION WEIGHTS

Criteria	Institution s	Human Ser. and Research	Infrastructur e	Market Sophisticatio n	Business Sophisticatio n	Informatio n and Techn. Outcomes	Creative Outputs
Azerbaijan	2	6	5	2	3	6	2
Kazakhstan	1	2	2	6	2	4	4
Kyrgyzstan	3	3	4	5	4	5	6
Uzbekistan	5	4	3	1	5	2	5

Tajikistan	6	5	6	3	6	3	3
Turkey	4	1	1	4	1	1	1
Criteria weights	6	4	5	7	3	2	1

As can be seen in Table IV, Turkey is in the best position in all criteria except institutions and market development criteria, while Kazakhstan is in the first place in the institutions criteria and Uzbekistan in the market development criteria.

IV. CONCLUSION AND EVALUATION

Today, innovation has a great place in the economic development of countries. Innovation is considered as a sustainable growth tool, especially for businesses. With this awareness, in the 21st century, many countries and businesses around the world have begun to show the necessary importance to the concept of innovation. It is seen that the countries that determine and implement innovation strategies are at the top of many reports and indices published globally in different fields or have become the leaders.

The purpose of this study; By using Entropy and TOPSIS methods from MCDM methods, Turkey, Azerbaijan, Kazakhstan, Uzbekistan, Kyrgyzstan and these countries, as well as Tajikistan, according to the GII data, which is a global study that is published every year and contains up-to-date data. In the study, the innovation indices of the countries were calculated by making evaluations on 7 basic criteria in total, 5 criteria belonging to the innovation input sub-index published in GII 2021, 2 criteria belonging to the innovation output sub-index.

In similar studies, comparisons were made on the innovation indices of OECD countries, European Union candidate countries and Turkey, but in this study, a different analysis was tried to be made by putting the Organization of Turkish States in the center. It can be said that the study is one of the rare studies in this aspect.

In the analysis phase, the weights of 7 basic criteria were calculated by the Entropy method. “Creative outputs” criterion has been the most effective criterion in innovation performance with a weight value of 0.401. The criterion of “knowledge and technology outputs” was the second most influential criterion on innovation performance with a weight value of 0.167. The “market sophistication” criterion has the least impact on innovation performance with a weight value of 0.013.

According to the results of the analysis, Turkey, which has a clear advantage among the Turkic states in the GII and TOPSIS rankings, is the country with the best innovation performance. Azerbaijan is in the second place, followed by Kazakhstan, Tajikistan, Uzbekistan and Kyrgyzstan in the sixth place.

As a result, the GII, which is published every year and contains important indicators for the countries, contains important and key statements in terms of the economic, technological and social developments of the countries. These data should be analyzed clearly and the results should be included in the strategic decisions of the countries. From this point of view, it is very important for countries to determine a sustainable policy by creating innovation-based plans and strategies so that they can rank higher in the GII. Existing situations should be improved and existing strategies should be constantly renewed. Only in this way will countries be able to reach the power to compete in the globalizing world.

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Analyzing Market Potential of Particle Board by Using Data Envelopment Model for Turkey

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Abstract— Today, export has become very important for countries. Exporting reduces the dependence of countries on the domestic market and provides the opportunity to expand competition in the domestic market by entering foreign markets. The nonparametric Data Envelopment Analysis (DEA) technique is based on linear programming. The goal of DEA is to compare the relative efficacy of decision-making units (DMUs) that generate similar outputs from similar inputs. In this study, particle boards have been chosen for analysis. Strategies are presented for different scenarios to increase Turkey's particleboard exports using an output-oriented data envelopment model.

Keywords— Data envelopment model, Turkey, market potential, export, consumption, particle board

I. INTRODUCTION

The global economy faced an unexpected epidemic in 2020. The most important pressure of the epidemic, which has multifaceted effects in every field, manifested itself in the form of a 3.1% contraction in the global economy. In 2020, while the global economy experienced the sharpest contraction of the last decades; developed countries shrank by 4.5%, while developing countries shrank by 2.0%.

After the Covid-19 shock in 2020, the global economy entered 2021 with more optimistic expectations. The main reason for this optimism has been the successful developments in vaccine studies against the epidemic. Accordingly, the global economy is predicted to grow again in 2021.

The Turkish economy showed a strong growth performance in 2021. Turkey's Gross Domestic Product (GDP); It increased 7.0% in the first quarter of the year, 21.7% in the second quarter due to the base effect of the epidemic, 7.4% in the third quarter and 9.1% in the last quarter of the year. With this performance, the Turkish economy grew by 11% in 2021. Turkey was the fastest growing economy among G20, EU and OECD countries in 2021. In other words, Turkey became the fastest recovery economy after the epidemic.

Turkey showed a strong foreign trade performance in 2021. Turkey's exports in 2021 amounted to 225 Billion dollars, this figure is 33% more than in 2020, and it was Turkey's highest annual export figure [1].

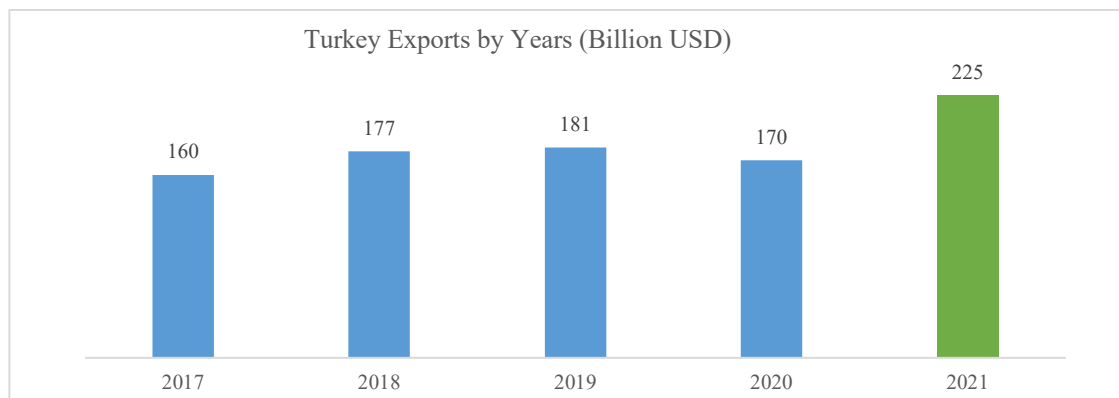


FIGURE 1

TURKEY EXPORTS BY YEARS (THOUSAND USD)

Particleboard is an engineered wood product manufactured from wood chips bonded with a synthetic resin or another suitable binder under exposure to a hot press at certain pressure and temperature. One of the most common wood-based goods traded internationally is particleboard. In recent years, both its global demand and production have increased. The global market for particleboard will be worth 21 billion US dollars in 2020, according to IMARC Group. Over the following six years, the group projects a compound annual growth rate (CAGR) of 4.4% [2].

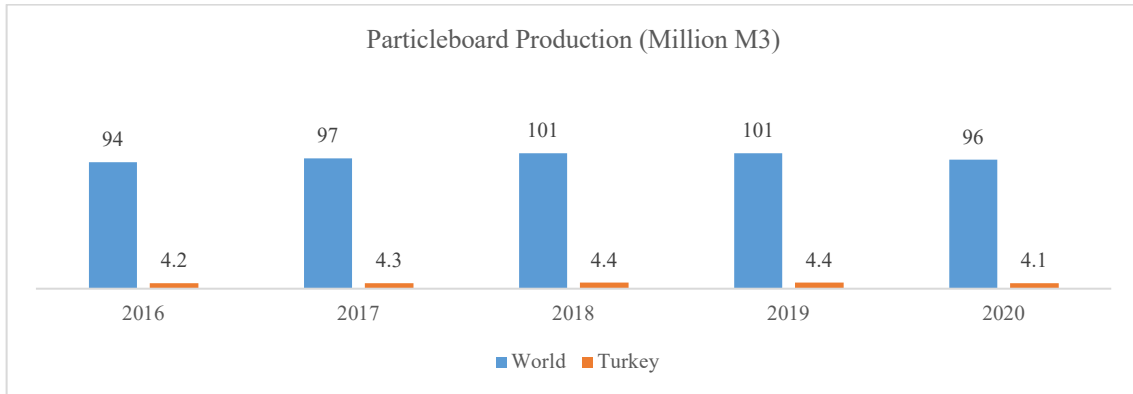


FIGURE 2

WORLD AND TURKEY PRODUCTION VOLUME [3]

According to the Turkish Statistical Office, Turkey's particleboard exports reached 242 Million Dollars in 2021. Looking at the performance in the first eight months of the year, it can be predicted that it will close the year 2022 with 245 Million Dollars [4]. On the other hand, the country's imports decreased every year. According to FAO data, the country's production level has remained almost at the same level over the years [3]. Based on all these, it can be easily said that the country is able to feed its domestic market and export the surplus.

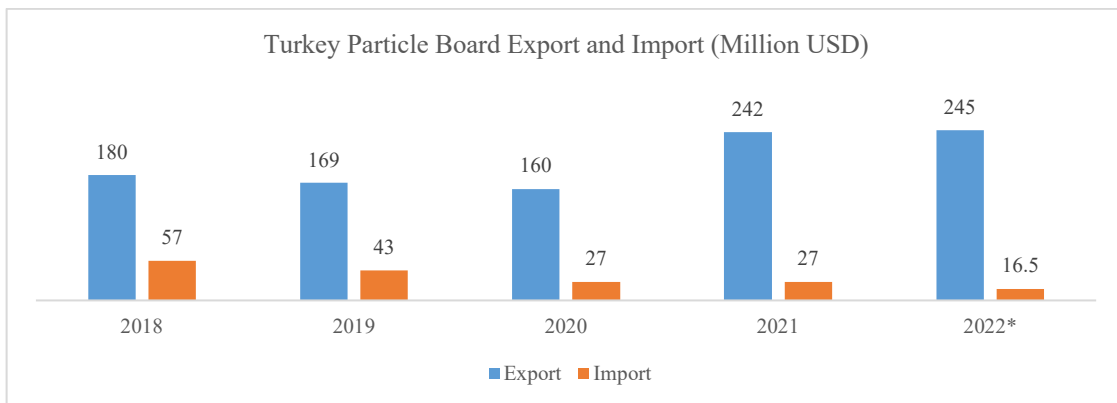


FIGURE 3

TURKEY PARTICLE BOARD EXPORT AND IMPORT (MILLION USD) [4]

Data Envelopment Analysis (DEA) is one of the most used methods in efficiency measurement. DEA is an approach used to evaluate the performance of similar units called the Decision-Making Unit (DMU), which transforms a large number of inputs into a large number of outputs. Today, DEA is widely used by many researchers in different fields such as education, banking, agriculture, information technologies and information systems, computer industry, power plants, airline transportation, stock market and supply chain.

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There are two DEA models commonly used in the literature. These models are the CCR model introduced by Charnes, Cooper and Rhodes (1978) with the assumption of constant returns to scale, and the BCC model, which is based on the assumption of variable returns to scale, introduced by Banker, Charnes and Cooper (1984). The CCR model is discussed as “Input-Oriented CCR” and “Output-Oriented CCR”. The input-oriented CCR model aims to minimize inputs to meet the minimum output level. The output-oriented CCR model aims to maximize the output value without needing more of the input values [5].

In this study, global countries were analysed with using output-oriented CCR to understand their market potential. The countries were grouped according to Turkey performance and finally strategies were determined for each group.

II. METHODOLOGY

Firstly, the biggest consumers in the world were listed according to FAO, 2020. In the list, 500,000 m3 is determined as the lower limit.

$$\text{Apperant consumption} = \text{Production} + \text{Import} - \text{Export}$$

TABLE III
 THE BIGGEST CONSUMERS IN 2020

Area	Export Quantity (M3)	Production (M3)	Import Quantity (M3)	Calculated App. Consumption (M3)
China	248.447	29.432.000	873.779	30.057.332
Poland	672.604	5.270.000	1.265.781	5.863.177
Germany	1.670.342	5.556.360	1.903.282	5.789.300
Russian Federation	1.739.410	6.731.000	299.000	5.290.590
United States of America	361.365	4.136.077	1.462.129	5.236.841
Türkiye	870.000	4.075.000	29.000	3.234.000
Italy	549.102	2.670.000	958.811	3.079.709
Brazil	508.291	3.348.000	11.622	2.851.331
United Kingdom	85.639	1.698.399	590.417	2.203.177
South Korea	2.085	807.000	1.069.358	1.874.273
Ukraine	308.366	1.686.544	214.185	1.592.363
France	1.205.137	2.221.000	531.380	1.547.243
Spain	643.124	1.689.712	446.331	1.492.919
India	5.412	1.200.000	183.699	1.378.287
Mexico	23.347	754.000	626.460	1.357.113
Lithuania	51.399	785.000	470.895	1.204.496
Japan	13.321	961.000	240.944	1.188.623
Canada	759.429	1.415.504	492.022	1.148.097
Australia	14.062	967.675	52.040	1.005.653
Sweden	80.000	568.174	468.543	956.717
South Africa	112.255	1.015.031	45.613	948.389
Romania	902.110	1.595.049	217.094	910.033
Iran	17.181	840.000	796	823.615
Thailand	2.551.396	3.334.000	8.466	791.070
Uzbekistan	6.145	255.668	531.802	781.325
Austria	1.918.859	2.330.000	303.985	715.126
Malaysia	276.907	310.000	634.931	668.024
Belgium	948.698	1.196.886	328.277	576.465
Portugal	438.430	700.000	287.618	549.188
Kazakhstan	11.473	214.600	333.453	536.580
Belarus	1.013.100	1.400.000	124.600	511.500

Secondly, some of the countries were eliminated from the table because of their country profile such as the European countries, China, Russia, USA and Türkiye. European countries were eliminated because of they are red ocean. These countries generally closed to other countries, and they are feeding each other. China, Russia, and USA are both big producers and consumers. Finally, Türkiye is the origin country for this study.

Then output-oriented CCR was applied. Production, Export and Turkey Export are taken as inputs and export and apparent consumption are taken as output. Because of the production and export are effects output opposite way, they were normalized.

$$F_k = Maks \beta + \varepsilon \sum_{i=1}^m s_i^- + \varepsilon \sum_{r=1}^p s_r^+$$

$$\sum_{j=1}^n X_{ij} \lambda_j + s_i^- - X_{iK} = 0$$

$$\sum_{j=1}^n X_{rj} \lambda_j - s_r^+ - Y_{rK} = 0$$

$$s_r^+, s_i^-, \lambda_j \geq 0$$

F_k = efficiency of k decision units

Y_{rK} = The r th output produced by the k th decision unit

X_{iK} = The i th input used by the k th decision unit

X_{ij} = The i th input used by decision unit j th

n = number of decision units

m = number of inputs

t = number of outputs

ε = a small enough positive number

β = coefficient of expansion of output

s_i^- = The idle value of the i th input of the decision unit k

s_r^+ = The idle value of the r th output of the k decision unit

λ_j = Intensity value of the j th decision unit

If the investigated decision unit fulfills the conditions $F_k = 1$ and $s_i^- = 0, s_r^+ = 0$, it is fully efficient and still exists in the reference set. If $F_k = 1$ and idle values for the analyzed decision unit are different from 0, this decision unit is weakly efficient. Efficiency values of inactive DMUs are greater than 1.

$$n \geq 3x(m + t) + 1$$

$$n = 17 \text{ countries} \geq 3x(3 + 2) + 1 = 16$$

A sufficient number of DMUs were included in the analysis.

The final data set was as follows.

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 İstanbul Technical University & Bahçeşehir University

TABLE IV
 THE FINAL DATASET

DMU	Input 1: (1/Production)	Input 2: (1/Export)	Input 3: Exp. From Turkey	Output 1: Import	Output 2: App. Consump.
Brazil	0,000000299	0,000001967	0,00000	11.622	2.851.331
South Korea	0,000001239	0,000479616	0,00000	1.069.358	1.874.273
Ukraine	0,000000593	0,000003243	4.055	214.185	1.592.363
India	0,000000833	0,000184775	211.089	183.699	1.378.287
Mexico	0,000001326	0,000042832	20	626.460	1.357.113
Japan	0,000001041	0,000075069	0,00000	240.944	1.188.623
Canada	0,000000706	0,000001317	74.350,	492.022	1.148.097
Australia	0,000001033	0,000071114	0,00000	52.040	1.005.653
Sweden	0,000001760	0,000012500	58,00000	468.543	956.717
South Africa	0,000000985	0,000008908	0,00000	45.613	948.389
Romania	0,000000627	0,000001109	186249,00000	217.094	910.033
Iran	0,000001190	0,000058204	0,00000	796	823.615
Thailand	0,000000300	0,000000392	0,00000	8.466	791.070
Uzbekistan	0,000003911	0,000162734	10038,00000	531.802	781.325
Malaysia	0,000003226	0,000003611	0,00000	634.931	668.024
Kazakhstan	0,000004660	0,000087161	0,00000	333.453	536.580
Belarus	0,000000714	0,000000987	0,00000	124.600	511.500

Model Excel DEA Frontier add-in was used. It was solved by creating DEA models for both output and input oriented, and it was observed that the results were the same. The countries that were found to be fully efficient as a result of the analysis were Brazil, South Korea, Ukraine, Mexico, Thailand and Malaysia. Sweden was not fully efficient because of the second output slack value.

Output-Oriented CRS										
DMU No.	DMU Name	Efficiency	$\Sigma\lambda$	RTS	Benchmarks					
1	Brazil	1,00000	1,000	Constant	1,000	Brazil				
2	South Korea	1,00000	1,000	Constant	1,000	South Korea				
3	Ukraine	1,00000	1,000	Constant	1,000	Ukraine				
4	India	2,57290	1,440	Decreasing	0,949	Brazil	0,381	South Korea	0,110	Canada
5	Mexico	1,00000	1,000	Constant	1,000	Mexico				
6	Japan	1,29911	0,769	Increasing	0,387	Brazil	0,153	South Korea	0,228	Malaysia
7	Canada	1,00000	1,000	Constant	1,000	Canada				
8	Australia	4,73981	1,814	Decreasing	1,550	Brazil	0,141	South Korea	0,123	Malaysia
9	Sweden	1,00000	1,000	Constant	1,000	Sweden				
10	South Africa	3,37673	1,282	Decreasing	1,068	Brazil	0,013	South Korea	0,202	Malaysia
11	Romania	1,40835	1,264	Decreasing	0,031	Brazil	0,610	Canada	0,623	Thailand
12	Iran	13,79843	3,986	Decreasing	3,986	Brazil				
13	Thailand	1,00000	1,000	Constant	1,000	Thailand				
14	Uzbekistan	3,59542	3,018	Decreasing	0,089	South Korea	2,794	Mexico	0,134	Canada
15	Malaysia	1,00000	1,000	Constant	1,000	Malaysia				
16	Kazakhstan	3,15061	1,696	Decreasing	0,161	Brazil	0,171	South Korea	1,364	Malaysia
17	Belarus	1,04398	0,417	Increasing	0,111	Brazil	0,104	Thailand	0,201	Malaysia

FIGURE 4
 RESULT OF THE DEA

DMU No.	DMU Name	Input Slacks			Output Slacks	
		Girdi 1: (1/Üretim)	Girdi 2: (1/İhracat)	Girdi 3: TR'den ihracat	Çıktı 1: İthalat	Çıktı 2: Tüketim
1	Brazil	0,00000	0,00000	0,00000	0,00000	0,00000
2	South Korea	0,00000	0,00000	0,00000	0,00000	0,00000
3	Ukraine	0,00000	0,00000	0,00000	0,00000	0,00000
4	India	0,00000	0,00000	202910,69549	0,00000	0,00000
5	Mexico	0,00000	0,00000	0,00000	0,00000	0,00000
6	Japan	0,00000	0,00000	0,00000	0,00000	4312984,12000
7	Canada	0,00000	0,00000	0,00000	0,00000	0,00000
8	Australia	0,00000	0,00000	0,00000	0,00000	89242733,78072
9	Sweden	0,00000	0,00000	0,00000	0,00000	11885623,16650
10	South Africa	0,00000	0,00000	0,00000	0,00000	1987470,05351
11	Romania	0,00000	0,00000	140898,69547	0,00000	0,00000
12	Iran	0,00000	0,00005	0,00000	35338,42426	0,00000
13	Thailand	0,00000	0,00000	0,00000	0,00000	0,00000
14	Uzbekistan	0,00000	0,00000	0,00000	0,00000	1304417,21748
15	Malaysia	0,00000	0,00000	0,00000	0,00000	0,00000
16	Kazakhstan	0,00000	0,00000	0,00000	0,00000	106916523,15250
17	Belarus	0,00000	0,00000	0,00000	0,00000	217994,13405

FIGURE 5

SLACK VALUES

III. CONCLUSIONS

Every unit from the production, service and finance sectors in domestic and foreign competition conditions enters the application field of Data Envelopment Analysis. Numerous studies have been conducted on Data Envelopment Analysis in many public areas such as hospitals, post offices, banking, pharmacies, courts, police stations, shipping, and educational institutions. Data Envelopment Analysis has also been widely used to measure inter-firm technical efficiency in the for-profit production and service sectors [6].

In the literature review, one of the studies aimed that investigates the sales performance of insurance companies. The investigation looked at the number of agents, bank branches, and employees. are utilized as input; the outputs are the number of policies and premium production. As a result of the study, 6 of the 12 insurance companies examined were found to be fully effective, and reference sets and potential improvement tables were created for the other 6 companies that were not fully efficient [9].

According to analysis results Brazil, South Korea, Ukraine, Mexico, Thailand, and Malaysia are fully efficient. These countries can be evaluated in two groups according to whether there is an export from Turkey or not. Accordingly, Brazil, South Korea, Thailand, and Malaysia can be defined as Group 1, and Ukraine, Mexico and Canada as Group 2. The countries in Group 1 are new countries for Turkey that have not been exported before. The countries in Group 2 are countries that Turkey currently exports to. The proposed market strategies for the two groups should be different.

For the countries in Group 1, it is necessary to know the competitive environment well and to adopt a modern marketing approach. Environments to be considered in international marketing; are demographic environment, economic environment, socio-cultural environment, legal environment, political environment, technological environment, financial environment, ecological environment, and competition environment [7]. Within the scope of foreign market research, potential customers of the market should be determined as a first step. In order to do this research properly, field visits by the sales team are very important. With these visits, market construction can be determined. After that, a comparison is done with similar products to identify any competitive advantages by benchmarking. A marketing plan is constructed on these competitive advantages. Finding the links that can be exploited to reach customers is another important point. In addition to the network, analysis sending a free test and promotional products to customers will increase their trust.

For the countries in Group 2, increasing exports will not be easy if the product is not more attractive than that of competitors or if the product does not have an "added value" that no competitor can imitate. In order to be different from the competitors, it is necessary to be special in the material, design, and workmanship of the product. For this, it is necessary to improve the product design, to avoid being similar to cheap products from far eastern countries in the market, or to provide a feature that will make the product the only seller in the market. For some consumer products, it is important to create a product concept or product group. When designing a new product, it can be presented as a product group with different accessories [8].

In conclusion, the data envelopment model is useful when more than one market condition is necessarily considered. This study can be a reference for future studies to analyze market potential and determine market strategies from different views. Even though corporates have their own sales team, third-party analysis as this study can be helpful for impartiality. Moreover, market analysis is expensive and time-consuming for corporates. By using this study methodology, non-effective markets can eliminate, and only potential markets can analysis deeply.

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Application of Digital Image Analysis to Automate Aggregate Gradation Evaluation

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Abstract— Aggregates make up 60-70% of concrete and their properties, especially their size distribution, which is one of the factors greatly affecting the strength and properties of concrete. Aggregates size distribution is usually evaluated by experimental laboratory testing, sieve analysis and main disadvantage of sieve analysis is its difficulty to be applied in the field as it is a laboratory test. The lack of fast, practical, and precise testing of particle size distribution of aggregates on construction sites has recently led to the development of digital methods. This study is the first step of developing an automated in-situ system that transforms time-consuming experimental sieve analysis in to a faster and practical image-based evaluation of aggregate particle size distribution. With the help of the image processing method used in this study, the analysis and characterization of the aggregates, which have an important place in the concrete content, can be evaluated with a faster system, and thus, it will be an important step in the development of automation systems in concrete production. In this study, experiment-wise sieve analyses were carried out for 5 different aggregate mixtures with 3 repetition each for comparison with the distribution curves from the developed methods. Subsequently high-resolution images including the real dimension were captured. The processed steps for image processing consist of identification and separation of each aggregate particle from the rest, computing the area of each particle, minimum inclusion diameter and obtaining the size distributions of each sample. The verification is done via comparing with the conventional sieve analysis results. The results yielded a favorable outcome for using image analysis for analyzing the aggregate size distribution although more fine-tuning is needed to improve the precision of the calculated parameters.

Keywords— image analysis, particle size distribution, digital technologies, automation, sieve analysis

I. INTRODUCTION

This study is the first step of developing an automated in-situ system that transforms time-consuming experimental sieve analysis in to a faster and practical image-based evaluation of aggregate particle size distribution. One of the main disadvantages of sieve analysis is its difficulty to be applied in the field. Image analysis is more attractive and beneficial as it can be practically applied in-situ since it does not need any experimental equipment. With the help of the image processing method used in this study, the analysis and characterization of the aggregates can be evaluated with a faster system, and thus, it will be an important step in the development of automation systems in concrete production. In this study, various aggregate mixes were prepared and evaluated both with sieve analysis and image analysis. The image analysis results were compared with those obtained from the laboratory sieve analysis to examine the feasibility of using the digital imaging technique in the field.

II. LITERATURE REVIEW

Aggregate size distribution is of utmost importance in concrete mix design. Ideally, it should be well-graded, meaning that the aggregate size distribution curve doesn't contain any significant gaps or inconsistencies indicating a disproportionate amount of a certain particle size group(s) in the mix, which affects the concrete properties. Sieve analysis is the standard testing method used in laboratories and is one of the simplest yet accurate techniques especially for a specific range of particles diameter [1]. In this method, the sorting of the grains is achieved based on the diameter. The ratio of each portion is defined by its weight [2]. There are some major drawbacks however, such as being a time-consuming and labour-intensive process as well as obtaining

deviations in the results due to experimental methods. Therefore, there is a need for a more practical, fast, and accurate technique which is possible with the help of image-based systems.

Image processing techniques have been applied in civil engineering and concrete engineering [3] [4], [5], [6], [7], [8]. Image analyses were mainly carried out using 2D images, and in a few studies the shape properties of aggregates were also studied with 3D images [9] In addition, the size properties of aggregates including particle size distribution by image analysis technique were also discussed in previous studies [10], [11], [12], [13], [14].

According to the previous studies, there are two main common problems encountered in the application of image analysis for particle size distribution, (i) finding the most suitable image analysis technique, (ii) determining how 3D aggregate parameters can be reached from the extracted data of the 2D images. In order to determine the most suitable method for error threshold and standardization, many types of programs and combinations of different techniques were used although the precision of each method wasn't precisely quantified. There is no standard way to obtain the required parameters. The reason for using different methods is mainly due to the various available technology for image capturing and various type of aggregate used. To transform the data extracted from the 2D aggregate images into 3D aggregate parameters, there is a need of a conversion factor. This conversion factor is needed to compare the areas of the aggregates obtained from the image analysis with the masses of the aggregates obtained from the sieve analysis. most studies chose to convert area to mass rather than mass to area. Kumara et al. [8], determined the volume of the particles by choosing an ellipse shape for the particles from which axis length data and area were obtained and using a Vernier scale, the 3 axes were measured and the average value of the ratio of the short axis to the intermediate one from 50 samples was used as a conversion factor. Mora et al. [15], used a parameter depended on the flakiness of the particle to obtain the thickness and then multiplying that by the area to obtain the volume. Since the group found that the sieve analysis curves and DIP curves weren't in agreement, they suspected it was caused by the circular shape of the apertures of the sieves thus, they converted the circular shaped sieves into square ones by applying a correction factor C which is found by trial and error until a best match is found. They reported that the limitation of this technique is particles that are touching and aggregates which aren't from the same source. Z. Q. Yue and I. Morin [4], took horizontal (for the area) and vertical (for the height) cross sectional images of the aggregate samples based on the assumption that an horizontal and vertical cross sectional images are related by an index which they then used in subsequent calculations.

III. METHODOLOGY

As a result of the sieve analysis, the aggregate particle size distribution curve is produced by measuring the mass of the aggregate remaining on each sieve. In the image analysis technique, a gradation curve can be drawn based on volume or mass, area or particle count. However, since 2D images cannot measure the volume of particles directly and 2D images were collected in this study, the volume of particles was determined from 2D images with the help of some assumptions and formulas. As mentioned in previous studies in the literature [9], [11], [14] usually the volume of particles is determined using 2D images with some assumptions or time-consuming processes where the mass of individual particles is measured.

A. Experimental Sieve Analysis

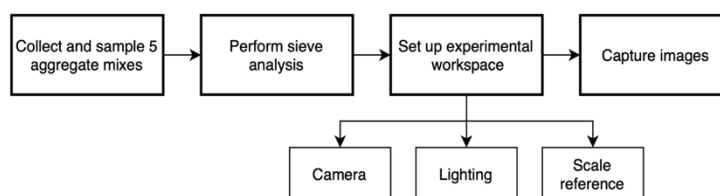


FIGURE 4
SIEVE ANALYSIS METHODOLOGY

For the experimental part, five sets of aggregate mixes, each with a total weight of about 500g, were collected, sampled, and labelled as set M1, M2, M3, M4 and M5. Each set had a different average fineness modulus of 6.36, 5.94, 4.62, 5.45, and 5.05 for sets M1, M2, M3, M4 and M5 respectively. Next, sieve analysis was performed on each set. Standard sieving method (TS EN 93301:2012(EN)) and standard sieve set was used to perform the sieve analysis by placing the aggregates on the topmost sieve and letting the sieves vibrate for 5 minutes. After the vibration period was over, the mass retained on each sieve for each set was noted to eventually calculate the cumulative percent of passing weight. The data for the cumulative percent of passing weight was then used to plot the aggregate size distribution curve as seen in Figure 1. Sieve analysis was performed three times for each mix to for verification purposes. The results are shown in Figure 2.

B. Image Capturing and Analysis

Image capturing was done on the aggregate mixes and aggregates retained on the pre-determined sieves with 16, 8, and 4 mm opening for later verification with the image analysis software. The aggregates were placed on white, non-reflecting paper with a ruler on the side to provide the scale needed for measurements in image analysis and a camera was placed at a constant height of 34 cm above the aggregates. Two white light lamps were placed around the setup to provide for better and clearer images. Although many attempts were made to minimize the effect of shadows, unfortunately, some aggregate images were captured with the minimum amount of shadow allowed within the setup. The aggregates were placed as flatly as possible on the paper surface to avoid scale related problems between different aggregates with different heights due to stacking, instead of laying, during measurements in image analysis.

The laboratory scale digital image processing set-up consisted of a CMOS camera with high-resolution lens, mounting parts, telescopic support legs, a white background, LED lights, a computer and an image processing software. For each mix, at least 2 sets of images for 16, 8 and 4 mm aggregates were taken in which the aggregates were either touching each other or separated from each other, i.e. with spaces between the individual aggregate particles.

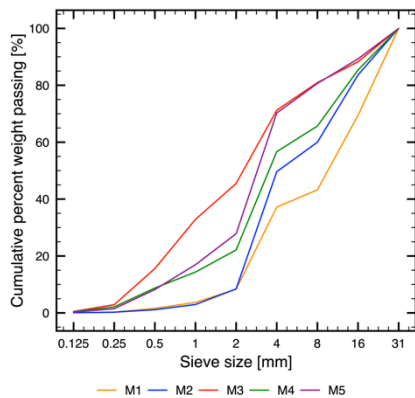


Figure 6: Aggregate size distribution using sieve analysis

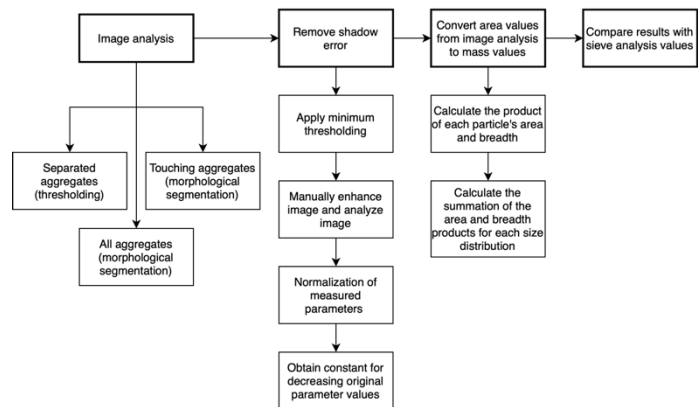


Figure 5: Image analysis methodology

Image analysis was performed using Fiji and was performed differently for the touching and separated aggregates due to the constraints of the used techniques. Separated aggregate images were easier to analyse using an automatic thresholding technique since the program was able to differentiate the aggregate particles from the background. Since shadows caused by the light setup directly above the aggregates were also measured, consequent error removal caused by them was performed in the calculations step, as shown below.

To perform image analysis on separated particles, the images were scaled and converted to greyscale. Fiji's default thresholding algorithm was used. After some cleaning of the edges of the particles, min and max Ferret's diameters and their areas were calculated.

Image analysis of the touching aggregates was performed using MorphoLibJ library [21] due to the difficulty of separating the individual aggregate particles caused by their irregular shape and additional constraints of the

thresholding method. Amongst MorphoLibJ's available image analysis methods, such as the auto local thresholding algorithm, Canny Edge detector, watershed segmentation and trainable WEKA segmentation, it was found that morphological segmentation yielded the best results. It still had its constraints and using this algorithm can result in a labor-intensive analysis afterwards, but the resulting segregated regions were the most accurate and it was also able to differentiate the individual touching aggregates to a much higher extent than the previously mentioned algorithms.

Similar to analyzing the separated aggregate images, the touching aggregate images were first scaled, converted to greyscale, cropped and any other background objects removed. After selecting the desired combination of gradient type and parameters, the watershed lines image is obtained. By homogenizing the particles and erasing extra lines or regions, the desired parameters for analysis are chosen, in this case the area, Ferret and minimum Ferret's diameters, and the analysis is performed.

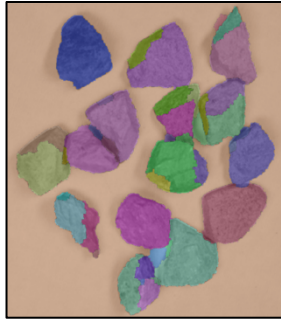


Figure 7: Morphological segmentation



Figure 8: Watershed lines



Figure 9: Camera setup

C. Calculations and data interpretations

To eliminate the shadow error, image analysis was redone on all separated 16mm aggregate images using a combination of thresholding and manual image enhancement. Similar to the image analysis explained previously, the images were thresholded using Fiji's default threshold method, but they were thresholded to a very minimum amount without measuring the shadows. Afterwards, normally analysis was done to determine the area, Ferret diameter and minimum Ferret's diameter. Nearly all the shadows were eliminated with minimal error to the area of the aggregates. The calculations of the percent differences later would prove the efficiency of the method. The process was repeated for all five samples of the separate 16mm aggregate images.

After obtaining the new parameter values for all samples, normalization of the values was performed. First, the percent difference between the automatically thresholded and minimally thresholding values was calculated using

$$\text{percent difference [\%]} = \frac{a - b}{\frac{a + b}{2}} * 100 \quad \text{Equation 1}$$

where a is the automatically thresholded diameter value and b is the minimally thresholded diameter value. Then the average percent difference of every sample was calculated, and the average of that average was calculated and found to be $k = 4.42\%$. Finally, the diameter and Ferret's diameter of all image samples were decreased by the same constant k . Unlike previously, the new obtained parameter values of each sample were greater than their corresponding sieve size, which proves the efficiency of the method used.

After removing the shadow error, a variation of Mora et al. (1998) group's [11] proposed method was used to convert the masses into volumes in order to compare the sieve analysis results with the image analysis results. In summary, it was proposed that in order to convert the mass image analysis results to volumetric sieve analysis results, the following equations may be used:

$$\text{percentage by mass passing a sieve} = \frac{(\text{area} \times \text{breadth})_i}{\sum_{i=1}^n (\text{area} \times \text{breadth})} \quad \text{Equation 2}$$

where the summation in the denominator is for all particles. The breadth of the particle in this work is defined as the minimum Ferret diameter of that particle.

After having obtained these values, it was possible to convert the image analysis results of masses to volumes using equation 2. The percent differences between the sieve analysis and image analysis results are summarized in Figure 6.

IV. DISCUSSION OF RESULTS

From Figure 6, it can be seen that generally, the percent difference is the lowest for the first mix and gradually increases by the 5th mix, with some exceptions.

For the separated aggregate images, large percent differences can be seen between each aggregate size as well as in the same mix as well. For example, the percent differences for the first mix largely differ from one aggregate size to another. The lowest percent difference was found to be for the separated 8mm aggregates while the largest difference was observed in the second mix for the 16mm aggregates. The results are slightly surprising since the separated images were the easiest to analyse from a program point of view, especially the larger aggregates.

In the touching aggregate images, the percent differences between each aggregate size as well as in the mix itself remain large. The largest was found to be in the fourth mix for the 4mm aggregates while the lowest was in the fifth mix for the 8mm aggregates. The results are, again, surprising, since the more easily identifiable 16mm aggregates, especially in the first mix, which contains a larger number larger aggregates, should've had the lowest percent difference.

Lastly, in the mixed size distribution images, the percent differences followed a general trend throughout the samples: the accuracy of the image analysis results in comparison to the sieve analysis results increased with increasing aggregate size. The largest percent difference is observed in the less than 4mm aggregates of the third mix while the smallest percent difference is in the less than 16mm aggregates of the first mix. The results are in line with the expected outcomes due to the used methods.

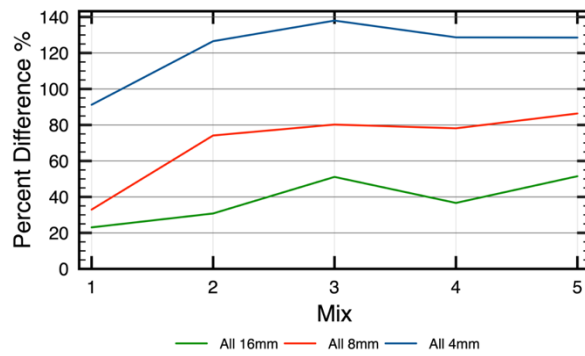


Figure 10: Percent difference of mixed aggregate images

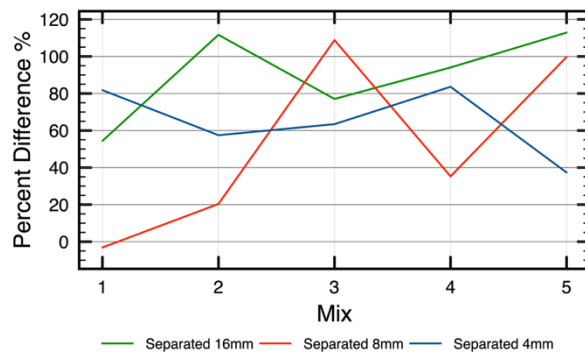


Figure 11: Percent difference of separated aggregate images

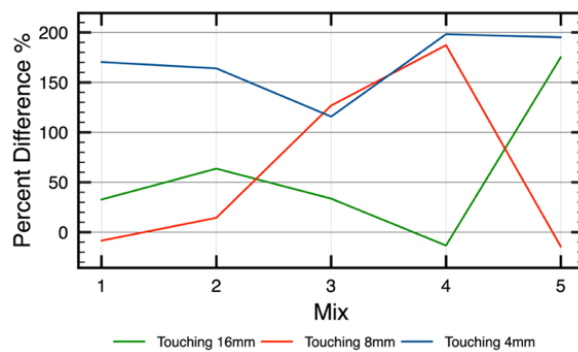


FIGURE 12

PERCENT DIFFERENCE OF TOUCHING AGGREGATE IMAGES

V. CONCLUSIONS

In this study, a two-dimensional image processing technique and analysis scheme is proposed and used for the characterization of aggregate mixtures and particle size distributions in order to propose a practical technique for use in-situ. It was emphasized to find a relationship between the projected areas of the aggregates and the diameter and length parameters. Thus, the alternative use of image analysis, which is a practical technique, instead of the experimental traditional method has been examined. This study gave an idea about the suitability of the aggregate projection areas measured as a result of image analysis to represent the percentage

of aggregate weight remaining on the sieve. Based on the study findings, the following conclusions can be drawn:

- It is very important to understand the aggregate grading structure in detail in order to understand the final performance and mechanical behaviour of concrete. Because performance criteria such as concrete final strength are directly affected by the aggregate rating in the concrete and the concrete mix design.
- Aggregate grading of concrete is commonly done with the standard experimental method "Sieve Analysis Test", but practical methods are needed since this method is a time-consuming and human error method.
- The results yielded a favorable outcome for using image analysis for analyzing the aggregate size distribution although more fine-tuning is needed to improve the precision of the calculated parameters.

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Applying the Principles of Engineering Management to Ethical Issues: The Case of Patient Centered Care

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Abstract— This study explores the potential of the principles of engineering management in addressing ethical issues such as those arising in health care settings. Patient centered care has been a Holy Grail in the provision of medical care but there are still many questions to answer and there are many potentials for ethical issues to arise, including around informed consent, data privacy, the relationship with care providers and the degree to which decision-making can be shared. The role of the patient versus technology also presents a continuous need for re-evaluation. Through literature review this paper evaluates ethical dilemmas associated with patient centered care and considers the principles of engineering management as a useful vehicle in addressing these issues. The analysis reveals the following issues; engineering management can assist with the three major components of patient centered care of treating the patient as a whole, developing rapport, and input into decision-making, especially given the increasing role of technology in health care. The results suggest that Engineering Management has strong potential in improving the ethical delivery of patient centered care.

Keywords— engineering management, ethical issues, patient centered care, shared decision-making, relationship with the care provider

I. INTRODUCTION

The delivery of healthcare is a complex matter and made even more complex by huge developments in digital technology. Opportunities provided by technology and engineering include you is the ultimate challenge: how to foster the innovation that is needed so that healthcare can keep up with the emerging possibilities and at the same time maintain an ethical approach with the patient at the centre. Adapting new technology while not sacrificing the focus on the person is a challenge in many fields of health now. How much should decision-making power be shifted towards technology and engineering, and how much should be retained by human oversight? Technology allows us to be innovative, adaptable, and resilient. Having human oversight allows us to maintain the patient as a central focus. Engineering Management (EM) offers a holistic approach to management within engineering and technology driven endeavors and contains a body of knowledge which will be useful to enable holistic management. This paper attempts to build a link, using the body of knowledge of EM as a mechanism to optimize technological advances in healthcare.

II. A CONTROVERSIAL ISSUE: PATIENT CENTERED CARE

The concept of patient centered care (PCC) has been around for several decades. The early work of Engel [1] explained the need to replace the earlier reductionist biomedical model of health with his biopsychosocial model, which proposes that health and disease need to be considered together. In this approach, healthcare providers should seek to understand day-to-day aspects of people's lives and to care for the whole person, rather than just treating the disease or injured part of the body. Over the past decades there have been many renditions of PCC and various models, but all propose that the focus needs to be on the patient as opposed to other agents in the healthcare context. One important initiative is to break down the power differential between provider and patient. The formerly common reductionist top-down view of healthcare is now viewed as inadequate.

Many studies have shown that a high level of perceived PCC is associated with improved health outcomes [2], including enhanced satisfaction by both parties [3], shorter hospital stays and lower costs [4]. It has now become expected by patients that the former authoritarian approach is less appropriate and acceptable, and patients expect to be placed in a more central role in terms of information and decisions [5]. They expect to be treated by providers who display emotional intelligence [6]. Many decades ago, Grönroos [7] differentiated

technical/competency care from practical care/relational care, including the quality of the interaction and the courtesy and warmth shown [8].

A. Components of PCC

PCC is a broad concept but is generally considered to have aspects of patient involvement [9], engagement and empowerment [10], as well as provision of good communication [11] and appropriate and timely information [12]. A quantitative study by Manzoor, et al. [13] showed that the provider's behavior was a moderator influencing patient satisfaction. Lack of continuity of care has also been mentioned as a problem and a source of complaints [14]. People do not like having to tell their story repeatedly to different providers and they do not like spending a lot of time in waiting rooms.

Recent work by Hansson and Fröding [15] asserted three pillars of PCC: holism, a personal relationship with the provider, and shared decision-making. Holism means that people need to be seen in the entirety of their life, placed within their biosocial settings. The patient's situation needs to be considered from many angles, including emotional, social, family, financial, and employment, among other aspects. The second pillar concerns the personal relationship between the caregiver and the patient considered in a much broader perspective than the traditional paternalistic top-down relationship. The third pillar is shared decision-making, which means that there is a joint decision when it comes to deciding upon treatment. Each of these three pillars contains potential conflicts when considering PCC on the one hand and healthcare principles and objectives on the other. Healthcare is a complex business, and it would not be surprising to find that there can be opposing forces at work when PCC is put into practice. The model of Hansson and Fröding [15] is adopted within this paper to explore shortcomings in PCC that result in shortcomings in ethical practice and how principles of engineering management could be of assistance.

B. PCC and Ethical Dilemmas

Ethical delivery of a service is generally considered to entail compliance with accepted moral norms. Almost all professions have ethical codes of conduct, as do large organizations. Codes of ethics lay out a set of core ethical principles guiding practice in a particular domain and the fundamental values and responsibilities therein. Ideally an ethical procedure will respect the four principles of autonomy, justice, beneficence, nonmaleficence [16]. The principle of autonomy means that all people have intrinsic worth and should have the power to exercise their capacity for self-determination. Justice means fair and equitable treatment of persons. Beneficence is the obligation of providers to act for the benefit of the patient. Nonmaleficence is the obligation not to harm or cause suffering [17]. These principles may overlap and even conflict with each other under certain circumstances. Refusing treatment, for instance, represents a clash between autonomy and beneficence.

Ethical dilemmas are riddled throughout the healthcare setting. Issues include informed consent, budgetary constraints, data privacy and sharing, fair and equitable access to limited resources, and patient privacy. Hansson and Fröding [15] addressed ethical issues in terms of their three proposed pillars of holism, the relationship between the provider and the patient, and shared decision-making. They consider that each presents their own unique ethical problems. Holism, for example, brings about a conflict with patient privacy. For a holistic picture to emerge, the patient needs to share information about their lives, and they may reveal sensitive information. They may not know how much information to share. Sharing of non-medical issues such as family conflicts and economic problems is certainly part of the broader picture that may be relevant to treatment options and decisions. Another issue regarding personal information is the maintaining of personal data within medical records. Further, providers need to be confident that they can deal appropriately with such non-medical issues (or only partly medical issues) without being judgmental. This mindset and other factors could bring about preferential treatment of wealthy and educated patients and unequal access to care for those who are less educated, have limited language proficiency, and are perhaps less assertive [18].

The question of personal relationships raises many ethical issues. Professional bodies have long had codes of ethics detailing what is and is not acceptable in terms of the closeness of the health relationship. Such relationships are distinctly different from private relationships. There have been many instances where the relationship developed over time has become too close and been considered inappropriate, with negative outcomes for the patient. But what is the nature of an appropriate and close rapport, developed over time? Certainly, it is different from the authoritarian top-down approach still unfolded in some contexts. But the requirement for providers to present a unique approach for each patient, devoid of professional detachment,

will certainly be demanding and represent a difficult juggling act. How to find the dividing line between professional detachment and empathic involvement is challenging [19].

In terms of the third pillar of shared decision-making, Charles, et al. [20] describe a decision process in which information and treatment preferences are shared and the decision is made jointly. Patients and care providers make decisions together, with information flowing both ways and this is an important part of helping patients to participate in choices regarding treatment. However, the patient is often in an inferior position regarding decision-making, given their lack of technical knowledge and the power differential. Some patients may not feel confident enough to ask the questions they want to ask within this setting. They may also be suffering stress due to their illness, which could be a further impediment to their equitable involvement in decision-making, given that their comprehension and problem-solving ability may be reduced [21].

III. TECHNOLOGY AND ETHICS

Healthcare 4.0 now being unfolded enables smart real-time customization of healthcare using a technology driven approach [22]. There are now billions of interconnected internet of things (IoT) data sources providing real-time information on a massive array of personal data. This is revolutionizing healthcare. Telehealth technologies and seamless data sharing, as well as smart technologies, are creating digitized healthcare products and services, and such systems are becoming increasingly powerful. However, whenever new technologies are introduced into the market, there are likely to be unexpected consequences: and there is often a lag in addressing those issues [23]. It is very easy to lose sight of the patient when dramatic technological advances occur. Feelings of depersonalization can be a side effect of the dramatic high-tech progress currently occurring. Healthcare is more and more driven by technology, and healthcare environments reflect that development. The risks and societal implications of such vast transformations are discussed by Dzau and Balatbat [24], who note possible risks to patients if the new technologies are not sufficiently understood or regulated. Ma, et al. [25] highlighted the benefits of the smart healthcare system with improved diagnostic efficiency through monitoring, but also the issues around confidentiality of personal information; and propose searchable encryption technology as a way of protecting data privacy. As smart healthcare systems proliferate, the amount of data produced grows rapidly, requiring a similar growth in methods to protect privacy and security. There is also a need for empathy in the way that these emerging technologies are rolled out, and ethical norms and standards need to be updated to keep up with this rapid technological advance. Risks need to be mitigated by informed leadership and management and patients must not become invisible. The balance between technology and people needs to be assessed and maintained in a process of continuous improvement [26].

IV. THE PRINCIPLES OF ENGINEERING MANAGEMENT

This study considers the field of EM and its applicability to better approach the various ethical issues arising in PCC. As healthcare becomes more technology driven, the discipline of EM is ideally suited to provide solutions, given that it relates the principles of management to the domain of engineering practices and is therefore a business application of engineering. Engineering managers combine technological problem-solving capacity with management abilities in the process of overseeing complex engineering businesses. Engineering managers are faced not only with technical design problems but also need to satisfy societal norms and maintain a high standard of ethics [27]. EM is an interdisciplinary approach, and this provides many benefits. Healthcare is now becoming more dependent upon engineering, and the term “healthcare engineering” has been proposed to cover the contribution of engineers and healthcare professionals in the advancing of healthcare via engineering approaches [28]. Smart healthcare is an emerging concept deriving from the use of intelligent devices and other smart technology within health. As noted by Rodić-Trmčić et al [29]; “...smart healthcare can be considered as an engineering discipline that is positioning itself in the intersection of traditional biomedical engineering and modern IT engineering.” There is a fine opportunity now to adopt best practices, especially in terms of the interface between people and technology. Yet integration of that interface presents many ethical issues. The platform of EM provides a way of improving cyber physical integration in terms of both efficiency and effectiveness and highlighting the ethical issues that arise. Issues about professional responsibility and legal matters must be considered when making changes in patient care. Otherwise, the introduction of new approaches may be deleterious to individual patients or groups of patients despite having an economic benefit. Where technology is dominant and rapidly changing, managers need to think carefully about the impact. Decision-making becomes much more difficult under conditions of increasing complexity

with limited time and a huge amount of data; and prudent analysis is essential. High levels of complexity make it more difficult to produce a win-win result when the way forward is ambiguous, and there are many choices. Managing diverse workgroups and patients requires sensitivity. Systems thinking is also a critical skill in considering how best to deliver care in a holistic fashion [30].

A siloed approach with insufficient communication between various stakeholder groups is still often reported and integration is sorely needed. When introducing new treatment approaches, both individual and systemic risks need to be assessed. Maintaining high quality in services is certainly essential when dealing with safety and health. Modelling and simulation (M&S) can be useful including concerning optimal deployment of certain treatments, best usage of facilities, and so on. Testing out approaches before their application in real life is prudent and can prevent injury and save money. Many of the issues outlined above have been addressed specifically within the domain of EM. The pool of knowledge areas and fields of interest within EM offers many points of contact with the requirements of ethically delivered PCC.

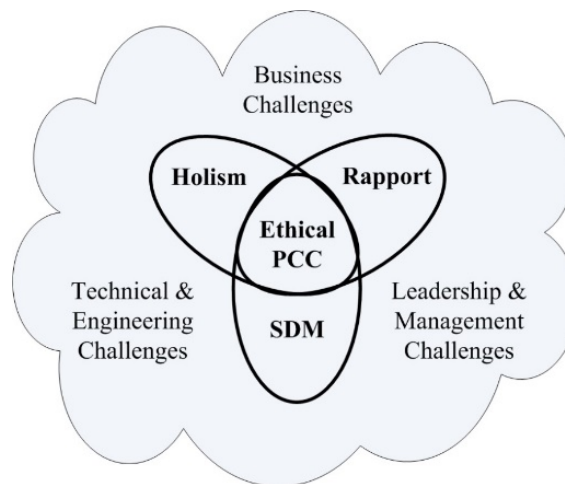


FIGURE 1

PROVIDING ETHICAL SOLUTIONS WITHIN THE THREE PILLARS OF PCC THROUGH EM STRENGTHS OF LEADERSHIP AND MANAGEMENT, TECHNICAL AND ENGINEERING, AND BUSINESS.

Figure 1 shows that the field of EM is in a strong position to assist in providing ethical solutions to many of the dilemmas now being observed when practitioners aspire to provide PCC. As PCC is increasingly technologically driven, the ethical issues arising from the interface between technology, people and business demands will only grow. What is needed is a platform to approach ethical issues in an informed way that is multidisciplinary in nature. The purpose of EM is to build that interface and to provide a multidisciplinary approach to technological and other aspects of human factor management within the field of PCC. This platform that can be highly beneficial in the application of PCC. Business management lacks a focus on the engineering processes highly suited to application within health care settings, especially given recent technological advancements such as we see in Healthcare 4.0.. Table 1 maps out the connections between the three broad themes of engineering management and four major pillars of PCC. The table shows how various elements of engineering management can make significant inroads into the issues that arise in PCC now and into the future. It can also be noted that the fourth column, “Entraining technology to best advantage” overlaps significantly with the other three. Indeed, this column highlights the unique advantage of bringing on board engineering managers in addressing the other pillars of PCC, given the interdisciplinary nature of their training.

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TABLE 1.
 THE RELATIONSHIP BETWEEN ENGINEERING MANAGEMENT PRINCIPLES AND ISSUES WITHIN PATIENT CENTRED CARE

Three broad themes of EM	Patient involvement and empowerment	Relationship with the care provider	Treating the whole patient and continuity of care	Entraining technology to best advantage
Leadership and management challenges	Engineering managers understand the need for processes which encourage patient involvement at various steps in the treatment process. They can convince providers to embrace this concept in their interactions with patients, model this for other healthcare providers, and build it into organizational processes, with the aim of maximising the input of patients into treatment choices.	Management understands the needs for building rapport and allows time for this. Leaders can understand and enact the creation of positive and respectful relationships with patients and the value adding this brings to all parties in the interaction, as well as reducing the likelihood of complaints.	Engineering managers can develop processes which maximise continuity of various aspects of treatment and facilitate patient access. They understand the need for leaders to forge connections between healthcare personnel and to take responsibility for having a holistic view in the way they practice their profession, knowing that insufficient or unethical relationships bring immense costs both personally and to the organisation	Engineering managers can use their special skills to look at the connections between technology and care provision and ensure that they mesh together and interact in optimal ways. They can convince leaders of the need for systemic approaches in the integration of technology and health outcomes. The rapid rollout of healthcare 4.0 can result in ethical dilemmas and engineering managers understand the need for standards, regulations, and ethical norms consistent with professional bodies and training.
Technical and engineering challenges	Engineering managers build patient involvement possibilities into technological activities where possible, and highlight the importance of this, understanding that it is easy for the patient to get lost when technology becomes dominant	Engineering managers use available technology to enhance creation of relationships between patients, care providers and other stakeholders. They take responsibility for keeping current with the opportunities that technology brings to create meaningful and authentic two-way relationships	Engineering managers promote the use of technological solutions to enable patients to access care in an equitable way, so that vulnerable groups can also be included. They also use technology to harmonise care provision amongst various providers.	The training of engineering managers enables them to create win-win situations using technology to maximise patient outcomes. The balance between technology and human factor needs to be understood and explained.

<p>Business challenges</p>	<p>Engineering managers can convince organisations that empowerment and involvement of patients does bring about cost advantages and better treatment outcomes, as well as meeting corporate social responsibilities. They can also relate that ethical treatment encompasses a more equitable sharing of information and decision-making input.</p>	<p>Policies which encourage mutual relationships minimise the likelihood of costly and negative action arising from poor relationships with care providers. Engineering managers can make the case that inappropriate relationships will result in reputational harm, and that paternalistic, top-down relationships of yesteryear are no longer considered acceptable by many patients.</p>	<p>Engineering managers can demonstrate that using a holistic lens to combine and interconnect the various aspects and providers of care will bring about many advantages including to the bottom line.</p>	<p>Engineering managers are well-placed to explain to organisations the many benefits of embracing new technology and the dividends it brings.</p>
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V. CONCLUSION

PCC is about placing the patient at the centre of decision-making and giving them personal control, autonomy, input, respectful and clear communication, and the information they need to be more involved in decisions about treatment options. As Healthcare 4.0 unfolds quickly and new developments such as artificial and augmented intelligence, smart devices, big data analysis, and augmented reality become par for the course, there are huge potential benefits in increasing the interactivity between patients and solutions. At the same time there is also a need not to focus on the beguiling technology itself to the detriment of the patient. The patient must be kept in strict focus and their interests optimized, through ethical treatment. The integration of the principles of EM with healthcare practices would be a major step in the right direction in assisting providers striving for PCC that maintains its focus upon the patient and the patient’s preferences. Many professionals trained in technical areas do not have experience in building a bridge between technical success and outcomes for people. This paper argues that the discipline of EM can build that bridge and optimize decisions made within the complex quagmire of current challenges in the provision of ethical healthcare.

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Assessing the Potential of Sustainability in Transport Sector Using Fuzzy Set Theory and Monte Carlo Simulation

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Abstract— Growth in urbanization poses both risks and opportunities in the transport sector. The risks manifest mainly in the increase of greenhouse gas emissions, and traffic congestion. On the other hand, opportunities for economic growth, social well-being, and human health. The use of economic, social and environmental indicators for evaluating the sustainable transport sector has been the main core of recent studies in urban areas. The main goal of this paper is to analyse the impact of sets of sustainability indicators that have emerged in the scientific literature based on fuzzy set theory and Monte Carlo simulation. The presented methodology is able to help decision makers to deal with the uncertainty related to the indicators, and also decide the influence of each indicator on the sustainability of the transport system.

Keywords— Fuzzy set theory, Monte Carlo Simulation, Sustainability indicators.

I. INTRODUCTION

Cities are becoming largely complex from a management perspective, as the population increases, the flow of goods and passengers increases, resulting in a growing share of areas that is assigned to transport and transportation infrastructures inside cities. Therefore, measuring the performance of the transport system is considered as a key element in developing and adopting efficient policies and plans.

Transport sector is considered an indispensable element for economic growth and urbanization, nowadays the evaluation of transportation sustainability is becoming increasingly common throughout different scientific fields despite the vagueness related to the definition of sustainability in the transportation sector [1]. In general, a transportation system can be considered as a sustainable one, when the planning practices and policies meet the economic, social and environmental objectives [2]. Where the system is able to maintain an economic growth and at the same time minimize the greenhouse gas emissions and noise level, besides assuring the accessibility and safety to users.

A comprehensive assessment to evaluate the performance of the transport system has emerged as a core of recent research, where sustainability is defined based on a set of environmental, economic and social indicators that must be satisfied in order to fulfil the goal of sustainability. This study evaluates a set of well-known sustainability indicators that is used extensively in the literature using a method based on fuzzy theory and Monte Carlo simulation. This paper is organized after this introduction as follows: brief literature review and problem description is presented in section 2. Section three is devoted to describe the presented methodology procedure. In section 4, a description of the case study is presented. Finally the conclusion is provided.

II. LITERATURE REVIEW

In the literature, the number of studies that discuss sustainability indicators to evaluate the transportation system is increasing steadily. The sustainability indicators involved a combination of environmental, social, and economic indicators. Reference [3] presented a conceptual monitoring and evaluation framework for the sustainability assessment of micro-transit systems to build realistic and profitable value propositions for urban transport systems from three different perspectives; economic, social, and environmental. Reference [4]

presented a comparative evaluation for sustainable transport using multi criteria analysis. The authors designed a hybrid approach consisting of three selected Criteria Decision Making/Multi-Criteria Decision Analysis methods: DEMATEL, REMBRANDT, and VIKOR.

Reference [5] presents a multi-criteria decision making approach to assess and select sustainability in urban transportation systems based on fuzzy set theory. The presented approach contains three main steps, starting with identifying the criteria to be used in sustainability assessment of transportation. Next, the experts provide linguistic ratings for alternatives. This step followed by Fuzzy TOPSIS to generate aggregate scores for sustainability assessment and selection of best alternatives. Reference [6] assessed the performance of transportation alternatives using Monte Carlo simulation using social, economic and environmental indicators for the route between the cities of Rio de Janeiro and Niterói. According to the authors, the indicator with the greatest influence on the individual transportation alternatives is cost, while the most relevant one for the collective alternatives is trip time.

Although there have been several researches discussing the different aspects of sustainability in urban freight operations, a systematic approach to measure the sustainability has not previously been developed. To achieve this, a method based on fuzzy theory and Monte Carlo simulation has been proposed to assist in evaluating the sustainability in urban freight operations while including the uncertainty associated with defining and measuring the indicators. The applied methodology is an extension of previous approaches that has been applied in other fields.

III. METHODOLOGY

We conducted a systematic review of international literature to identify a set of indicators used to measure the sustainability in transportation systems from three different aspects; environmental, economic and social and their measurements as presented in section table (1). A transport system can be defined as a sustainable one, if it provides the basic access needs of individuals safely while ensuring health and equity. Also it is affordable, efficient and it is able to minimize the emissions, the waste, noise, pollution, and the use of the land and non-renewable resources [7]–[9]. In general, a transport sustainable system is the one that contributes to environmental enhancement, economic growth and social equity [10].

The analysis is based on a combination of multiple criteria decision making using Fuzzy set theory and Monte Carlo simulation. Figure.1 illustrates the 8 steps of the presented method while the rest of this section clarifies the main steps.

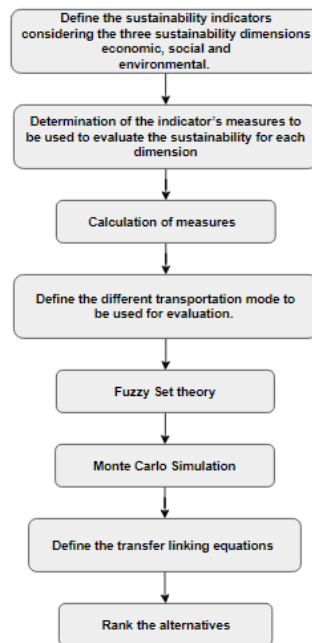


FIGURE 1

THE EVALUATION METHOD FOR TRANSPORT SUSTAINABILITY.

Fuzzy set theory is able to handle the uncertainty related to the sustainability indicators (Fu, 2008). The indicators can be divided mainly into two categories; benefit and cost indicators depending on their effects on the transport system. Therefore, the benefit indicators should be maximized, while the cost one should be minimized [11].

The fuzzification process transforms crisp sets with normal values into fuzzy membership function. For a fuzzy set A, the membership function is defined by $\mu_A(x) \in [0, 1]$ and it represents the degree of membership of x to the fuzzy set A. the triangular membership functions feature is one of the most widely accepted and used membership function, it specified by three parameters by three parameters {a, b, c}. Where a, and c presents the base of the triangle and b define the height of the triangle as shown in figure 2. The membership function of a fuzzy set A is defined by $\mu_A(x)$ where $\mu_A(x) [0, 1]$ and it represents the degree of membership of x to the fuzzy set A. The membership function $\mu_A(x)$ for each value x is represented below.

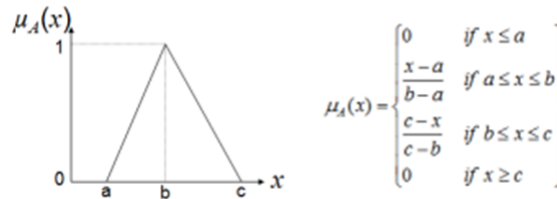


Figure XIII: Triangular fuzzy number

In addition, the fuzzy set theory is able to deal with both quantitative and qualitative data which may apply on sustainability indicators in the transport sector. For qualitative data, to transform the linguistic terms into fuzzy numbers, a scale of 1-9 is used to convert criteria and alternatives, table (1,2) present the linguistic variables used for criteria and alternatives respectively.

TABLE V

LINGUISTIC VARIABLE FOR THE IMPORTANCE WEIGHT OF EACH CRITERION

Very Low (VL)	(0,0,0.1)
Low (L)	(0,0.1,0.3)
Medium Low (ML)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
Medium High (MH)	(0.5,0.7,0.9)
High (H)	(0.7,0.9,1)
Very High (VH)	(0.9,1,1)

TABLE VI

LINGUISTIC VARIABLE FOR THE IMPORTANCE WEIGHT OF ALTERNATIVES.

Very Poor (VP)	(0,0,1)
Poor (P)	(0,1,3)
Medium Poor (MP)	(1,3,5)
Medium (M)	(3,5,7)
Medium Good (MG)	(5,7,9)
Good (H)	(7,9,10)
Very Good (VG)	(9,10,10)

The various followed steps of fuzzy are presented as follows:

1) *Construct the Fuzzy Decision Matrix:* Let's assume that $A = \{A_1, A_2, \dots, A_m\}$ are all possible alternatives, against n criteria $C = \{C_1, C_2, \dots, C_n\}$, x_{ij} present the rating of alternatives A_i with respect to Criterion C_j , w_j define the weight of each criterion C_j .

$$D = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ A_1 & \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{matrix},$$

$$W = [w_1 \ w_2 \ \cdots \ w_n],$$

2) *Normalize the Fuzzy Decision Matrix:* The quantitative data are identified in measurable units, which need to be converted into normalized values between 0 and 1, so that the different indicators can be compared easily. The indicators can be divided mainly into two categories; benefit and cost indicators depending on their effects on the transport system. Therefore, the benefit indicators should be maximized, while the cost one should be minimized [11].

3) *Construct the Weighted Normalized Matrix:* In this step the weighted fuzzy values (w_n) and the normalized fuzzy decision matrix are multiplied to get the weighted normalized matrix \tilde{v} .

4) *Monte Carlo Simulation and ranking alternatives:* The next task is to apply Monte Carlo simulation as a tool to assess the weighted normalized matrix \tilde{v} . The weighted based on a specific probability distribution associated with the values to overcome the uncertainty in the final results. The weighted normalized matrix \tilde{v} is a triangular distribution that can be used as the model input variables for Monte Carlo simulation. A transfer linking equation is needed to aggregate all indicators into an individual value for each alternative. And lastly, ranking all the alternatives.

IV. CASE STUDY

To ensure applicability, the methodology has been used to evaluate the sustainability of the transport system in Amman-Jordan. We selected the downtown area of the city of Amman for its importance for mobility as shown in the road map in figure.



FIGURE 3
THE MAIN ROUTE.

Numerous numbers of sustainability indicators are available in the literature (reference). Where the following sustainability indicators were selected based on the availability of data.

The second step involves identifying the alternatives which in this case are the transportation modes. The available alternatives in the city of Amman are the Bus Rapid Transit (BRT), Auto- Bus, and the small buses. The results will be shown and discussed in the summit.

TABLE VII
 APPLIED INDICATORS TO ASSESS THE SUSTAINABILITY

Sustainability dimensions	Indicators (criterion)	Performance measures	References
Economic	Operating costs	Cost of operating vehicles.	[12]
	Mobility	The density of the transport system	[13]
	Affordability	Transportation cost per capita	[3]
Environmental	CO2 emissions	Amount of CO2 emissions by transport system	[14]
	Land use	Percentage of land for transport system infrastructure	[13]
	Noise	Percentage of roads with excess noise	[6]
	Vehicle pollution	Intensity of noise emitted by vehicles	[6]
Social	Safety and security	The total number of accidents.	[2], [3]
	Congestion	Vehicle occupancy rate.	[15]
	Accessibility	Number of used passengers.	[6]
	Availability	Number of daily trips	[13]

The second step involves identifying the alternatives which in this case are the transportation modes. The available alternatives in the city of Amman are the Bus Rapid Transit (BRT), Auto- Bus, and the small buses. The results will be shown and discussed in the summit.

V. CONCLUSIONS

A set of indicators has been developed from the literature so that all sustainability dimensions are incorporated. In addition, the measurement of each indicator has been defined. A methodology that combines a multi-criteria decision making approach using fuzzy set theory and Monte Carlo simulation has been used to evaluate the indicators. The presented methodology is able to help decision makers to deal with the uncertainty related to the indicators, and also decide the influence of each indicator on the sustainability of the transport system.

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İstanbul Technical University & Bahçeşehir University

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A Test Foresight Study in the European Region

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Abstract-- In line with the topic of this conference, we aimed to contribute to the relationship between technology foresight and knowledge management. Undoubtedly, technology foresight and knowledge management are the most discussed topics of the knowledge-based economy era. The reason for this is the multiplicity of techniques used in shaping the future and the differences between them. We will examine the evaluation and results of a test foresight study involving European Union countries in terms of information management. 383 experts from 15 countries participated in the technology foresight study conducted within the framework of ERA-Net Forsociety. The results of the survey covering the issues related to the future of Europe were analyzed in terms of competitiveness, environment, RTDI activities, stability, and social welfare of Europe. The participating experts were also asked about the timescales and realization rates in shaping Europe's future. We think that the study, in which very interesting results were obtained, will guide the knowledge management for the Europe of the future. The study was carried out before the pandemic period. One of the interesting results is the opinions of the experts about the pandemic before the pandemic.

However, other results can be said to shed light on shaping the future of Europe. We think that the study, in which very interesting results were obtained, will guide the knowledge management for the Europe of the future.

Keywords—Foresight Study, Delphi Survey, Foresight Assessment, Foresight Case Study, Future Shaping

I. INTRODUCTION

The Delphi method is an expert survey in two or more rounds (the Delphi survey remains open to participants for more than one successive period, those periods are called Delphi rounds 1-8).

Carrying out the survey in more than one round is an important characteristic of a Delphi exercise. Starting from the second round, feedback is given about the results of the previous round. The same experts assess the same matters once more, having the possibility to consider opinions of other experts.

Compared with traditional surveys, the Delphi survey is different in its content. Instead of questions, a Delphi survey is composed of statements which are required to be evaluated against a set of variables (time to occurrence, impact on competitiveness of Europe, impact on the European political system, etc) [9-14].

II. GENERAL INFORMATION ABOUT DELPHI EXERCISE

The ForSociety, a Coordinated Action Project funded under an ERA-Net fund, performed several transnational foresight exercises since the starting the network 2004 by taking up the challenge and need of transnational communication and coordination.

The Delphi survey with the task code 3.3 within the ForSociety ERA-Net is a pilot exercise in a transnational approach in which 15 countries participated. Due to the multi-national character of the exercise, participants of experts from different countries across Europe enable transnational comparison. Preparation and Implementation of the Delphi Survey Process

All of the partners¹ of the ForSociety project were involved in the Delphi Exercise. 3320 experts from partner countries in the related fields were selected by every project partner on the basis of the position they occupy for the survey.

¹ Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Malta, Netherlands, Norway, Romania, Sweden, Turkey, United Kingdom of Great Britain and Northern Ireland

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Topics and Variables Covered in the Delphi Survey
 There are five topics in the Delphi survey. These are;

- Economy and business
- Environment and Natural Resources
- Policy and governance
- Society and culture
- Technology and RDI (Research, Development, and Innovation) activities

These topics are defined as panels in the survey. In each panel, there exists 5 Delphi statements.

TABLE 1.
 DELPHI STATEMENT AND RELATED PANELS

No	PANELS	STATEMENTS
1	Policy and governance	A robust institutional arrangement for world governance has displaced the UN and can effectively prevent wars between nations
2	Policy and governance	A multipolarised world has emerged, in which Europe efficiently plays a strong role in international governance
3	Policy and governance	The European Union splits into several strongly opposing blocs
4	Policy and governance	Conflicts arise between leading countries to secure access to critical natural resources (oil and gas as well as precious minerals like platinum)
5	Policy and governance	The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy
6	Economy and business	Economic globalisation has slowed down, with a majority of consumers now choosing to buy locally produced goods rather than products imported from a long distance away
7	Economy and business	The dollar is no longer the international monetary standard
8	Economy and business	Public economic policies are ineffective in a world dominated by large, multinationally organised research clusters, producing companies, financial trusts and media consortia
9	Economy and business	Most public services (security, transport, education...) are privatised or subcontracted to the private sector
10	Economy and business	Ageing and a natural reduction in the active population compel the national government to extend compulsory work-time in terms of both hours (more than 40 hours/week) and years (beyond the age of 70)
11	Society and culture	The public social security and pensions system collapses in your country
12	Society and culture	The rate of immigration from Africa and Asia to your country rises considerably (double the rate in 2006)
13	Society and culture	In a society in which the public no longer tolerates risk, the "precautionary principle" is now the main criterion when making decisions
14	Society and culture	The use of private cars has halved. This drastic reduction could be due to a combination of various factors: adequate "on-demand" public transport systems, transport tolls in cities, new public awareness, high oil prices...
15	Society and culture	Metropolisation comes to an end and people are starting to reinvest in rural areas
16	Environment and natural resources	A worldwide epidemic has occurred, with disastrous consequences for the economy
17	Environment and natural resources	No technologically and economically viable alternative has been developed "on-time" for widespread use as a substitute to petrol in cars, while oil prices are now well above the production costs of bio-fuels

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 İstanbul Technical University & Bahçeşehir University

18	Environment and natural resources	The management of useable water as a scarce resource is at the origin of serious conflicts in Europe between regions or between professional groups (agriculture, industries...)
19	Environment and natural resources	The major reduction in biodiversity (40% of known species have disappeared) threatens the whole of humanity
20	Environment and natural resources	Individual energy production is becoming compulsory and "zero energy" buildings are widespread (every new building is obliged to include in its conception means like solar panels to produce its own energy)
21	Technology and RDI	Technologies that are directly embedded in human bodies and that can communicate and interact with the external environment have become a reality
22	Technology and RDI	Breakthroughs in bio- and nano-technologies have favoured the development of environmental technologies allowing Europe to take the lead in the knowledge-based bio-economy
23	Technology and RDI	The concept of the Internet as a unique network comes to an end, resulting in division into several independent networks
24	Technology and RDI	Fuel cells and hydrogen become a technologically and economically viable solution for car propulsion
25	Technology and RDI	The public accepts the development of nuclear energy to complement renewable energies, as a solution that will not alter the global environment in the near future

Delphi statements are evaluated by using variables below.

Respondents Degree of Expertise, with this variable the respondent is expected to evaluate the degree of expertise with respect to the given Delphi statement.

- *Unfamiliar*: the respondent has no knowledge about the content of the given Delphi statement
- *Familiar*: the respondent has a special interest in the topics and following the related news and activities from various media
- *Expert*: the respondent has a strong background about the given Delphi statement (having work experience and may have published papers, presentations, proposals related to the given Delphi statement)

Probability to happen, with this variable the respondent is expected to evaluate the given Delphi statement has any possibility to happen.

- *High*: the respondent strongly agrees that the event / result given in Delphi statement will occur
- *Medium*: the respondent thinks that the event / result given in Delphi statement will probably occur
- *Low*: the respondent thinks that it is not likely that the event / result given in Delphi statement will occur
- *Never*: the respondent strongly disagrees with the idea that the event / result given in Delphi statement will occur

Time of occurrence, with this variable the respondent is expected to evaluate the realization time for a given Delphi statement. If the probability to happen is answered as "Never" this field will not be open to evaluation)

- *Before 2015*: the respondent believes that the given statement will occur before 2015 arrives
- *Between 2015 and 2030*: the respondent believes that the given statement will occur between 2015 and 2030
- *Beyond 2030*: the respondent believes that the given statement will occur after 2030

The respondents are expected to evaluate the given Delphi statement according to the impacts listed below:

- Impact on the stability of the European political system,
- Impact on the social welfare in Europe,
- Impact on the competitiveness of Europe,
- Impact on the environmental quality,
- Impact on Technology and RDI activities.

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Each of these impacts is rated by using the options given below:

- High positive impact: the respondent believes that the given statement may have dramatic consequences and will cause desirable effects on the given variable
- High negative impact: the respondent believes that the given statement may have dramatic consequences, but will cause undesirable effects on the given variable
- Uncertain high impact: the respondent believes that the given statement may have dramatic consequences, but he/she cannot decide what type of effects will occur due to the given statement
- No significant impact: the respondent believes that the given statement will have no dramatic consequences

During the survey period, the registration page of the system is kept open for respondents where basic information about the respondents (Nationality, age, gender etc...) are collected and the respondents also declare the username/password pairs they would like to use during the survey. When the first round the Delphi survey is activated, the respondents can log-in the online survey, receive Delphi statements and evaluate them. During the period between the first and the second round of the survey, the respondents are not allowed to log-in the system. In the second round, a respondent is allowed to reach his/her answers in the first round and for each Delphi statement, the respondents is able to reach the total answers. By the end of the second round of the survey, the online survey is permanently closed to respondents.

III. OUTCOMES OF THE DELPHI SURVEY

Total number of invited respondents to the Delphi Survey from fourteen participant countries were 3320 (Table 1). Nearly 12% of the invited respondents were participated in the Delphi Survey.

TABLE 2.
PARTICIPATION OF THE SURVEY

Respondents	Number	%
Respondents Invited	3320	100
Respondents Participated	383	11,5

France has the highest number of invited respondents of 1403. On the other hand, Sweden was not participated in the Survey (Table 2).

TABLE 3.
DISTRIBUTION OF PARTICIPANTS BY COUNTRY

No	Countries	Number of Respondents	Respondents Invited
1	TURKEY	93	314
2	FRANCE	91	1403
3	HUNGARY	38	270
4	UK	31	301
5	CZECH REPUBLIC	28	170
6	GREECE	24	188
7	GERMANY	19	232
8	ROMANIA	17	81
9	NETHERLANDS	10	91
10	DENMARK	9	43
11	FINLAND	7	62
12	MALTA	6	102
13	NORWAY	6	48
14	BULGARIA	4	15
15	SWEDEN	0	0
	TOTAL	383	3320

Probability to happen

Experts are expected to answer Probability to Happen variable with respect to *High, Medium, Low, Never* options. According to the results, there is a significant difference between the experts' answers and total respondents' answers. 38% of the experts' answers state that statements have *High* probability to happen, while 25% of total respondents' answers indicate that statements have *High* probability to happen. However, nearly 5% of total respondents' answers and experts' answers agree on the statements that *Never* will happen (Table 4).

TABLE 4.
EXPERTS' AND TOTAL RESPONDENTS' ANSWERS TO THE PROBABILITY TO HAPPEN VARIABLE

	Probability to happen				
	High	Medium	Low	Never	Total
Experts' answers	292	251	180	43	766
Experts' answers (%)	38	33	23	6	100
Total respondents' answers	1535	2448	1835	243	6061
Total respondents' answers (%)	25,3	40,4	30,3	4	100

Highest rated Statements by Experts to Probability to Happen as “High”

According to the answers, ten statements have the highest rate of probability to happen as *High*.

5. The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy (*Policy and governance*)

10. Ageing and a natural reduction in the active population compel the national government to extend compulsory work-time in terms of both hours (more than 40 hours/week) and years (beyond the age of 70) (*Economy and business*)

12. The rate of immigration from Africa and Asia to your country rises considerably (double the rate in 2006) (*Society and culture*)

17. No technologically and economically viable alternative has been developed "on-time" for widespread use as a substitute to petrol in cars, while oil prices are now well above the production costs of bio-fuels (*Environment and natural resources*)

18. The management of useable water as a scarce resource is at the origin of serious conflicts in Europe between regions or between professional groups (agriculture, industries...) (*Environment and natural resources*)

Time of occurrence

Participants are expected to determine the realization of the statements with the time of occurrence variable. Respondents were asked to give their opinion on the Time of occurrence of each Delphi statements by selecting one of the choices from *Before 2015, Between 2015 and 2030* and *Beyond 2030*.

51% of total experts' answers and 49% of total respondents' answers points the time of occurrence between *2015-2030*. This followed by the rate of 27% time of occurrence *Beyond 2030*. Time of occurrence *Before 2015* has the rate of 22,6% expert answers' and 24% total respondents' answers (Table 5).

TABLE 5.
TIME OF OCCURRENCE

	Time Of Occurrence			
	Before 2015	Between 2015 and 2030	Beyond 2030	Total
Experts' answers	161	361	190	712
Experts' answers (%)	22,6	50,7	26,7	100
Total respondents' answers	1348	2791	1526	5665
Total respondents' answers (%)	24	49	27	100

There is a correlation between experts' answers and total respondents' answers. Both experts' and total respondents' answers agree on the time of occurrence of most of the Delphi statements *between 2015-2030*.

Highest Rated Statements by Experts to Time of Occurrence “Before 2015”

Four statements answered by experts have the highest rate of Time of occurrence before 2015. These Delphi statements are;

2. A multipolarised world has emerged, in which Europe efficiently plays a strong role in international governance (*Policy and Governance*)
5. The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy (*Policy and Governance*)

Highest rated Statements by Experts to Time of Occurrence “Between 2015 and 2030”

Seventeen statements have the highest rate of Time of occurrence between 2015-2030. These are;

3. The European Union splits into several strongly opposing blocs (*Policy and governance*)
4. Conflicts arise between leading countries to secure access to critical natural resources (oil and gas as well as precious minerals like platinum) (*Policy and governance*)

Highest Rated Statements by Experts to Time of Occurrence for “Between 2015 and 2030” and “Beyond 2030”

Two statements have the same rate of time of occurrence of *Between 2015-2030 and Beyond 2030*:

14. The use of private cars has halved. This drastic reduction could be due to a combination of various factors: adequate "on-demand" public transport systems, transport tolls in cities, new public awareness, high oil prices. (*Society and Culture*)
16. A worldwide epidemic has occurred, with disastrous consequences for the economy (*Environment and natural resources*)

The result illustrates that the experts have the tendency of selecting time of occurrence *Between 2015-2030*.

Impact on the competitiveness of Europe

Impact on the competitiveness of Europe variable is rated by using High positive impact, *High negative impact*, *Uncertain high impact*, *No significant impact* options.

TABLE 6.

EXPERTS' AND TOTAL RESPONDENTS' ANSWERS TO THE COMPETITIVENESS OF EUROPE VARIABLE

	Competitiveness of Europe				Total
	No significant impact	High positive impact	High negative impact	Uncertain high impact	
Experts' answers	76	282	238	151	747
Experts' answers (%)	10	38	32	20	100
Total respondents' answers	733	1701	1901	1558	5893
Total respondents' answers (%)	12,4	28,9	32,3	26,4	100

Highest Rated Statements by Experts to Competitiveness of Europe as “No Significant Impact”

Only one Delphi statement has the highest rate of *No Significant Impact* to Competitiveness of Europe:

10. Ageing and a natural reduction in the active population compel the national government to extend compulsory work-time in terms of both hours (more than 40 hours/week) and years (beyond the age of 70) (*Economy and business*)

Highest Rated Statements by Experts to Competitiveness of Europe as “High Positive Impact”

2. A multipolarised world has emerged, in which Europe efficiently plays a strong role in international governance (*Policy and governance*)
7. The dollar is no longer the international monetary standard (*Economy and business*)

Highest Rated Statements by Experts to Competitiveness of Europe as “High Negative Impact”

3. The European Union splits into several strongly opposing blocs (*Policy and governance*)
4. Conflicts arise between leading countries to secure access to critical natural resources (oil and gas as well as precious minerals like platinum) (*Policy and governance*)

5. The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy (*Policy and governance*)

Highest Rated Statements by Experts to Competitiveness of Europe as “Uncertain High Impact”-

One Delphi statement has the highest rate of *Uncertain High Impact* to Competitiveness of Europe:

1. A robust institutional arrangement for world governance has displaced the UN and can effectively prevent wars between nations (*Policy and governance*)

Highest Rated Statements by Experts to Competitiveness of Europe “High Positive Impact” and “Uncertain High Impact”

One Delphi statements has the same highest rate as both *High Positive Impact* and *Uncertain High Impact*.

14. The use of private cars has halved. This drastic reduction could be due to a combination of various factors: adequate "on-demand" public transport systems, transport tolls in cities, new public awareness, high oil prices. (*Society and culture*)

3.5. Impact on Technology and RDI (Research, Development and Innovation) Activities

Impact on Technology and RDI variable is rated by using *High positive impact*, *High negative impact*, *Uncertain high impact*, *No significant impact* options.

TABLE 7.

EXPERTS’ AND TOTAL RESPONDENTS’ ANSWERS TO THE TECHNOLOGY AND RDI VARIABLE

	Technology and RDI activity				
	No significant impact	High positive impact	High negative impact	Uncertain high impact	Total
Experts’ answers	112	352	110	155	729
Experts’ answers (%)	15,4	48,3	15,1	21,3	100
Total respondents’ answers	1113	2190	813	1605	5721
Total respondents’ answers (%)	19,5	38,3	14,2	28,1	100

Highest Rated Statements by Experts to Technology and RDI as “High Positive Impact“

Most of the highest rated Delphi statements on degree of impact on technology and RDI for Each Delphi statement given by experts are clustered in *High Positive Impact*. Fourteen statements are within this group. The number of the statements which have the highest rate of

1. A robust institutional arrangement for world governance has displaced the UN and can effectively prevent wars between nations (*Policy and governance*)

2. A multipolarised world has emerged, in which Europe efficiently plays a strong role in international governance (*Policy and governance*)

Highest Rated Statements by Experts to Technology and RDI as “High Negative Impact“

3. The European Union splits into several strongly opposing blocs (*Policy and governance*)

11. The public social security and pensions system collapses in your country (*Society and culture*)

Highest Rated Statements by Experts to Technology and RDI as “High Positive Impact“ and “Uncertain High Impact”

Delphi statement which has number 5 has the same highest rate of *High Positive Impact* and *Uncertain High Impact*.

5. The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy (*Policy and governance*)

When we overview the distribution of highest rates according to panels, there seems to be a significant clustering of highest rated Delphi statements of *High Positive Impact* in Policy and Governance, Environment and Natural Resources and Technology and RDI panels.

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 İstanbul Technical University & Bahçeşehir University

TABLE 8.
 PROBABILITY TO HAPPEN “HIGH” STATEMENTS BY EXPERTS

No	PANELS	STATEMENTS	Probability to happen			
			High	Medium	Low	Never
5	Policy and governance	The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy	8	3	0	0
10	Economy and business	Ageing and a natural reduction in the active population compel the national government to extend compulsory work-time in terms of both hours (more than 40 hours/week) and years (beyond the age of 70)	14	9	8	2
12	Society and culture	The rate of immigration from Africa and Asia to your country rises considerably (double the rate in 2006)	5	4	3	0
17	Environment and natural resources	No technologically and economically viable alternative has been developed "on-time" for widespread use as a substitute to petrol in cars, while oil prices are now well above the production costs of bio-fuels	28	15	11	4
18	Environment and natural resources	The management of useable water as a scarce resource is at the origin of serious conflicts in Europe between regions or between professional groups (agriculture, industries...)	20	15	5	0
19	Environment and natural resources	The major reduction in biodiversity (40% of known species have disappeared) threatens the whole of humanity	14	5	5	1
20	Environment and natural resources	Individual energy production is becoming compulsory and "zero energy" buildings are widespread (every new building is obliged to include in its conception means like solar panels to produce its own energy)	33	14	6	2
21	Technology and RDI	Technologies that are directly embedded in human bodies and that can communicate and interact with the external environment have become a reality	31	4	1	0
24	Technology and RDI	Fuel cells and hydrogen become a technologically and economically viable solution for car propulsion	26	13	7	1
25	Technology and RDI	The public accepts the development of nuclear energy to complement renewable energies, as a solution that will not alter the global environment in the near future	19	14	10	2

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From these 10 statements 2 statements are expected by experts to happen *Before 2015* (Table 9).

TABLE 9.

PROBABILITY TO HAPPEN “HIGH” AND TIME OF OCCURRENCE “BEFORE 2015” STATEMENTS BY EXPERTS

No	PANELS	STATEMENTS	Time of Occurrence		
			Before 2015	Between 2015 and 2030	Beyond 2030
5	Policy and governance	The permanent threat of terrorism is completely incorporated into daily lives of citizens, shaping their mobility choices and restricting their freedom and individual privacy	7	4	0
17	Environment and natural resources	No technologically and economically viable alternative has been developed "on-time" for widespread use as a substitute to petrol in cars, while oil prices are now well above the production costs of bio-fuels	21	17	15

From these 10 statements 6 statements are expected by experts to happen *Between 2015-2030* (Table 10).

TABLE 10.

PROBABILITY TO HAPPEN “HIGH” AND TIME OF OCCURRENCE “BEYOND 2030” STATEMENTS BY EXPERTS

No	PANELS	STATEMENTS	Time of Occurrence		
			Before 2015	Between 2015 and 2030	Beyond 2030
10	Economy and business	Ageing and a natural reduction in the active population compel the national government to extend compulsory work-time in terms of both hours (more than 40 hours/week) and years (beyond the age of 70)	8	17	5
12	Society and culture	The rate of immigration from Africa and Asia to your country rises considerably (double the rate in 2006)	3	7	2
18	Environment and natural resources	The management of useable water as a scarce resource is at the origin of serious conflicts in Europe between regions or between professional groups (agriculture, industries...)	10	17	13
20	Environment and natural resources	Individual energy production is becoming compulsory and “zero energy” buildings are widespread (every new building is obliged to include in its conception means like solar panels to produce its own energy)	3	27	24
21	Technology and RDI	Technologies that are directly embedded in human bodies and that can communicate and interact with the external environment have become a reality	9	20	7
24	Technology and RDI	Fuel cells and hydrogen become a technologically and economically viable solution for car propulsion	4	23	18

25	Technology and RDI	The public accepts the development of nuclear energy to complement renewable energies, as a solution that will not alter the global environment in the near future	12	24	7
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From these 10 statements 1 statement is expected by experts to happen *Beyond 2030*. (Table 11)

TABLE 11
 PROBABILITY TO HAPPEN “HIGH” AND TIME OF OCCURRENCE “BETWEEN 2015-2030” STATEMENTS BY EXPERTS

No	PANELS	STATEMENTS	Time of Occurrence		
			Before 2015	Between 2015 and 2030	Beyond 2030
19	Environment and natural resources	The major reduction in biodiversity (40% of known species have disappeared) threatens the whole of humanity	5	8	11

IV. CONCLUSION

The rate of participation differs among the countries variously. Although France and Turkey have nearly the same of participation, the participation from other countries is very low. This makes it difficult to make analysis and comparison between countries.

Potential rupture statements presented in Table 9 show us that five major issues have been underpinned by most of the European experts. Those statements are about the threat of terrorism, ageing, immigration, energy and environment. As can be expected, two statements that is related with threat of terrorism (statement number 5) and energy (statement number 17) have the highest rate from experts to happen before 2015. This expectation may be the result of the foresee of experts or the social reflex which arise from the new paradigm about the fearful future and climate change that is affecting the globe.

Web based survey and communication is used in Forsociety Delphi exercise. E-communication makes it difficult to reach a significant number of respondents from each country. Invitation letter is sent by e-mail to all respondents. After sending the invitation letter by e-mail, it would be better to make telephone calls to experts whether they received the letter and persuade them to participate to the Delphi survey. This method may increase the participation rate.

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Complications in big data-based communication in the wake of COVID-19: A comparison of North American and Nordic practices of multinational healthcare corporations

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Abstract—COVID-19 challenged health authorities to interpret rapidly changing data, monitor ongoing research developments, and communicate critical information to the public across regions with a wide variety of demographic audiences. Thus, the risks involved in healthcare communications significantly intensified. We focus on (1) challenges involved in healthcare communication; (2) communications approach across the Nordic countries (Denmark, Finland, Norway, and Sweden) and the U.S.; and (3) risks involved in communicating information derived from big healthcare data to understand possible implications during the COVID-19 pandemic. Through a series of semi-structured in-depth interviews with practitioners involved in healthcare communications, we explore the communicators' experiences with public health-related big data from the United States vs. Nordic countries. Results indicate three core elements unique to communication in the healthcare industry: (1) big data, (2) the business context and operating environment, and (3) the healthcare communication development process itself. Findings indicate that there are similarities between the U.S. and the Nordics across all three areas. However, the differences are particularly pronounced in the business operating environment. Conclusions offer improvement in healthcare communications by reducing current exposure to risks in disseminating misinformation and addressing future challenges in responding to future global health crises.

Keywords—COVID-19, pandemic, infodemic, big data, healthcare communications, public health

I. INTRODUCTION

The World Health Organization hosted a media briefing on COVID-19 in February 2020 to inform the public that they were not only fighting a pandemic but also an infodemic, which is defined as "*an abundance of information — some accurate and some inaccurate — that makes it difficult for people to find trustworthy sources and trustworthy guidance when they need it*" [1]. Public health officials were confronted with a global health crisis together with a worldwide communications crisis. Effectively combating the COVID-19 pandemic required clear, concise, and efficient communication of complex health-related data. However, those developing communications to disseminate healthcare information was frequently inexperienced or inadequately trained in synthesizing such data, which could lead to the potentially dangerous circulation of misinterpreted data or the spread of incorrect information. This paper examines the challenges of pandemic healthcare communication in the United States (U.S.) and the Nordic countries (Denmark, Finland, Norway, and Sweden). The findings illuminate the risks associated with communicating public health information derived from big data during COVID-19 and provide implications for improved communication in times of similar future crises.

During the unprecedented pandemic times of rapidly evolving, fast-paced scientific discovery, resulting in high volumes of data and public health information, it became necessary to swiftly determine how to communicate data successfully. During the pandemic, the already present complexity of big data, analysis, and intelligence was heightened when considering the interactions and relationships across industries, organizations, countries, and regulatory parameters [2, 3]. Subsequently, this study focused on the following research questions to understand possible implications during the COVID-19 pandemic: (1) What are the challenges involved in healthcare communication? (2) How do the challenges differ in the Nordics vs. the U.S.? (3) What are the risks involved in communicating information derived from public healthcare big data? The following sections

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 İstanbul Technical University & Bahçeşehir University

provide a description of the study’s methodology, including an overview of the interviewees and the sampling approach. Next follows a summary of the results and discussion. Lastly, implications and risks associated with public health communications during the COVID-19 pandemic are outlined.

II. METHODOLOGY

The interpretation and dissemination of big data through healthcare communication channels in the United States and the Nordic countries are investigated using qualitative research. In March and April of 2020, thirteen semi-structured interviews (lasting between 40 and 70 minutes) were conducted through snowball sampling as COVID-19 rapidly spread throughout the United States and the Nordics (Table 1 for detailed interviewee information). Sampling focused on the Nordics and the United States, the former of which is renowned for its population-wide public health data registries and the latter of which has the largest healthcare industry in the world. In addition, nearly 60 percent of all healthcare research and development in high-income countries (such as the Nordics and the United States) is funded primarily by for-profit and privately funded organizations [4]. Thus, the study focused on communication-responsible professionals in the United States and the Nordic region who work for publicly traded healthcare and life science research multinational corporations.

TABLE I.
 INTERVIEWEE BACKGROUND INFORMATION

Code	Job Title	Industry	Business Area	Geography	Seniority (years in the healthcare industry)	Education
I-1	Senior Business Insights Analyst	Pharmaceuticals	Business intelligence	Nordics	4	Chemistry (B.Sc. and M.Sc.)
I-2	Communications Specialist	Healthcare data analytics	Internal communications	The U.S.	4	Strategic Communications (B.A.) Healthcare Communications (M.A.)
I-3	Senior Business Analyst	Healthcare data analytics	Data communications	The U.S.	4	Communications (B.A.)
I-4	Director of Real-World Evidence	Pharmaceuticals	Medical affairs Public affairs	Nordics	13	Sociology (B.A.) Nursing (B.Sc.) Epidemiology (Ph.D.)
I-5	Head of Communications and Public Affairs	Pharmaceuticals	Public relations Product communications Internal communications Public affairs	Nordics	11	Economics (B.Sc.) Media and Communications (Certificate)
I-6	Director of Product Communications	Pharmaceuticals	Product communications Internal communications Public relations	The U.S.	20	History (B.A.) M.B.A.
I-7	Product Manager	Biotechnology and medical devices	Product development	The U.S.	12	Cognitive Science (B.Sc.) M.B.A.
I-8	Medical Advisor	Pharmaceuticals	Medical affairs Population health research	Nordics	13	Chemistry (B.Sc.) Neuropharmacology (Ph.D.)
I-9	Senior Business Analyst	Healthcare data analytics	Data communications	The U.S.	4	Human Resources (B.A.)
I-10	Head of Communications and Public Affairs	Pharmaceuticals	Internal communications Public relations	Nordics	14	English (B.A., and M.A.)

I-11	Brand and Communications Manager	Biotechnology and medical devices	Internal communications Public relations Corporate social responsibility Brand	Nordics	1	Language Studies (B.A.) Executive Communication Management (Certificate)
I-12	Vice President of Communications	Pharmaceuticals	Internal communications Public relations Corporate social responsibility Patient advocacy	The U.S.	23	Education (B.A.) Public Relations Management (Certificate)
I-13	Head of Communications	Biotechnology and medical devices	Internal communications Public relations	Nordics	1	Communications (B.A.)

III. RESULTS

The findings revealed three core elements unique to communication in the healthcare industry - that were exacerbated during the COVID-19 crisis: (1) big data, (2) the context and requirements within the business environment to process and utilize the big data, and subsequently (3) the communication development process itself.

A. The Big Data

Interviewees from the Nordic region reported that the majority of the data in their studies come from patient health registers, electronic medical records, and pharmacy registries. They emphasized that access to the register, quality of data, and quantity of data within the registries varies across each Nordic country. Interviewees based in the U.S. primarily cited data derived from health insurance claims as the foundation of communications.

I-4.1: “The data that we use primarily in the Nordics is from the national healthcare registers. We have prescription drug registers, cancer registers, and patient registers. You name it, and there is probably a register for that. We pool together data of millions of patient lives.”

I-3.1: “The data we were looking at was based off of employees' [health insurance] claims. Based on their [medical] history. We would say this is what we know, and then we used predictive modeling to predict what would happen in a year. That’s how we would tell the story of the population’s health.”

Regardless of the data source, the processing and preparation of the data were extremely thorough and extensive processes in both the Nordics and the U.S. designed to ensure that data is applicable, accurate, and prepared appropriately.

Interviewees also provided examples of instances in which big data was deemed unuseful for their communication needs. Data were either incomplete, there were concerns about the accuracy or integrity of the data, or it was considered irrelevant to the target audience.

I-1.1: “Going back to data accuracy or data gaps. Sometimes I don’t have everything. Sometimes I have to go back to the business and say that with the data we have, this is missing...I have to account for gaps and communicate that to the business. I have to be clear on how much data we have and how much we don’t have. Whereas in terms of “bad data.”

I-3.2: “This is the health of your employees on your insurance. You have multiple women having children; you should look at a women’s health program that we offer. You have high diabetes in your population. You should consider this program.”

Interviewees said that in some circumstances, the big data itself was accurate, but the data experts had concerns about the accuracy of the algorithms or the tools used to interpret the data. Any concerns were immediately flagged and discussed before moving forward in the communication development process. Interviewees attributed this sensitivity to data veracity as distinct within the healthcare industry, where scientific accuracy is critical. Any possibility that communication would jeopardize the company’s credibility meant the project was put on pause until they had the right data, or the communication development stopped altogether.

B. The Business Environment

Interviewees emphasized business environment requirements, including (i) establishing how the communication itself supports business objectives and strategic priorities of the organization; (ii) ensuring that the message can be communicated within the confines of international regulatory and legal parameters; and (iii) collaborating effectively with internal stakeholders. Interviewees said, determining the data generation, collection, and incorporation into the communication is secondary to ensuring the business aim is clear and well established. The communication must be aligned to the overarching product or brand strategy associated with the multinational corporation.

I-1.2: *“The goal is to answer the business question. Everything communications do is aligned to the overall strategy of the products and the corporation.”*

I-4.2: *“[The aim] always comes from internally within the business, and then we think how do we collect this data? How do we translate this data and help the business?”*

The communication objective was frequently focused on informing internal and external stakeholders about findings from scientific studies or status updates on product development, regulatory approvals, as well as the initiation of applications for approvals. Interviewees said public relations and internal organizational communications objectives are often focused on demonstrating company progress and the success of the company’s strategy.

I-5.1: *“Frequently, the marketing communications aim is to communicate the product portfolio, while the public relations’ aim is to promote and safeguard the company brand.”*

Interviewees engaged and reached their audiences effectively while also maintaining compliance and minimizing legal or reputational risks by following international regulatory protocols and adapting communications to geographic markets.

I-8.1: *“There is a rule in Europe where we can’t communicate pharmaceutical products to patients. If they have a question, they can contact us, and we can answer it, but we don’t do any proactive or direct consumer marketing communication. We can market it to clinicians and healthcare professionals, but only after the drug is approved. Once the drug is prescribed, you can give the patient a leaflet that has instructions on how to take medicine. It can only be informative, though. No claims about efficacy or anything.”*

The interviewees described specific legal parameters and protocols concerning each country for communicating health information. In the Nordics, communicators must account for the regulations in each country if there is more than one audience. Whereas in the U.S., each state had similar legal parameters and thus did not require significant communication changes before distribution. Amending the communication per each country's requirements was a highly time-consuming process and delayed distribution. Another factor that slowed the dissemination of key messages was the internal approval process among various business unit stakeholders. Interviewees from both regions provided examples of multiple stakeholders involved in the communication development process, which resulted in a time-consuming iterative drafting process.

C. The Process of Developing Communications

Health-related big data was utilized to achieve messaging goals by (i) describing, (ii) diagnosing, (iii) predicting, or (iv) recommending action. Interviewees explained how data could *describe* product efficacy to provide a health safety message to the public.

I-6.1: *“I worked on a ten-year clinical trial that had 25,000 patients, and what they were looking at was, is [product name redacted] safe to take for patients with cardiovascular disease? This was a landmark study and very high profile. The New York Times, the Wall Street Journal, all the network television stations... getting the message out there that the drug is [product name redacted] is safe. That was exciting. That was helping people. They don’t have to worry if my blood pressure is going to go up. Am I going to have a heart attack if I take this? There’s a lot of health information we can offer through clinical trial data in our product communications.”*

Additionally, interviewees *described* the health of a particular patient population to provide *recommendations* for addressing the audience's immediate health concerns (I-3.2). Finally, interviewees *diagnosed* causal relationships between life science market factors to explain market phenomena, subsequently leading to communications aimed at providing forecasts or *predictions*.

I-1.3: *“Often, we use data from market research to understand gaps and areas we don’t understand. In business intelligence, you collect a lot of information on our performance, how we are tracking ourselves, but then how our competitors are performing and what is happening in the market. You need to understand the data so we can track where we are and position ourselves for the future. We use the data to help stakeholders internally make business decisions.”*

Message development was dependent on how well the communications professional understood the data. Interviewees cited ways to improve the process by building strong relationships with data science experts to strengthen their translation process and communicate the meaning and information derived from the data more accurately.

Building effective communications also demanded audience analysis, which involved a highly complex ecosystem of stakeholders for healthcare communicators. The audience's communication needs must be understood to tailor the message to best reach them. Demographic information, such as geographic region (e.g., language and intercultural communication norms), level of education, and experience within the healthcare field, were often utilized to create customized communications. For example, the communication needed to be adapted depending on whether it was directed to hospital clinicians or patients. Customization allowed for the bifurcation of each audience to communicate more directly.

IV. DISCUSSION

The study revealed that the primary factors hindering effective communications centered around (1) big data, (2) environment, and (3) the communication development process. These areas also clarified risks for public health communication, particularly in the context of COVID-19. Additionally, the study's comparative design allowed for the identification of similarities and differences between the multinational healthcare companies' U.S. and Nordic countries' communication approaches.

Interviewees indicated that a challenge unique to communicating health-related big data was the preparation and processing of the data itself. The time-intensive process of gathering, analyzing, and utilization of data was cited as one reason for the delayed distribution of critical health information. The drafting of communication could not begin if the dataset, and data source, did not adhere to a high standard of accuracy. Interviewees referred to high volumes of low-quality data and low volumes of high variety data as bad data, missing data, or data gaps.

I-3.3: *“One of the challenges is communicating when the data is bad. You can have all this data, but if we pulled the wrong data or the numbers are wrong, you cannot present that. We can't jeopardize our credibility. The communication after that is telling the medical director or the account executive, “We're sorry the information does not look correct. You can't present this”. Communicating when and why the data is bad. The data they have might not work with our algorithms, or maybe the data is coming from too many vendors, or a company switched insurers, and we don't have access to those medical claims. Incomplete, incorrect data or jeopardizing the statistical significance of this data was a big challenge.”*

I-1.4: *“Depending on whom I am giving the information will help me decide how I am going to frame the information for them. I need to think about how they will read this information because they will be the ones using it later on. If the data is going to finance, I may leave part of it in Excel or the raw numbers because they will understand it. But if it is going to sales and commercials, I would translate using graphics and visuals and add comments explaining the trends and clearly describe this is what is driving this outcome.”*

The risk posed by this data-related challenge was that communicating incorrect or misleading information derived from low veracity data could result in distributing misinformation and possibly jeopardize the credibility, reputation, and scientific integrity of the organization.

Another distinct challenge was the broad range of audiences and stakeholders. Interviewees explained that they critically assessed their audience to guide their decisions around how to frame the information (I-1.3). Shared examples addressed this challenge by using standardized communications templates or uniform approaches to communicate with each audience and expediting the communication development process. Ultimately this was considered ineffective because each audience had different communication needs.

I-3.4: *“It was hard because we had a standardized template that we thought we could use for each employer. But then we realized that each population is different. Sometimes they would want to focus on different things.”*

In the communications drafting process, interviewees emphasized that the hardest part was customizing the messaging and translating data into an accessible language to the target audience without oversimplifying. Communicating health data requires the preservation of accuracy in the data, results, or findings when distilling the information's complexity into clear and comprehensible terms.

I-5.2: *“Crucial thing here when we communicate something externally to a wider audience, we need to align with those third parties or our partners. At the same time, the company is very cautious to communicate too much about our clinical program, so if I read their guidelines very carefully, we can only*

talk about data when there is a publication sitting in the public domain. That is super safe. But when it comes to intentional communication, everyone gets reluctant or hesitant... When I use the press channels, I try to simplify data as much as I can. Often when we get press releases from global, they are quite lengthy. Of course, I need to stay consistent, but locally there are different traditions or expectations for how the press release should be. The local media outlets demand something different. I try to adopt it and make it as short as possible and adapt it as much as possible.”

When simplifying information derived from data, interviewees explained that they provided context to limit potential misinformation by offering guidelines and definitions. Internal collaboration between communicators and scientists or data experts was a strategic tool [5], yet it could lead to a time-intensive iterative drafting process only to prevent agile information communication. A major challenge differentiated between the U.S. and the Nordics was the legal and regulatory parameters communicators must follow within their respective geographic areas. Interviewees acknowledged the necessity of these regulatory measures as important consumer protections; however, the laws around health data communication vary extensively from country to country.

I-12.1: *“We are a data-driven industry and a highly regulated industry. There are a lot of parameters that govern how we can talk and when we can talk. [...] It advances the business because we are sharing credible, accurate, scientific information. The challenge with scientific information is that it is a point of time data. It can try to predict the future, but it is not always predictive of the future. Data is about what we know now. Tomorrow could be different.”*

Interviewees who had communication responsibilities across the Nordics faced different challenges than those who communicated across various states in the U.S. since Nordic data was specific—often more prohibitive—to a particular country. Data sources and regulations in the Nordics resulted in studies with procedures, restrictions, requirements, and regulations unique to each country.

I-1.5: *“I work across all four [Nordic] countries for immunology, and they are all so different. If I am short on data for Norway, I can't use data from Sweden and apply it to Norway because the markets are so different. The data is very specific to the country. There are also so many regulations for the collection of market research data in each country. For example, in Sweden, if you're asking a doctor or testing your message, you can compare your drug to a competitor drug. But in Denmark, you are not allowed to know who is sponsoring the study.”*

Interviewees explained that the strength of the patient registries was that they were available in each Nordic country, and the registers account for all patients in the healthcare system. In contrast, most of the population health data in the U.S. was tied to health insurance claims data restricted to specific age groups (e.g., Medicare, a government health insurance program for people aged 65 or older), income groups (e.g., Medicaid, a government health insurance program for people with limited income), or members of private insurance plans [6]. This meant that the data was not representative of the whole population. Thus, the health outcomes for those without insurance claims data, presumably in a lower socioeconomic segment of the population, were unknown. Scientists risked inequality and generalizability as the data represents the higher-income population in the U.S.

Interviewees indicated that the healthcare communication development process in the U.S. and the Nordics were similar. There was consensus acknowledging the need for regulations aiming to safeguard consumers from predatory or harmful marketing. However, interviewees collectively agreed that these regulations could also prevent communicators from being agile and reaching wider audiences at a faster pace. Furthermore, the primary driving factor for communicators in both regions was ensuring communications aligned with business objectives and publishing all research results in line with scientific transparency.

I-6.2: *“In order to do this job, you really need to spend a lot of time understanding the science even if you aren't a scientist.”*

Particularly in a pandemic, when the need for reliable information was global, its awareness became critical. Communication challenges in healthcare magnified risks in communications related to COVID-19 because they limited the timely distribution of relevant critical information. In a pandemic, speed and accuracy were essential.

V. CONCLUSIONS

The challenges involved in healthcare communications were exacerbated by COVID-19. Recognizing these challenges in communicating health information also meant that there were opportunities to address

unmet medical needs in society and deliver critically important health care information worldwide. Communications could function as a mechanism for solving public health crises.

Interviewees maintained information accuracy and data integrity in the translation and simplification process through education and training about the subject matter to bridge the knowledge gap between scientists and communicators. To work in healthcare communication, understanding the science, despite not being a formally trained scientist, was a core requirement (I-6.1). Not only do the communicators need to expand their core skill set, but also the technical data practitioners must develop their communication acumen. As communicators faced an abundance of new data and a lack of familiarity with the information, this could subsequently delay the communication development process as a whole.

I-1.6: *“The technical people don’t always have the soft skills to communicate effectively. Companies really need to invest in people development and offer training courses in this area. When you come into a role that demands both technical and soft skills, it is difficult... It’s probably one of the best things I’ve done. It was a 3-day course.”*

I-13.1: *“Right now, we are running a speaker coaching program for 17 of our key opinion leaders, so really scientific people, and helping them tell stories. This is their big concern. They say, “I don’t want to be a storyteller. I want to be a scientist.” But I say, “I want your science into this story.” There is a conflict there. It is not simple. You need to get curious and say, “What is it about this data that thrills these scientists? Why did this expert fall in love with this data?” You can get to that emotion, and that helps drive the story. You can find a gem of a story that way.”*

The healthcare sector was intricately rooted in the legislative, regulatory, and political arena, so the policy implications were significant. The better healthcare companies could leverage their data to communicate with lawmakers, the more likely they would be to collaborate more effectively and advance R&D priorities in regulatory scenarios. As one of the core tenants of big data was velocity, data accumulated and grew at a rapid speed, allowing public health professionals to derive meaningful information from data faster than ever before, which then could be delivered to lawmakers to improve patient outcomes and health care systems. In the context of COVID-19, with uncountable numbers of cases and deaths, speed was more necessary than ever before.

Global public healthcare demands a worldwide approach to healthcare communications. The combination of regulatory diversity and a variety of data sources around the world hindered the possibility of establishing a global healthcare system that communicated simultaneously, accurately, and timely relevant information across countries. Despite these challenges, there were ways to reduce the risks involved in communicating healthcare data. Policy-makers need to understand the country and regional regulatory requirements that could enhance the speed and quality of the distributed information, target communications specifically to diverse audiences, and address the healthcare stakeholders. In response to the World Health Organization’s dual crisis of addressing an infodemic accompanying a pandemic, different practices in developing healthcare communication that led to misinformation need to be identified and eliminated to establish a successful unified global public health response.

DATA AVAILABILITY STATEMENT

The interview data that support the delivered findings – together with the implemented semi-structured interview guide - is to be made available open access [DOI:10.5281/zenodo.6344804] following the publication of this research.

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Corporate Big Data Analytics Capabilities and Performance Relationship: A Research for Turkey

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Abstract— Since the announcement of big data technologies, expectations from big data are high, but many companies have not reached the full potential of big data. This research aims to reveal how company resources should be organized in order to provide the expected benefits from big data in its tenth year. The resources required for big data are examined in three main dimensions: tangible resources (data, technology, basic resources), human resources (technical skills and managerial skills), and organizational capabilities (organizational learning, data-driven culture, structured practices, relational practices, and methodical practices). The suitability of the survey conducted with big data experts from 107 companies in Turkey to the model designed with the Partial Least Squares Structural Equation Model (PLS-SEM) was tested. As a result of the research, whether the data used is suitable for big data analytics and the right technology selection, as well as the technical and management skills of big data analytics employees and managers, and the importance of the company's trust in data were emphasized. Apart from technical resources, the research reveals the importance of human resources and organizational capabilities.

Keywords— big data, big data analytics capabilities, firm performance, resource-based theory, organizational capabilities

I. INTRODUCTION

Along with technological changes, the way firms compete has also changed [1]. Today, data has become more valuable than ever, and to create a competitive advantage from the data, companies have started to obtain and use data from external sources in addition to their own internal data [2]–[4]. With the increasing importance of data, companies have turned to information technology (IT) to gain competitive advantage [5]. This shift has increased the importance of big data as a result of the increase in data volume, diversity and speed [6].

Big data deals with, stores, analyzes and visualizes data types that previous technologies were difficult to handle; big data provides answers to the issues that previous systems could not investigate, enabling businesses to respond quickly to changes [7], [8]. Thanks to big data, unstructured and semi-structured data from internal and external sources and insight about customers and markets are developed [9], [10] and new business opportunities and transformation for companies are created. Therefore, sophisticated big data analysis (BDA) tools are needed to understand the relationships and underlying meanings within the data. BDA are techniques, technologies, systems, practices, methodologies and practices that analyze critical business data to better understand an organization's business [11], [12]. BDA is a holistic approach to manage, process and analyze big data that differs from other datasets [13], [14] in terms of its volume [15], speed, variety [16], validity [7], expected value [17], variable meanings in different contexts and visualization in a user-understandable way through interpretation [11].

The use of BDA is important for the development of capabilities such as Internet of Things, Artificial Intelligence, cyber physical system, cloud computing and manufacturing, digital twin, 5G [18], [11], [12]. BDA supports companies in processes such as logistics optimization, instant stock tracking, customer needs analysis, demand forecasting, and new product development [19]. It tries to prevent human errors caused by simplification of human affairs and lack of information [20]. Thanks to BDA, companies can obtain more information about their customers from external data which they cannot produce; therefore, they can pass on more insights about current trends and the future [21]. BDA is transforming how information exchanges and extracts value from data between and within companies [6], [22], [23]. Unfortunately, it is not always possible to use BDA correctly. Although it has been ten years since big data came to the fore

and its applications started to be used; today, 15-40% of companies said that they can provide the benefits they want from big data applications [24]. In a study conducted in the financial sector, 29% said they derive sufficient business value from big data [25], [26]. The low success rates indicate that there is a problem in BVA applications. This raises new questions about whether and how big data contributes to value creation and competitive advantages, and what factors influence or determine the effects of big data. The application perspective of big data through rigorous academic research and theorization is still evolving. To date, many researchers have examined the advantages of BVA in relation to firm performance.

In this study, which resources companies should develop in order to obtain the desired benefits from big data analytics are investigated. Within this scope, the relationship between the resource-based view (RBV) and the firm's big data analytics capabilities (BDAC) and firm performance is examined. In order to investigate the relationship between BDAC and firm performance, a three-level model was developed based on the existing literature; BDAC is considered in three different dimensions in the model. Tangible resources [21], [27]–[30] refer to the resources that the firm can purchase, outsource; human resources [21], [27]–[30] refers to the technical and managerial capabilities of the company in the stages of procurement, processing, analysis and distribution of big data; organizational resources deals with the company's trust in data [21], [27]–[30], internal data ownership, internal information flow, organizational learning level [28], [29]. The model tested with PLS-SEM. The study was conducted in Turkey, a developing country. The fact that the current literature mostly focuses on developing countries has led the developing countries to use BDA effectively to compete with big data.

II. CONCEPT AND THEORETICAL BACKGROUND

A. Big Data and Creating Value

According to Gupta & George [27], who emphasize the effect of BDA on performance and what companies should focus on to increase it, and the high failure rates of big data applications with conceptual and empirical researches, the necessary resources for the effective use of BDA into three dimensions; tangible resources (data, technology, basic resources), human resources (technical and managerial skills), and intangible resources (data-driven culture, organizational learning). Thus, Gupta & George [27] formed the basis for subsequent studies. As in the reference [28], the BDAC model is adapted to the dynamic capabilities view and expanded the literature. It is found that the same BDAC has a positive relationship with the view of dynamic talents and performance innovation. It also pointed out the moderating influence of environmental factors such as dynamism, heterogeneity and hostility on the link between BDAC and innovation [29]. Wamba et al. [31] extended the research streams by examining the direct effects of BDA capabilities on firm performance, as well as the mediating effects of process-oriented dynamic capabilities on the relationship between BDA capabilities and firm performance. Mikalef et al. [30] explained the competitive performance by using the BDAC structure developed by Gupta & George. Surbakti et al. [32] investigated the impact of traditional Information Technology (IT) resources on the effective use of BDA. Yasmin et al. [20] investigated IT dependency and the impact of these capabilities on firm performance using an integrated multi-criteria decision-making methodology. Utilizing three different multiple criteria decision-making tools, which are Intuitionistic Fuzzy Decision-Making Trial and Evaluation Laboratory (IF-DEMATEL), analytical network process (ANP) and simple additive weighting (SAW), the relative importance of BDA capabilities and their relationship to firm performance are evaluated [20]. Rialti et al. [33], on the other hand, proposed a model investigating whether organizational versatility and agility mediate the relationship between BDAC and performance, and tested the model with the view of dynamic capabilities.

B. Big Data Analytics Capabilities and Theory

Most BDA investments show that organizations are getting started or deploying BDA tools before they are ready [27]. Therefore, organizations cannot provide the benefits they expect from BVA tools, in order to prevent this situation, companies should review their own resources before starting to use BDA applications. BDAC refers to the organizational capabilities that enable the operational planning, decision-making and execution at all stages from the acquisition of the data to the analyzes extracted from the data [34]; in this way, institutions can create value by gaining insight from data [35]. Within the scope of this study, BDA capabilities are divided into three different subheadings based on the existing literature; tangible resources, human resources and organizational resources. The proposed model is shown in Figure 1.

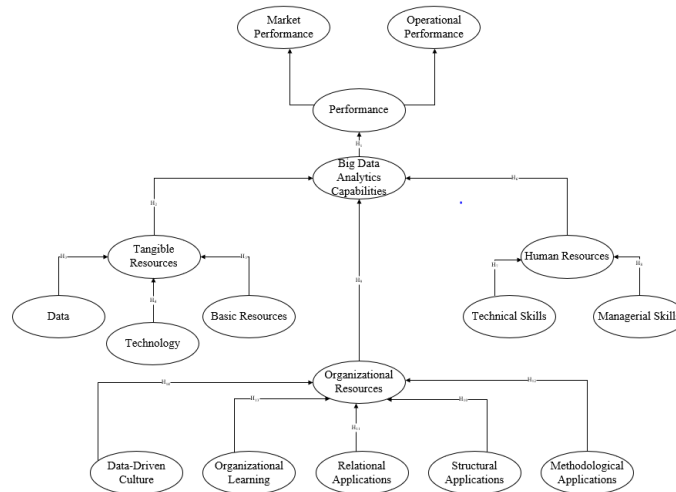


FIGURE 1
 HIERARCHICAL MODEL [27]–[29].

H1: Big data analytics capabilities are positively related to firm performance.

Tangible Resources: According to RBV, tangible resources are resources that can be bought or sold. Tangible resources for IT and big data consist of data, technology and basic resources. Data can come from internal and external sources. It is necessary to provide the necessary data in accordance with the BDA [27], [36]. Before starting BDA studies, the company should research the technologies required for BDA, receive the necessary training on how to use these technologies, and adapt to the technologies [27], [37]. Basic resources such as time [38] and finance [39] should also be provided in order to provide the necessary resources for the effective use of BDA [27], [37].

H2: Tangible resources are positively related to big data analytics.

H3: Data is positively related to tangible resources.

H4: Technology is positively related to tangible resources.

H5: Basic Resources are positively related to tangible resources.

Human Resources: An organization's human resources consist of the experience, knowledge, business acumen, problem-solving skills, leadership qualities and relationships of its employees [40]. IT research divides human resources into technical skills and management skills [41], [42]. Similarly, for big data, human resources are important and require big data-specific capabilities. Big data analysts need to have technical skills such as statistical analysis, machine learning to understand their problems, as well as familiar skills such as problem-solving skills and communication [43]. Organizations can develop technical skills by recruiting or training existing employees. Management skills, on the other hand, are company-specific and are developed over time by individuals working in the same organization. These skills are developed as a result of strong interpersonal bonds between organizational members working in the same (or different) departments. It is the ability of BDA experts and managers to understand and interpret the needs of departments, BDA's requirements and outputs [27], [39].

H6: Human resources are positively related to big data analytics.

H7: Technical skills are positively related to human resources.

H8: Managerial skills are positively related to human resources.

Organizational Resources: While some argue that organizational culture covers almost all areas of an organization, others have defined it as the glue that holds an organization together [44]. It defines key IT and non-IT decision makers and their corresponding roles and responsibilities when it comes to structured applications, data ownership, value analysis and cost management. It includes procedures for setting policies and standards at the stages of data protection and use [28], [45]. Relational applications, on the other hand, are about informal relationships within and outside the company. They include knowledge sharing, education and training, and strategic planning practices and tools [28], [46]. Organizational learning refers to the speed with which the institution acquires and adapts to new information [27]. Data-driven culture expresses the confidence that companies have in data and whether they use data actively in decision making [27], [47], [48]. Methodical applications are part of data management within the organization; it relates to activities involving data transfer, data storage, cost of data, analytical procedures and access rights [28].

- H₉: Organizational resources are positively related to big data analytics.
- H₁₀: Structural applications are positively related to corporate resources.
- H₁₁: Relational applications are positively related to corporate resources.
- H₁₂: Methodological applications are positively related to institutional resources.
- H₁₃: Organizational learning is positively related to institutional resources.
- H₁₄: Data-driven culture is positively related to corporate resources.

Firm Performance: To test the BDAC model, performance is divided into two different dimensions as market and operational performance. Firm performance is measured in such a way as to allow a firm to outperform its competitors [27], [49], [50]. Only their own achievements may be insufficient in measuring the performance of firms; at the same time, the performance gains/decreases of the firms against their competitors are also included in the evaluation [49], [51]–[53].

III. METHODOLOGY AND DATA COLLECTION

In the study, SMART PLS (Partial Least Squares) program was used for SEM. The reason for using SMART PLS is that it allows working with more than 50 variables more easily, while also allowing a smaller sample size. Also, normality is not a prerequisite in PLS-SEM studies. The main goal of using SMART PLS software as a tool for structural equation modeling is to maximize the disclosed variance of internal latent structures known as dependent variables. SMART PLS is an implicit variable modeling technique that includes multiple dependent structures and clearly recognizes measurement error [54], [55].

Regarding PLS, a number of analyzes need to be performed. This includes reflective measurement model analysis, formative measurement model analysis, and structural model analysis. PLS-SEM is based on a non-parametric resampling procedure to test the coefficients for their significance. In resampling procedure, called bootstrap, sub-samples larger than the original sample are taken in replacement, that is, when a random observation is selected from the population; are placed back into the population before the next observation is selected. Therefore, the observation was always taken from a population containing the same elements. A high number of resampling samples is preferred; the minimum number of resampling samples is at least equal to the number of valid observations in the dataset. The bootstrap size must have at least the total number of valid cases in the dataset. Hair et al. [56] suggested a sample size of 5000 resampling as a rule of thumb [55].

In the research, the questionnaire that data collected with was prepared with a 5-point Likert scale and the average was calculated by dividing the participants' agree or disagreement rates by the number of participants. A total of 118 people from different companies were reached for the survey. The target audience for the questionnaire is experienced senior and middle level managers who have taken part in BDA projects in Turkey. For this reason, the survey results of 11 people who stated that they did not have big data experience were excluded from the analysis, and the analysis continued with the answers of the remaining 107 people. All of the results were explained out of 107 answers. 18% of the respondents have a BDA experience of 1 year. 70% of them have BVA experience between 1-3 years, while 12% of them have BDA experience between 4-6 years. In the study, no specific sector restrictions were made, and the opinions of BDA managers from various sectors were taken.

IV. MODEL VALIDITY

Factor analysis was carried out with the rule of preserving the characteristics of the model; since, the factor weights should be above 0.7 in the first loading, the weights of the observed variables were calculated in order to maintain the factor loadings of 0.60 in the confirmatory factor analysis, and the variables with the square of the factor weight below 0.50 was excluded from the study. After the variables were removed one by one, factor analysis was performed again, and it was tested whether the new factor weights met the desired conditions. By removing the variables from the model, the multicollinearity problem was solved. Variance Increasing Factor (VIF) values of the variables removed from the model are all greater than 5.

The variance increasing factor (VIF) is used to understand the multicollinearity between dependent and independent variables. VIF values below 5 indicate that there is no multicollinearity, and an acceptable multicollinearity problem occurs when VIF is below 10 [54], [57]. VIF values of the model are all below than 5 in the last case as of the removal of the variables.

Before starting the study, reliability tests were applied to latent variables in order to confirm the accuracy of the questionnaire. One of the most frequently applied reliability analyzes, Cronbach's Alpha value between 0.6 and 0.7 is considered suspicious, between 0.7 and 0.8 is acceptable, and between 0.8 and 0.9 is considered good. Values of 0.9 and above are defined as perfect [58]. Since the Cronbach Alpha value is based on the correlation between the variables, a value above 0.90 is also desired because it indicates a high correlation [55]. Table 1 shows the reliability analyzes applied to the implicit variables of

BDAC and performance criteria. According to Cronbach's Alpha calculation, the variable D (Data) is doubtful, all other variables are at an acceptable level.

TABLE VIII
 THE RELIABILITY OF BIG DATA ANALYTICS CAPABILITIES

Latent Variables	Cronbach's Alpha	CR	AVE
Relational Applications	0,766	0,871	0,774
Market Performance	0,819	0,879	0,609
Operational Performance	0,879	0,926	0,806
Organizational Learning	0,833	0,922	0,855
Organizational Performance	0,879	0,926	0,806
Technology	0,808	0,876	0,640
Technical Skills	0,846	0,898	0,688
Basic Resources	0,881	0,944	0,893
Data	0,692	0,839	0,724
Data-Driven Culture	0,834	0,891	0,674
Managerial Skills	0,866	0,903	0,654
Structural Applications	0,736	0,875	0,779
Methodological Applications	0,842	0,869	0,797

For goodness of fit, Composite Reliability (CR) was applied. CR gives the level of explanation of a construct by the variable that composes it. The CR value can vary between 0 and 1. A CR value above 0.80 indicates the fit of the model [55]. As can be seen in Table 1, the CR values of the latent variables are over 0.80.

It is investigated whether the factors have a high correlation with each other with the Average Variance Extracted (AVE). The AVE value ranges from 0 to 1. It has been stated in the literature that the AVE value should be greater than 0.5 [54] but using the AVE value alone is not sufficient. AVE value should be lower when compared to CR [55]. The Human Resources variable remained below 0.50, but it was not excluded from the analysis because the variable was important for the analysis. All criteria meet the condition that the AVE value is less than the CR value.

The Fornell - Larcker Criterion is a frequently used analysis in SEM analysis for discriminant validity, it shows the correlation of latent variables among themselves. The highest values of the relevant column should be found along the diagonal where the latent variables intersect. The square root of each latent variable's AVE should be smaller than its correlation with any other variable. The largest value on the diagonal shows the relations and separations of the factors with each other [59], [60]. Cross Loadings is an analysis related to discriminant validity like Fornell-Lacker Criterion. The largest value of each observed variable should belong to its own latent variable [56]. Since the values belonging to the latent variables of the variables themselves are the largest values of the rows in which they are found in the result, the discriminant validity of the model can be mentioned.

As can be seen in Figure 2, there is a positive relationship between the firm performance and BDAC. BDAC explains for 71% of the performance improvement. BDAC has a positive effect on both market performance MP ($\beta = 0.92$, $p < 0.001$) and operational performance OP ($\beta = 0.926$, $p < 0.001$). The model explains 84% of the MP variance and 85% of the OP variance.

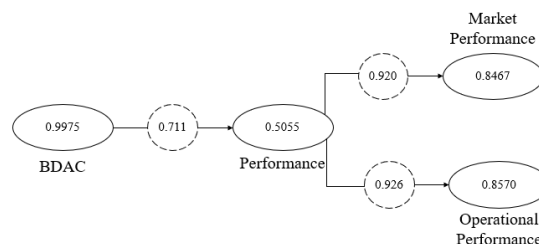


FIGURE 2

BIG DATA ANALYTICS CAPABILITIES – PERFORMANCE RELATIONSHIP.

Then, the factor weights of the 1st level variables to the 2nd level variables in the model were examined; the weights of data ($\beta = 0.271$, $p < 0.001$), technology ($\beta = 0.512$, $p < 0.001$) and basic resources ($\beta = 0.322$, $p < 0.001$) over tangible resources; the weights of technical skills ($\beta = 0.592$, $p < 0.001$), managerial skills ($\beta = 0.61$, $p < 0.001$) on human resources; the weights of methodological applications ($\beta = 0.073$, $p <$

0.001), relational applications ($\beta = 0.116$, $p < 0.001$), organizational learning ($\beta = 0.19$, $p < 0.001$), data-driven culture ($\beta = 0.404$, $p < 0.001$), structural applications ($\beta = 0.392$, $p < 0.001$) on organizational resources were calculated. It was observed that the effects of structural practices ($H4 = 0.073$), relational practices ($H4 = 0.116$) and organizational learning ($H4 = 0.190$) on BDAC were low. For the significance level of 0.05, t-test results were accepted for all hypotheses. ($t > 1.96$) [55].

TABLE IXI
 THE EFFECTS OF BIG DATA ANALYTICS CAPABILITIES ON PERFORMANCE

Variables	BDAC	Performance	Market Performance	Operational Performance
Human Resources	0,3094	0,2200	0,2024	0,2036
Technical Skills	0,1787	0,1271	0,1169	0,1176
Managerial Skills	0,1888	0,1343	0,1236	0,1243
Tangible Resources	0,4092	0,2909	0,2677	0,2693
Data	0,1111	0,0790	0,0727	0,0731
Technology	0,2094	0,1489	0,1370	0,1378
Basic Resources	0,1318	0,0937	0,0862	0,0867
Organizational Resources	0,4468	0,3884	0,3574	0,3596
Organizational Learning	0,0850	0,0604	0,0556	0,0559
Data-Driven Culture	0,1801	0,1280	0,1178	0,1185
Relational Applications	0,0519	0,0369	0,0340	0,0342
Methodological Applications	0,1751	0,1245	0,1145	0,1152
Structural Applications	0,0325	0,0231	0,0213	0,0214

V. DISCUSSION AND RESULTS

Gupta and George attributed the reason for the failure of big data to reach its potential is that research and applications focus on technical features of BVA and move away from theoretical and organizational elements [27]. While Gupta and George emphasized the function of IT to fulfill the daily functions of organizations, they stated that big data requires a culture based on trust in data in organizations [27]. From this perspective, big data has a different structure from IT and must have different resources from other IT resources [27]. The BDAC model designed with RBV by Gupta and George [27], and developed by Mikalef et al. [28] aim to reveal which resources are important to increase the impact of BDA on performance.

In order to understand the effect of BDAC on firm performance, a SEM was used with Smart PLS, and the suitability of the data obtained from the survey conducted with 107 BDA managers in firms in Turkey was tested for the model. The study emphasized the importance of various non-technical resources as well as technical resources such as data and technology required to create BDAC. This study also tests the validity of the model while listing the BDAC of the sources evaluated in three groups.

It tries to enlighten BDA executives who misconception that creating value from big data is not only about investing, collecting chunks of data, having appropriate and advanced technology, but also having usability [61]. It has been tried to emphasize the technical and managerial skills specific to big data, the importance given to organizational learning, the value given to the information obtained from the data, and the importance of an organizational culture that acts accordingly [62]. Organizational learning and data-oriented culture, which are actually a part of corporate culture, which are intangible resources in the literature, are classified as institutional resources [27]. Besides, unlike the literature; the effect of the company's internal functioning on big data analytics was investigated under three different levels of corporate resources, namely relational, structural and methodological applications [28], [37]. It is the sum of all these resources that will create a firm-specific big data capability. The findings of the study are important sources for value creation from BDA.

The most influential factors in the creation of BDAC that will affect the performance increase of the firm are the technology used, the skills of BDA management and the data-driven culture developed by the firm (Table II). Firms' research, evaluation and use of BDA technologies play an important role in the performance increase to be obtained from big data. Choosing the right technology significantly affects the effective use of BDA, but this alone is not enough to create business value from big data. Organizations using similar technologies may have different benefits from BDA. This indicates that BDA has not only technical but also organizational and human aspects [27]. BDA management has a great responsibility to increase gains from BDA; BDA is not limited to IT only and they need to understand the needs of other departments within the organization properly. Accordingly, the necessary resources for BDA should be created and/or arranged.

Along with the choice of technology, big data analysts must have technology mastery in the application of technology. In order to create business value from BDA, big data analysts must have the necessary training and sufficient experience in BDA. Compliance of the content of the data with the purpose of the BDA project, establishing procedures for storing, organizing, organizing, classifying the data within the institution and monitoring the costs contribute to the provision of BDA.

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Designing a Roadmap for Corporates to Manage Effectively In-House Ideas with an Intrapreneurship Structuring

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Abstract— Changing macroeconomic conditions, the need for sustainable growth, increasing costs, the widespread adoption of new technologies in business life, and the transformation of customer consumption habits are pushing companies to renew their business models and strategies. In today's fast-paced world where competition is deepening, commercializing innovation has become a necessity to maintain growth and differentiation. However, it does not seem possible to bring entrepreneurial innovative success to companies with traditional methods. The missing piece in companies is “entrepreneurship”. Designing entrepreneurship programs in institutions or taking steps to support entrepreneurial cultures within the institution is important for the innovation to work, but they cannot create the expected impact on their own. At this point, the commercialization of entrepreneurship gains great importance. Now, only 64% of companies with a corporate entrepreneurship program have commercialized ideas. In this study, a model was designed to manage the corporate entrepreneurship process in four steps.

Keywords— Innovation, business model, corporate entrepreneurship, roadmap

I. INTRODUCTION

Changing macroeconomic conditions, the need for sustainable growth, increasing costs, the widespread adoption of new technologies in business life, and the transformation of customer consumption habits are pushing companies to renew their business models and strategies. In today's fast-paced world where competition is deepening, commercializing innovation has become a necessity to maintain growth and differentiation.

However, it does not seem possible to bring entrepreneurial innovative success to companies with traditional methods. The missing piece in companies is “entrepreneurship”. Institutions can realize innovation only by bringing entrepreneurial methods into the company (internal entrepreneurship). In today's world, instilling entrepreneurship in organizations has created a sustainable competitive advantage. Designing entrepreneurship programs in institutions or taking steps to support entrepreneurial cultures within the institution is important for the innovation to work, but they cannot create the expected impact on their own. At this point, the commercialization of entrepreneurship gains great importance. Now, only 64% of companies with a corporate entrepreneurship program have commercialized ideas.

In the literature study, there are lots of studies about innovation. In this study, literature studying was narrowed under the business model innovation, intrapreneurship, and strategic management. A systematic review of the literature and gap analysis, surveys, business canvases, and statistical approaches are remarkable when the methodologies are investigated. One of the good examples of surveys is Nadia A. Abdelmegeed etc. studies in 2022 [1]. This study's aim is to determine employee satisfaction, intrapreneurship, and firm growth among managers in Pakistan. One of the conclusions of the study is pay and incentives may encourage intrapreneurship among managers of Pakistani businesses. The results also show that their happiness might be fostered by a supportive company culture, which would motivate them to enhance their intrapreneurship performance.

Achieving sustainable growth and creating a competitive advantage in companies are among the priority targets. For this, a systematic approach is needed that allows the end-to-end innovation processes from idea to product to run quickly and effectively. On the other hand, every company needs a topic set that includes projects that fit both company strategies and priorities as well as global and industry trends. A successful innovation structure is needed to manage these issues efficiently within the company.

Innovation is defined as all the processes followed to bring a new or improved product, service, or a different working method in terms of efficiency. In order to avoid unnecessary loss of resources, companies should define why they need innovation under their vision, mission, and strategy. Afterward, the identified pain points will be a starting point for innovation volunteers within the company to innovate. The senior management will be positioned in the company as an innovation sponsor/investor during the process.

In this study, concepts of innovation and strategy are investigated. The link between these two concepts was highlighted and finally, a roadmap that companies can follow independently of their sector and size was designed.

II. DEFINITION OF INNOVATION

Innovation, which has become imperative in order to achieve differentiation and sustain growth in today's rapidly changing, competitive environment, is defined in the OECD Oslo Guidelines as "the realization of a new or significantly improved product (good or service), process, new marketing management or a new organizational method [2],[3].

Recent research highlights that it is an indispensable success criterion for companies to constantly seek innovation and innovation in order to differentiate themselves from the competition. In 2017, 86% of respondents to Accenture's survey of 5,400 senior executives in 31 countries said that in order to maintain a competitive edge, companies need to focus on innovation with increasing momentum [2].

As a result of the comparative research conducted by the Stanford Research Institute in the USA on the enterprises that can hardly survive and the enterprises that develop at a fast pace, it has been seen that the enterprises that are open to innovation and change have a faster development curve and are the leaders of their sectors. This research innovation; reveals its role in growth, development, survival, providing an advantage in competition, and even being a leader.

Innovation in institutions; It offers advantages such as increasing productivity, providing superiority in competition, eliminating the imbalance of payments, developing social responsibility awareness, gaining a loyal customer base, institutionalization, and branding [4],[5].

A. Four Types of Innovation

There are four models of innovation activities: "product, process, marketing, and organizational" as defined in the Oslo Guide.

- 1) **Product and Service Innovation:** in this type of innovation, innovations related to the requirements of the customer emerge. You can acquire an idea as product innovation, convert it into a new or developed product, method, or service, introduce a new product to the market or new technologies used for production
- 2) **Process Innovation:** process innovation refers to a new or advanced, way of producing or delivering a product or service. Process innovations, reduce unit production or delivery costs, improve quality, or produce new or significantly improved products
- 3) **Marketing Innovation:** It is defined as the development and use of different, different, and new designs, packaging, and marketing methods in product design or packaging, product positioning, product promotion, or pricing in order to increase the sales of companies, to respond to customer needs in a better way and to shift customers to new markets or new positions, or to improve existing ones.
- 4) **Organizational Innovation:** Organizational innovation is the application of a new organizational method in the firm's business practices, workplace organization, or external relationships [6]. Organizational innovations can be predicted to improve firm performance by reducing administrative and transaction costs, improving workplace satisfaction, gaining access to non-commercial assets, or reducing the cost of equipment [3].

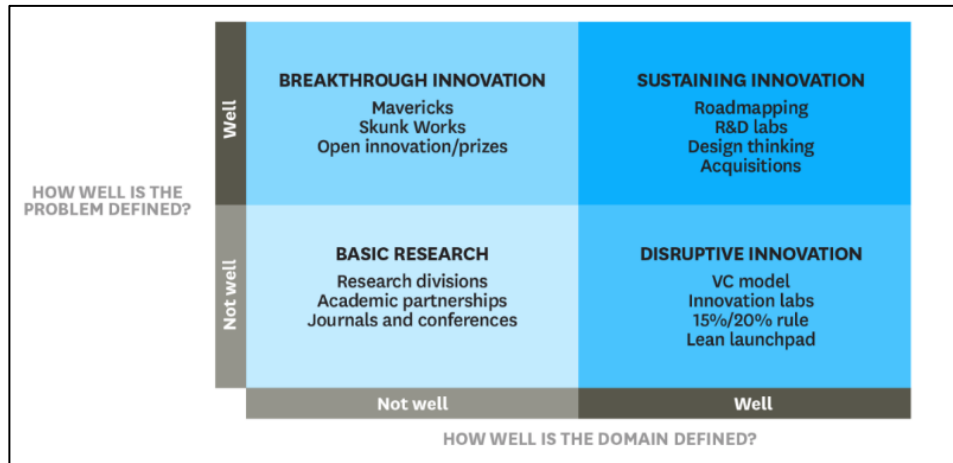


FIGURE 1

FOUR TYPES OF INNOVATION MODELS DESCRIBED BY GREG SATELL

B. Strategic Innovation

An organization's strategic planning can incorporate innovative thinking to generate new opportunities and improve market performance. The establishment of growth plans, new product categories, services, or business models that transform the market and produce significant new value for clients, customers, and the organization is referred to as strategic innovation. Strategic innovation follows a different path; it pushes an organization to think outside of its pre-existing professional bounds and to imagine possibilities in a free-thinking, innovative setting [7].

Intrapreneurship for Strategic Innovation

Global research shows that until 60 years ago, a company's length of time on the S&P 500 list was 61 years, but in 1995 it was down to 29, and in 2017 it was down to 22 years. On the other hand, a study by Deloitte shows that 88% of the companies on the Fortune 500 list in 1955 did not exist as of 2015 [8]. These companies have disappeared through some mergers and acquisitions, and most of them have gone bankrupt. Although it is not possible to reset the ratio new management tools are needed to reduce it.

Especially with the proliferation of companies doing similar jobs in recent years and the increase in competition related to this, it can be said that "differentiation" is an indispensable perspective for companies. The subject of differentiation is a very full concept. Differentiation is one of the most important issues of 'Strategic Management and has a very important place in strategic positioning.

In order for institutions to differentiate, the most important method chosen by companies in recent times is innovation. Although the subject of innovation has become a management tool and culture in the world's largest companies.

Intrapreneurship is a model equipped with the basic perspective of entrepreneurship. The in-house entrepreneur, just like the entrepreneur, has innovative, new opportunities and high return dreams. The in-house entrepreneur does not mean that the institution that implements its idea by taking start-up or investment or establishing its own company, but the institution where it works while working an institution invests.

This management model, which has come to life especially when the institution knows its goals and strategies and produces ideas for this and the corporate management invests in this idea, has recently started to be used by many companies, especially in the global arena. According to some research, we can say that there are results that 28% of multinational companies will develop policies that encourage internal entrepreneurship and will support the establishment of the necessary structures and systems for this.

III. METHODOLOGY AND THE ROADMAP

A real case study is a reference to conceptualize and design the roadmap. This real case is Yenyle. Yenyle is the first successfully commercialized project of the Kastamonu Entegre Intrapreneurship Program, and now it is three years old. Lots of models and methodologies have been tested both in the market and company with Yenyle for three years. Thus, with the help of these insights, the roadmap that corporates can follow to manage in-house ideas under the Intrapreneurship Program was designed.

To understand and measure the effectiveness of the roadmap, a survey will be useful. This survey will design by a Likert scale. The targeted survey participants will be innovation experts, regardless of gender and age. 250 people are expected to participate in the survey. Afterward, the results will be evaluated and interpreted on SPSS.

The innovation aims that change the corporate culture to be more open and prepared for world trends and market needs. It should not be forgotten that C-level managers, departments, and employees are linked to each other in the company. Building an innovation system in the company should consider and include all the components. Here are the commercialization roadmap steps of an idea.

- 1) As a first step is determining the Topic Set. The company should know why they need innovation. It is critically important that the needs of the institution are clearly and transparently clear in corporate in-house innovation.
- 2) The second step is gathering and filtering the ideas in the company. Providing appropriate idea collecting and evaluation system should need a professional software program within the company.
- 3) The third step is testing the filtered ideas in the market. In this step, the main purpose is to measure the quality of the idea for the market. If the idea can touch the pain point of the market, then it can start its commercializing process.
- 4) The final step is managing the commercializing process of the Minimum Valuable Product (MVP). In this step MVP business model is determined and the success is analysed by calculating the profit.

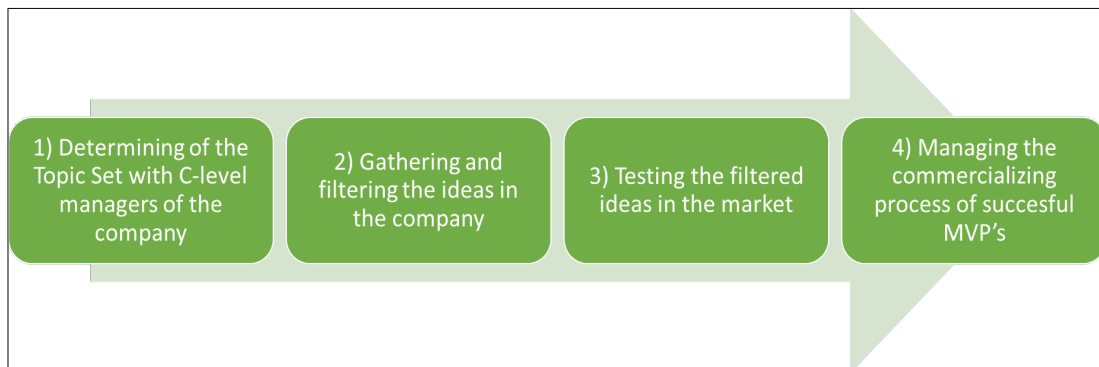


FIGURE 2

DESIGNING ROADMAP FROM IDEA TO COMMERCIALIZATION

IV. CONCLUSION

Intrapreneurship is an important management tool not only for institutions that want to pursue differentiation strategies but also for those who want to be strong in competition and make a difference in terms of efficiency and profitability. It should also be known that intrapreneurship plays an important role in the realization of strategic goals, retention of talent, and innovation management.

In conclusion, intrapreneurship is a strategic management tool that will provide a competitive advantage. Managers should be aware that Intrapreneurship will use it as a talent management tool in order to attract

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talented employees to the company or not to lose employees with innovative ideas. Managers should allocate necessary budgets for intrapreneurship and establish appropriate structures and systems. Managers should make an effort to make it a management culture, not as a temporary project or just an "idea-gathering theatre".

Successful business or entrepreneurial ideas should be rewarded and exhibit the necessary attitudes and behaviors to encourage creative thinking. Unsuccessful innovative ideas or works should not be criticized but should be considered as an experience for further studies. Managers should focus on the training and development activities required for the development of innovative and creative thinking competencies of the employees.

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E-Ticaret İşletmelerinde Sipariş İşleme Problemleri için Depo Otomasyon Çözümleri ve Bir Vaka Çalışması

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Özet— Bilgi teknolojileri geliştikçe perakendeciliğin doğasını değiştirmeye devam etmektedir. Dijitalleşmenin yayılması ve lojistik süreçlerin geliştirilmesi ile günümüzde ticaret, konumdan bağımsız hale gelmiştir. Böylece, e-ticaret sektörü bu küreselleşen sistemde önemli fırsatlar sunmaktadır. Son yıllarda e-ticaretin bu denli artış göstermesinin en önemli sebepleri arasında covid 19 pandemisi ve sosyal medya etkisi gösterilebilir. E-ticaret işletmeleri için stok dışı kalma ile tüketicilerin işletmeye sadakati arasında negatif korelasyon bulunmaktadır. Zamanında teslimatlar ve kişiselleştirilmiş hizmetlerin sağlanması, tüketici memnuniyeti ve sadakati üzerinde oldukça önemli bir etkiye sahiptir. İşletmelerin, çevrimiçi perakende satışlarında sipariş işlemlerinin tüm aşamalarında müşterilerinin beklentilerini karşılamaları ve hatta aşmaları gerekmektedir. E-ticaret işletmeleri müşteri hizmetlerini en üst seviyelere taşıyabilmek için çevrimiçi mağazalarında ürün çeşitliliğini mümkün olan en geniş yelpazede tutmak istemektedir. Ancak depolama sürecine gelindiğinde ürün çeşitliliğinin artırılması birçok sipariş işleme problemini beraberinde getirmektedir. İşletmeler günümüzde daha çok ürünü daha kısa sürede ve daha az çalışanla sevkiyata hazırlamak istemektedir. Bu problemin çözümü ise teknoloji yatırımında saklıdır. Bu çalışmada e-ticaret işletmeleri için depo otomasyonuna geçişte hangi teknolojilerin kullanımının uygun olduğuna nasıl karar verildiği araştırılmıştır. Otomatik depo ekipmanları üreten bir işletme ile çalışılarak, bir e-ticaret işletmesinin depo otomasyon süreci vaka analizi yöntemiyle incelenmiştir.

Anahtar Sözcükler— Otomatik depo sistemleri, depo otomasyon ekipmanları, sipariş işleme optimizasyonu, sipariş toplama, depolama, lojistik 4.0

I. GİRİŞ

E-ticarete her geçen gün eklenen yeniliklerle alışveriş deneyimi yeni bir boyut kazanırken dijital mükemmeliyet işletmeler için kaçınılmaz bir gereklilik haline gelmiştir. Dijital kanalların iş süreçlerine entegre edilmesiyle işletmeler fark yaratmak için hızlı ve güvenilir e-ticaret çözümlerine ihtiyaç duymaktadır [1]. Covid 19 pandemisinin başladığı ilk günlerde tüketiciler panik satın alma davranışı gösterdiler. Temel gıda maddeleri ve hijyen ürünleri satış noktalarında tükendi ve bir süre siparişler teslim edilemedi. Zamanla sokağa çıkma yasakları, karantinalar, kısıtlamalar ve tam kapanmalar da yaşanınca internet alışverişi en güvenli seçenek haline geldi. Böylece e-ticaret şimdiye kadar görmediği bir artış gösterdi [2]. E-ticaret işletmelerinin web sitelerinin sipariş işleme vaatlerine uymaması çevrimiçi satışlarına zarar vermektedir. Perakendeciler, web sitelerinde çok çeşitli ürün kategorileri sunarken, müşteri taleplerini tatmin etmek için daha yüksek envanter maliyetleri arasında bir karar noktası ile karşı karşıya kalmaktadır [3]. E-ticaret web siteleri geniş ürün çeşitliliği sağlamalı, siparişlerini doğru bir şekilde yerine getirmeli, olabildiğince çabuk ürünleri teslim etmeli ve makul bir zaman dilimi içinde tüketici taleplerine mümkün olduğunca duyarlı olmalıdır [4].

II. DEPOLAMA FAALİYETLERİNİN TEDARİK ZİNCİRİ İÇERİSİNDEKİ ÖNEMİ

Tedarik zincirinde; ürünlerin hammadde kaynağından son tüketicilere ulaştırılmasına kadar olan süreçteki tedarik ağının içerisinde, fiziksel akışı sağlayan birçok ara elaman bulunmaktadır. Bu ara elemanlar çoğunlukla ürünlerin yoğunlaştığı noktalarda bulunan depolama alanlarıdır. Maliyetler açısından bakıldığında, ürünler depoda beklerken değeri artmadığı gibi, depolama maliyetlerini arttırarak ürün kârlılığını olumsuz yönde etkiler. İşletmeler bu yüzden stoklarını minimize ederek depolama maliyetlerini düşük seviyelerde tutmak isterler [5]. Diğer yandan pazarlama dünyasındaki gelişmeler, ürün yaşam döngülerinin kısalmasına ve yüksek hacimlerde üretimden ürün çeşitliliği artırılmış küçük hacimlerde

üretime geçiş yapılmasına yol açmıştır. E-ticaret ve çok kanallı dağıtımların da etkisiyle, lojistikte daha da hızlanabilmek için süreçlerde otomasyona ihtiyaç artmaktadır [6].

A. Lojistik rekabette hız kazanmak için otomasyon

Depolama faaliyetleri denilince ilk olarak teslim alma, depolama, sipariş toplama ve sevkiyat akla gelmektedir [7]. Uygulama anlamında ise depolama, tedarik zincirinin kritik bileşenlerinden biri olarak müşteri hizmetleri üzerinde önemli bir etkiye sahiptir [8] [9] [10]. Küresel lojistik pazarında artan rekabet, talep belirsizliği, emek yoğun süreçlerde insan hatası potansiyeli ve endüstri 4.0'a artan ilgi nedeniyle, depolama şirketleri operasyonel performanslarını iyileştirmek, sistemlerini daha güvenilir ve verimli hale getirmek ve süreçlerini basitleştirmek için yeni teknolojilere ihtiyaç duymaktadır [11]. İşletmeler aynı zamanda, kamu bilincine yanıt vermek ve giderek artan sosyal sorumluluk sahibi bir dünyada rekabetçi kalabilmek için sürdürülebilir kalkınma uygulamalarını depolama stratejilerine dahil etmelidir [9] [12].

Otomasyon; bir süreç veya prosedürün insan yardımı olmadan gerçekleştirilmesini sağlayan teknoloji olarak tanımlanabilir. Bu tanım, genel bir tanımlama olmakla birlikte; otomasyon teknolojisinin insan yardımı ile birlikte kullanılabilmesi veya insan yardımı ile desteklenebileceği anlamına gelir [13]. Lojistik; taşımacılık, dağıtım, depolama ve envanter yönetimi ile iade sevkiyatı veya tersine lojistik gibi çeşitli işlevleri kapsamaktadır [14]. Son yıllarda ise endüstri 4.0 ile birlikte; siber fiziksel sistemler (CPS), nesnelerin interneti (IoT) ve diğer akıllı sistemler lojistiğe entegre olmuş ve yakın zamanda “Lojistik 4.0” (veya “akıllı lojistik”) terimi kullanılmaya başlamıştır [15]. Bu yeni teknolojiler, üretim ve lojistik firmalarına rekabet avantajı sağlamaları için fırsatlar sunmuştur. Literatürde çeşitli Lojistik 4.0 uygulamalarından bahsedilmektedir. Bu uygulamalar; depo yönetim sistemleri (WMS), malzeme akışlarının gerçek zamanlı takibi (otomatik kimlik teknolojisi, radyo frekansı tanımlama -RFID- etiketleri ve tarama cihazları aracılığıyla), otomatik ve kendi kendini kontrol eden malzeme işleme ve depolama (örneğin, yükleme, boşaltma ve toplama robotları, lazer güdümlü araçlar -LGV'ler-, otomatik kılavuzlu araçlar -AGV'ler-, otomatik depolama ve alma sistemleri -AS/RS'ler-, sesle yönlendirilen depolama -VDW- ve sınıflandırma konveyör sistemleri), otonom sipariş işleme, ürün dağıtımının gerçek zamanlı izlenmesi ve planlanması (ör. Akıllı ulaşım sistemleri -ITS- ve yükün konumunu ve ilgili verileri takip edebilen ve sürücülere en uygun rotayı önerebilen telematik kontrol ünitesi -TCU-) olarak sıralanabilir [16] [17] [18].

Otomasyonun rekabet üzerinde direkt etkisi olmakla birlikte, bir firmanın rekabetçi konumunu iyileştirmenin yanı sıra kötüleştirilebilir de [19]. Bu nedenle, olumlu bir etki sağlamak için doğru kullanılması son derece önemlidir. Bunu başarmak için, otomatik ekipmanın kullanılacağı ortamın gereksinimlerini ve gereksinimlere en uygun otomasyon düzeyini ve türünü bulmak önemlidir.

III. OTOMATİK DEPO SİSTEMLERİ

Depo yerleşimi; kullanılan alanın maliyeti ile elleçleme maliyetleri arasındaki optimal noktanın bulunarak toplam maliyetin düşürülmesini amaçlar [20]. Modern depo yönetiminde otomatik depolama ve boşaltma sistemleri kullanılır. Tipik bir depolama süreci, teslim alma, yerleştirme, depolama, ikmal ve sipariş toplama, sevkiyat ve geri dönüşlerin depolanması gibi standartlaştırılmış işlemlerin bir dizisidir [21] [22] [23]. Depolama süreçleri farklı depolama teknolojileri altında farklı şekillerde uygulanabilmektedir. Uygulanabilecek teknoloji türleri şu şekilde sıralanabilir: Düşük depolama teknolojileri (5.0-6.0 metreye kadar depolama yüksekliği ve geniş raf koridorları ile operasyonlar için çoğunlukla dengeli forkliftler kullanılarak), yüksek depolama teknolojileri (10.0 metreye kadar depolama yüksekliği ve geniş raf koridorları ile yük kaldırma/istifleme araçları kullanılarak), çok dar koridorlar (VNA) (VNA forkliftleri kullanılarak 12-15 metreye kadar depolama yüksekliği ve dar raf koridorları (yaklaşık 1.7-1.9 m) ile), otomatik depolama ve geri alma sistemleri (AS/RS) (Sınırsız depolama yüksekliği (depolanan malzemelerin yapısı elverdiğince) ve 1.4-1.5 metre koridor, istifleyici vinçleri kullanarak) [24].

IV. ARAŞTIRMA YÖNTEMİ VE UYGULAMA

Bu çalışmada e-ticaret işletmeleri depolarının otomasyona nasıl geçebileceğinin araştırılması hedeflenmiştir. Otomatik depolama ekipmanlarının hangilerinin hangi işletme için uygun olacağına karar vermede etkili olan faktörlerin belirlenmesi için bu alanda faaliyet gösteren bir işletme ile görüşmeler yapılmıştır. Derinlemesine görüşme yöntemiyle otomatik depolama ekipmanı türleri ve ekipman seçiminde önemli kriterler hakkında uzman görüşüne başvurulmuştur.

Çalışmanın yapıldığı dönemde döviz kurunun çok yüksek olması ve bu ekipmanların döviz endeksli fiyatlandırılması çalışmanın en büyük kısıtıdır. Döviz kurunun ani artışı sebebiyle ekipman fiyatları oldukça yükselmiş, bu durumun sonucu olarak otomasyon kararı ülkemizde faaliyet gösteren işletmeler

için oldukça maliyetli bir seçenek haline gelmiştir. Bu nedenle yurt dışında da faaliyet gösteren bir işletme seçilmiş ve yine yurt dışında faaliyet gösteren bir e-ticaret firması için otomatik depo ekipman seçimi incelenmiştir.

Uzman görüşüne başvurmak için farklı sektörlerden işletmelere depo otomasyon ekipmanları üreten bir firma seçilmiştir. Bu işletme, dinamik depolama ve geri alma sistemleri geliştiren, aynı zamanda entegre malzeme taşıma sistemleri ve otomatik yüksek bölmeli depolar hazırlayan bir üreticidir. 30'dan fazla ülkede yaklaşık 2.000 çalışanı bulunan firmanın Almanya'da iki, ABD'de ise bir adet üretim tesisi bulunmaktadır. Yapılan görüşmelerde e-ticaret işletmeleri için doğru depo otomasyon ekipmanlarının nasıl seçildiği hakkında bilgi alınmıştır.

Bir işletmenin otomatik depo kararı değerlendirilirken öncelikle işletmenin sipariş toplama stratejisi saptanmaktadır. En uygun sipariş toplama stratejisinin belirlenmesi için dikkate alınması gereken faktörler şu şekilde sıralanmıştır: sipariş profili, tek satırlık siparişlerin toplam siparişler içerisindeki yüzdesi, tesisteki malzeme akışı, siparişlerin sisteme nasıl ve ne zaman girildiği ve iş gücünün esnekliği. Ayrıca, durgun ve yoğun dönemler, sipariş toplama, konsolidasyon, paketleme ve nakliye alanları dahil olmak üzere tesisin fiziksel düzeni de oldukça önemlidir. Bir işletme için otomasyon ekipmanı kararlarında öncelikle işletmenin üç temel sipariş toplama stratejisinden hangisini uyguladığı belirlenmektedir. Bu stratejileri “seç ve geç”, “paralel toplama” ve “dalgalı toplama” şeklinde tanımlanmıştır.

Seç ve geç yönteminde sipariş için ürünler toplanarak bir yükleme noktasına getirilir. Burada ürünler siparişin toplanması ve daha sonrasında sevkiyata hazırlanması için manuel olarak ya da bir konveyör aracılığıyla bir sonraki bölgeye gönderilir.

Paralel toplama yönteminde ise siparişteki ürünler paralel olarak tüm bölgelerden toplanır. Kısmi siparişler, bir konsolidasyon alanına gönderilir ve sipariş için gereken parçaların geri kalanının gelişini bekler.

Dalgalı toplama yönteminde siparişler bağımsız bölgelerden toplanır ve bir konsolidasyon alanına gönderilir. Bu sipariş hatları daha sonra ayrı siparişlere birleştirilir ve paketleme ve nakliye gönderilir.

Yapılan görüşmelerde edinilen bilgilere göre işletmelerin sipariş işleme süreçlerini optimize edebilmeleri için atılması gereken adımlar şu şekilde sıralanabilir:

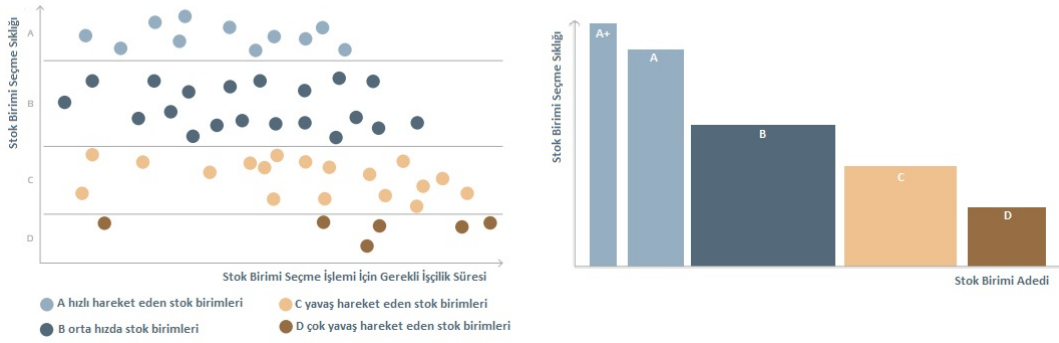
- Envanter birimlerinin tanımlanması
- Stok birimlerinin teknoloji ile eşleştirilmesi
- Sipariş işleme sürecinin kontrol edilmesi
- Envanterin sınıflandırılması
- Süreç haritalarının ve iş akışlarının çizilmesi
- Görünürlüğü en üst düzeye çıkarmak için sistemlerin entegre edilmesi

A. Vaka Analizi Çalışması (Bir e-ticaret işletmesi için uygun depo otomasyon ekipmanlarına karar verilmesi)

Görüşme yapılan işletme ile birlikte Avrupa'da faaliyet gösteren ve otomatik bir depo kurmak isteyen bir e-ticaret işletmesinin verileri incelenerek hangi otomatik depo ekipman türlerinin işletme için uygun olduğu tespit edilmeye çalışılmıştır. Öncelikle işletmenin sipariş işleme süreçleri incelenmiştir. İşletmenin deposuna parça siparişleri genellikle öğleden sonra gelmekte ve aynı gün sevkiyat gerçekleştirilmektedir. İşletmede dokuz işçi sadece altı saat içinde 1.200 siparişi tamamlamaya çalışmaktadır. İşçi sayısını arttırmak mümkün olmadığından, işletme ürünlerin depolandığı merkezde otomasyona geçmeye ve “seç ve geç” sipariş toplama yöntemini uygulamaya karar vermiştir. Aşağıdaki adımlarla işletmenin sipariş işleme süreçleri optimize edilmiştir.

1) Envanter birimlerinin tanımlanması

Bir tesisin envanterinin nasıl kategorize edilmesi gerektiği, ürün türleri, stokların hareket etme sıklığı ve hareket hızı gibi birçok faktöre bağlıdır. Çalışmada ele alınan e-ticaret işletmesinin stok biriminin çok sayıda olduğu ve stokların hareket hızının yüksek olduğu görülmüştür. Yine de tüm stoklar incelenerek hareket sıklıkları hızlı, orta, yavaş ve çok yavaş şeklinde belirlenmiş ve aynı kategorideki ürünlerin birlikte gruplandırılması uygun görülmüştür. Her bir stok birimini toplamak için gerekli olan süre ile stok birimi seçme sıklığını karşılaştırılarak bir maliyet grafiği oluşturulmuştur (Şekil 1).



ŞEKİL 1

ENVANTER BİRLERİNİN TANIMLANMASI

İşletmenin sipariş işleme faaliyetlerinin optimize edilmesinde en belirgin gelişmeler Pareto diyagramı aracılığıyla görülebilir (80/20 kuralı olarak da bilinir). Burada işletmenin deposundaki hareketlerin %80'inin envanterin %20'sinden (stok hareket hızı en yüksek envanter sınıfı) geldiği görülmektedir. Çoğu işletme optimizasyonu, hareket hızı en yüksek olan ve envanterinin %20'sini oluşturan envanter sınıfı üzerinde yoğunlaştırmaktadır. Ancak Pareto diyagramlarından da anlaşılacağı üzere; maliyet tasarrufu ve verimlilikteki en büyük kazanım, depolama alanının ve işgücü maliyetlerinin %80'nini oluşturan orta ve yavaş hareket eden envanter sınıfından olacaktır.

2) Stok birimlerinin teknoloji ile eşleştirilmesi

Birinci adım sonuçlandıktan sonra, stok birimlerinin boyut, ağırlık, sipariş büyüklüğü ve diğer farklı açılardan değişkenlik gösterdikleri açıkça görülmektedir. Her bir stok sınıfı, etkili elleçleme işlemleri gerçekleştirilebilmek için doğru teknoloji ile desteklenmelidir. Bu teknolojiler şunları içerir:

- Yatay karusel modülleri (HCMS), yatay olarak dönen oval bir palete monte edilmiş kutulardan oluşur. Bu sistemler, ürünü bir operatöre teslim ederek verimsiz taşıma ve arama süresini ortadan kaldırır.
- Dikey karusel modülleri (VCMS), bir pist etrafında dönen bir dizi raftan oluşan otomatik depolama ve geri alma sistemleridir. Depolanmış stok birimlerini ergonomik bir çalışma sayacına güvenli ve hızlı bir şekilde sunarak yürüyüş ve arama sürelerini ortadan kaldırır.
- Dikey Kaldırma Modülleri (VLMS) Bu kapalı sistem, merkezde bir inserter/ekstraktör bulunan iki tepsi sütunundan oluşur. Saklanan tepsiler otomatik olarak alınır ve bel yüksekliğinde bir pencerede operatöre teslim edilir, taşıma ve arama sürelerini ortadan kaldırır.
- Dikey tampon modülleri (VBMS), çok segmentli bir raf sistemidir. Ortasında, teleskopik bir tutucu olan hareketli bir direğin çalıştığı bir koridor vardır. Kontrol ünitesi, bir stok birimini seçer ve toplama istasyonuna taşımak üzere harekete geçer.

Yaptığımız görüşmelerde depolarında otomasyona gitmek isteyen işletmeler için hangi teknolojinin en iyisi olduğuna karar vermede; işçilik ayak izi, genişletilebilme potansiyeli, çıktı miktarı, verimlilik, tutarlılık, envanter kontrolü ve ergonomi gibi faktörlerin ele alındığını öğrendik. Edindiğimiz bilgileri bir tabloda birleştirerek ilgili faktörleri 1-5 arasında (5en yüksek olacak şekilde) puanlayarak hangi işletme için hangi teknolojinin en uygun olduğunu görebilmek amaçlı bir karar matrisi oluşturduk. Çalışma yürüttüğümüz e-ticaret işletmesi için çalışan ayak izinin azaltılması, operasyonlarda tutarlılığın artırılması ve işlemleri hızlandırmak amacıyla ergonominin geliştirilmesi en önemli kriterler olduğu için dikey kaldırma modüllerinin (VLM) en uygun otomatik ekipman türü olduğuna karar verilmiştir.

TABLO X
SAĞLADIĞI FAYDAYA GÖRE DEPOLAMA SİSTEMİ KARŞILAŞTIRMASI

Faydalar	Çekmece sistemi	Raf sistemi	Palet rafı	Ürün seçme modülü	HCM	VCM	VLM	VBM
Alan/Ayak izi	3	1	2	2	4	5	5	4
Çıktı	1	1	3	2	5	3	4	5
Verimlilik	1	1	1	2	5	3	4	5

Tutarlılık	2	2	3	2	5	4	5	5
Envanter Kontrolü	3	1	3	3	3	4	4	5
Ergonomi	1	1	1	2	4	5	5	5
Genişletilebilme	5	5	5	4	4	3	4	4

3) Sipariş işleme sürecinin kontrol edilmesi

Bu aşamaya kadar envanter birimleri tanımlanmış ve hangi teknoloji ile eşleştirileceğine karar verilmiş olduğu için kurulacak olan sistemi destekleyici teknolojilere karar verilmektedir. Destekleyici teknolojiler olarak yazılım yükseltme ya da gelişmiş barkod sistemi kurulması şeklinde olabilir. Karar verme noktasına ise cevaplanması gereken sorular şu şekilde belirlenebilir:

- Sipariş toplama işlemini hızlandırmak için hangi manuel adımlar kaldırılabilir?
- Stok birimleri nasıl daha hızlı teslim alınabilir ya da yerleştirilebilir?
- Stok birimleri ergonomik bir pozisyonda mı teslim alınmaktadır?
- Depolama alanlarından yeterince yararlanılmakta mıdır?
- Destekleyici yeni teknoloji eklenmesi operasyonlarda tutarlılığı artırabilir mi?

Örnek e-ticaret işletmesine barkod tarama sistemi, pick-to-light sistemi (ışıklı yönlendirme sistemi), envanter yönetim yazılımı ve bilgisayar destekli sipariş izleme sistemi kurulması önerilmiştir.

4) Envanterin sınıflandırılması

Envanterin sınıflandırılması işlemi, her bir stok birimini seçilen teknoloji içinde saklamak için en iyi yeri belirler. Sınıflandırma tipik olarak maksimum verimlilik ve depolama kapasitesine ulaşmayı amaçlar. Ortak hedefler Tablo 2’de sıralanmıştır.

TABLO XII
ENVANTER SINIFLANDIRMASININ AMAÇLARI

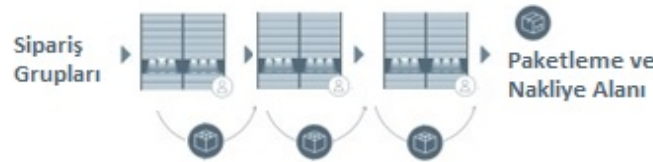
Alan kullanımının iyileştirilmesi	Operasyonlarda tutarlılığın geliştirilmesi
Stok birimlerinin elleçlenme süresinin en aza indirilmesi	Ergonominin geliştirilmesi
Verimliliğin artırılması	Stok birimlerinin depo içi taşıma süresinin en aza indirilmesi
İş akışının dengelenmesi	Arama süresinin azaltılması

Toplanan envanter verilerinin sınıflandırmasında dikkate alınacak hususlar şu şekilde belirlenmiştir:

- Stok birimlerini seçme yöntemi (örnek e-ticaret işletmesi “seç ve geç” yöntemini uygulayacaktır)
- Her bir stok birimi için kullanılacak palet, koli ya da kasa bilgileri
- Her bir stok biriminin siparişler için seçilme sıklığı
- Stok numaraları ve stok tanımları
- Stok birimlerinin siparişlerdeki adedi
- Sıklıkla birlikte seçilen stok birimleri
- Stok birimlerinin boyutları ve ağırlıkları
- Toplam stok sayıları, tekrar sipariş noktaları ve tekrar sipariş adetleri

5) Süreç haritalarının ve iş akışlarının çizilmesi

Bu aşamada envanter sınıflandırılması bitmiş bulunmaktadır. Bu noktada daha önceden belirlenmiş sipariş toplama yönteminin iş akışı çizilmelidir. Örnek çalışmamızda uygulanmasına karar verilen yöntem “seç ve geç” yöntemidir. İşletmenin depolama işlemleri incelenerek iş akışı şekil 2’de gösterilmiştir.



ŞEKİL 2

ÖRNEK İŞLETMENİN SİPARİŞ İŞLEME İŞ AKIŞ MODELİ

Bir sipariş için toplanan stok birimleri bir bölgeden bir toplama noktasına getirilmektedir. Toplama noktası, sipariş toplanıp, paketleme ve nakliye bölgesinde gönderilmeye hazır olana kadar bir konveyör tarafından veya manuel olarak bir sonraki bölgeye taşınmaktadır.

6) Görünürlüğü en üst düzeye çıkarmak için sistemlerin entegre edilmesi

Mümkün olduğunca, kurumsal kaynak planlaması (ERP), depo yönetim sistemleri (WMS), depo kontrol sistemleri (WCS) ve işgücü performans yönetimi (WPM) veya İşçi Yönetim Sistemleri (LMS) gibi iş sistemlerinin entegre edilmesi; sipariş toplama sürelerini ve envanter yönetimini daha kolay hale getirmektedir. Böylece, sipariş tamamlanma sürelerinin iyileştirilmesi ve tedarikçiler ve nakliyeciler de dahil olmak üzere kilit iş ortaklarına görünürlüğün artırılması sağlanabilmektedir. Ayrıca, bu entegrasyon sezonluk yükselişlerde ve satışların arttığı dönemlerde envanterde yeniden sınıflandırma yapmayı da kolaylaştırmaktadır. Entegre işletme çözümleri tüm sistemdeki verileri toplayarak tek bir rapor üzerinden takibinin yapılabilmesini sağlamaktadır.

V. SONUÇ VE ÖNERİLER

Sonuç olarak; sipariş işleme optimizasyonu sürecinin bir parçası olarak otomatik depolama ve geri alma sistemlerini uygulamaya sokarak, bir depo veya dağıtım merkezi, verimlilikte çok iyi kazançlar elde edebilir ve aynı zamanda müşteri siparişlerinin işlenmesi ile ilişkili maliyetleri de eşzamanlı olarak azaltabilir. Envanterin sınıflandırılması, tesis boyunca operasyonlardaki darboğazların elimine edilmesini de sağlayabilmektedir. Her ne kadar hızlı hareket kabiliyeti olan otomatik ekipmanları iş akışı alanı boyunca yerleştirmek iyi bir fikir gibi görünse de, pratikte zamanla tıkanıklıklar oluşabilir. Bu nedenle otomatik ekipmanları yalnızca daha çok çıktı almak amacıyla değil, aynı zamanda “ölü alanları” kullanışlı hale getirmek ve düşük faaliyet alanlarının performansını iyileştirmek için de uygulamaya geçirmek daha akıllıca olacaktır.

Örnek e-ticaret işletmesinde önerilen uygulamalar hayata geçirildiğinde depolama kapasitesinde %95, envanter sınıflandırma ve yerleştirme sistemindeki tutarlılık oranlarında ise %92 artış gerçekleşmesi beklenmektedir. İşletmenin deposunda 65 milyon dolar değerinde 46.000’den fazla ürün depolanmaktadır. Bu ürünler işletmenin çeşitli depo ve perakende müşterilerine gönderilmek üzere saklanmakta, elleçlenmekte ve sevkiyatı gerçekleştirilmektedir. İşletmeye, dört toplama bölgesinde konumlandırılmış 13 adet dikey kaldırma modülü (VLM) kurulması ve bu sistemlerin barkod tarama teknolojisi, pick-to-light sistemi, envanter yönetimi yazılımı ve bilgisayar destekli sipariş izleme sistemi ile desteklenmesi önerilmiştir.

Bu çalışma bir e-ticaret firmasını ele almaktadır. Ancak maliyet ile ilgili tüm konular çalışmanın kapsamı dışında tutulmuştur. Maliyet içerikli çalışmalarla konunun tüm boyutlarının ele alınması sağlanabilir. Alan çalışmaları, farklı faaliyet alanlarındaki işletmeler için depo otomasyon çözümlerinin incelenmesi ile zenginleştirilebilir. Ayrıca, depolarda mal kabul ve paketleme-sevkiyat alanlarında da otomasyon çözümleri ile tam otomatik depolara geçiş sağlanabilir. Bu alanlardaki çalışmalar da hem sektöre hem de literatüre geniş katkı sağlayacaktır. Son olarak lojistik 4.0 alanındaki diğer konularda da çalışmalar yapılması güncel konularda literatürün derinleştirilmesini sağlayacaktır.

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EGO-Driven Decision vs Strategy Audit Based Decision in the Case of International Crises

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Abstract— 88% of US executives say that strategy implementation is an important factor for their firms (Hobbs, 2015). But business leaders also make irrational, ad hoc decisions, instead of acting on a previously agreed, well-established strategy when a crisis occurs. Crises are frequently caused by external, mainly international, circumstances, such as lack of resources (e.g. gas, oil, raw materials, money) or highly significant events (including COVID 19, new regulations, climate change, war, etc). Without analysis of external factors, for example using PESTLE, there is no proper strategic planning. This is especially true if the company operates in the international market. Studies show that lack of implementation of a strategy can have different causes, such as a lack of a proper strategy planning process, or ego-driven behaviour running alongside strategy planning or implementation. Key ego players may not recognize their ego-driven behaviour or may deny, manipulate, modify or qualify organisational responses. Routine, political correctness, irrational media, or the fear that others will realise their weaknesses can blur leaders' views and discourage them from engaging in multi-step, fact-based strategic planning. Such triggers instead encourage ego-driven decisions. More recently, strategic audit is a key tool for building a well-established strategy. This management tool (and other similar approaches) helps organisations to prepare for a possible crisis situation in advance and excludes ego-driven decision-making. This paper reviews literature concerning strategic management, strategic audit, and barriers to following the strategic audit process arising from the personality of decision-makers.

Keywords— Ego, narcissism, hubris, fear, strategic thinking, strategic management, strategic audit

I. INTRODUCTION

In this extremely challenging world, there is a greater need for considered and planned decisions than ever before. Firms need to be highly adaptable in their management decision-making under conditions of radical change. It is time to refocus thinking about what strategic management (SM) consists of and to enable a more flexible and adaptable approach to the changing circumstances which presents tighter and more focused options. A challenge in SM is the high cost/high risk presented by high levels of uncertainty and the potentially exorbitant risk of mistakes. Companies allocate enormous resources to forecasting and strategic planning. It is not a one man show. In most organisations, a host of expert groups take part in the process. All-encompassing strategies, tactics, and action plans are developed to prepare for many possible scenarios. The risk of this process is that it considers possibilities in the future based on the information currently available. Therefore there is a need for an agile approach to SM, with frequent updates reflecting changing circumstances. There are situations that cannot be foreseen or do not have great significance at the present time. During the pandemic of the last two years, the changes in the status quo have been widespread, with far greater consequences than previously thought. Looking to the future, our current world with its disruptive environment is presenting many challenges for management, including for strategic decision-making under conditions of radical uncertainty and very rapid change.

Strategic planning and implementation is carried out by people. Human behaviour is therefore a key trigger for successful or unsuccessful strategy. This paper considers some of the factors and triggers at work when companies fail to follow previously decided strategy. Even following a complex strategic preparation process, decision-makers may decide to not follow the planned path at the point of making the decision. Another possibility is that decision-makers derail the process earlier while the planning is occurring. Literature has considered several personality factors that might negate the development or unfolding of a previously determined strategy. These factors have been variously called ego, narcissism, hubris, fear, and other terms. The paper therefore briefly discusses strategic thinking and strategic management and in particular the strategic audit, and then canvasses some negative personality styles and behaviours and how they can derail the predetermined plan.

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II. IMPORTANCE OF STRATEGIC THINKING IN THE CASE OF INTERNATIONAL CRISES - CLIMATE CHANGE

Climate change is playing a growing role in business decisions. More than half of the global executives surveyed by McKinsey & Company in 2008 selected “environmental issues, including climate change,” as the most important issue facing them over the next five years (Bonini, Hintz, & Mendonca, 2008). A 2005 survey of 27 large, publicly-held, multinational corporations based in North America revealed that 90% believed that government regulation was imminent and 67% believed that such regulation would be implemented between 2010 and 2015 (Hoffman, 2006). Eileen Claussen, President of the Pew Center on Global Climate Change noted a growing consensus amongst organisational leaders that climate change action will be a responsible decision. There are real risks and opportunities and companies must start planning for these although will lose ground to other competitors who are taking the issue more seriously. She noted: “Prudent steps taken now to address climate change can improve a company’s competitive position relative to its peers and earn it a seat at the table to influence climate policy. With more and more action at the state level and increasing scientific clarity, it is time for businesses to craft corporate strategies that address climate change” (cited in Hoffman, 2006). Porter et al. (2007) also assert that all companies need to consider their vulnerability to climate-related issues such as changes in the availability of water and energy, reliability issues concerning infrastructure and supply chains, and the threat of infectious diseases. Swiss Re, the world’s second-largest reinsurer, estimated that the overall economic costs of climate catastrophes related to climate change threatens to double to \$150 billion per year by 2014. The insurance industry’s share of this loss would be \$30–\$40 billion annually (Mills, 2005). The effects of climate change on industries and companies throughout the world can be grouped into six categories of risks: regulatory, supply chain, product and technology, litigation, reputational, and physical (Lash & Wellington, 2007). Although global warming remains a controversial topic, a convincing argument in favor of working toward environmental sustainability is a variation of Pascal’s work entitled ‘Wager on the Existence of God’: “The same goes for global warming. If you accept it as reality, adapting your strategy and practices, your plants will use less energy and emit fewer effluents. Your packaging will be more biodegradable, and your new products will be able to capture any markets created by severe weather effects. Yes, global warming might not be as damaging as some predict, and you might have invested more than you needed, but it’s just as Pascal said: Given all the possible outcomes, the upside of being ready and prepared for a “fearsome event” surely beats the alternative.” (Welch & Welch, 2007). In other words, it is best to be prepared.

III. STRATEGIC THINKING

There are many definitions of strategic thinking. Horwath (2008) defined strategic thinking as the process of generating and applying business insights on a continuous basis in order to accomplish a competitive advantage. This process should occur regularly as an integrated part of daily activities in an organization. Furthermore, Dionisio (2017) states that strategic thinking is “an essential component of strategy development, a mental, reflective and issue oriented process that has the purpose to develop new strategies and that may happen before, during or after strategic planning”. According to Bouhali, Mekdad, Lebsir, and Ferkha (2015), strategic thinking simply refers to “thinking about planning”. The concept of strategic thinking focuses on gaining competitive advantage as it seeks to set organizational goals for the longer term, develop and implement plans to accomplish these goals, and allocate needed resources to achieve these. Goldman, Scott, and Follman (2015) posited that strategic thinking has also been conceptualized in three major aspects; analytical techniques (coming up with new and creative strategies), mental processing (strategy formation through creative and critical thinking), and engaged behaviours (activities such as scanning, questioning, conceptualizing, and testing). This future oriented and outcome-based process involves other types of thinking or competencies including visionary thinking, systems thinking, contextual thinking, collaborative thinking, and visual thinking, as well as more specific activities such as data collection, analysis, debate and conversation about organizational governing conditions. Thus, strategic thinking through its continuous process of monitoring provides organizations with the means to create value and to achieve competitive advantage. In addition to strategic thinking, the strategic management process will require a planning component in order for it to be complete and meaningful (Asobee, 2021).

IV. STRATEGIC MANAGEMENT

Today what is certain is that everything is changing and nothing is certain, even for the short term. As Sharp (2020, p 11) commented recently in relation to developing programs for public services: ‘Nothing is clear, and everything keeps changing’ Well established status quos are no longer set in stone. We have seen war in Europe, substantial changes in standards of living, COVID 19, climate change, mass migration, resources depletion, and massive technological development. A well-designed strategy is more indispensable than ever. Strategic management, according to the Engineering Management Body of

Knowledge, is: “Utilising the tools and techniques to implement strategy and organising the efforts needed to quickly respond to a special event, before the formal planning/process recycles.” (Shah, 2018, p 78). The concept of strategic management has been greatly expanded over the last several decades. Thinking and acting strategically has become critically important in rapidly changing environments. Individuals, as well as organizations, are in a constant process of developing new and purposeful strategies to be more innovative, competitive and effective in the globalized world (Asobee, 2021). Strategic management is a set of managerial decisions and actions that determine the long-term performance of an organization. It includes environmental scanning (both external and internal), strategy formulation (strategic or long-range planning), strategy implementation, and evaluation and control. Originally called business policy, strategic management has advanced substantially through the concentrated efforts of researchers and practitioners. Today we recognise the application of strategic management techniques as being both a science and an art (Wheelen, Hunger, Hoffman, & Bamford, 2017). **Figure 1** (Adopted from Wheelen et al., 2017) lays out the steps in the phases from environmental scanning through to evaluation and control. It can be noted that there are several steps within the strategy formulation phase and the strategy implementation phase.

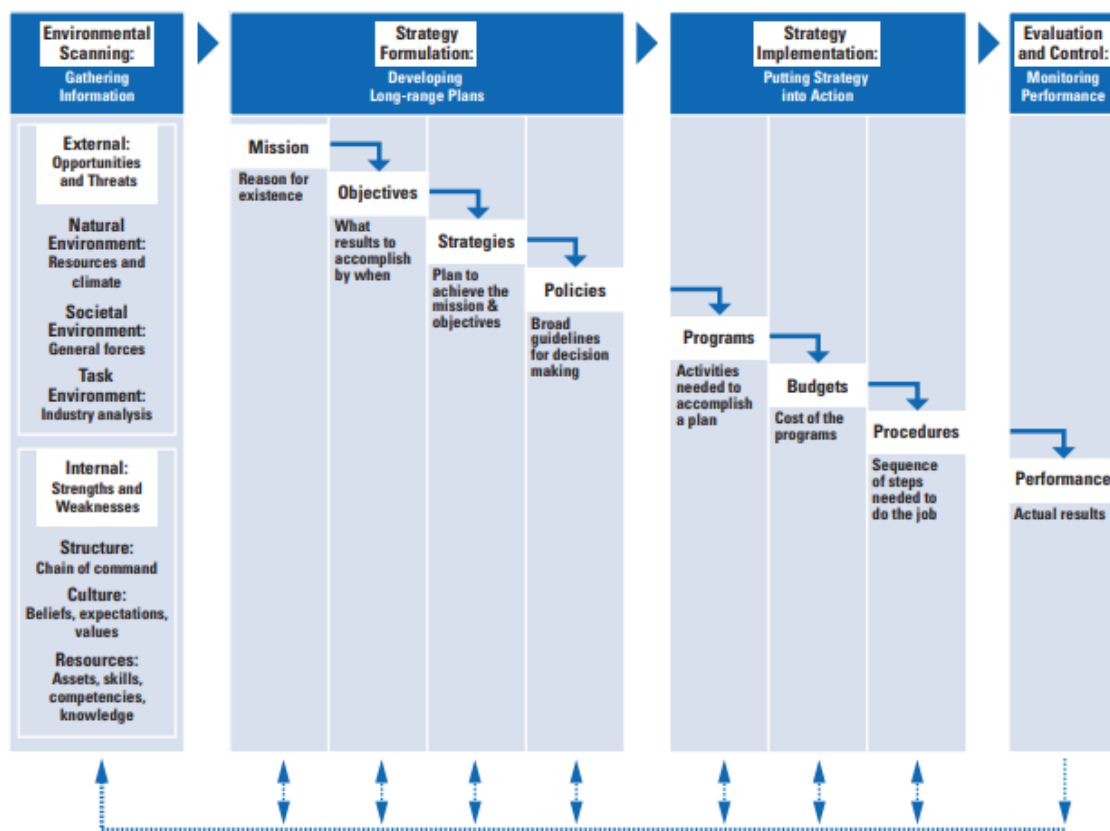


FIGURE 1

STRATEGIC MANAGEMENT MODEL

“Strategy” is a major concept of the contemporary era that has come to replace previous management activities such as “administration” or “planification.” The word strategy originated in the military domain and derives from the word “strategos” meaning “general” in Greek. Over time its meaning has evolved, and the term is now applied to other human activities, and especially to business strategies. One of the main problems for business strategists is gaining a comprehensive understanding of the competitive environment (Fuentes et al., 2020). SM scholars have begun the task of addressing important economic issues, such as how successful firms create difficult-to-imitate capabilities and entrain other technological and organizational resources that will enable them to innovate and to allocate assets more effectively than their rivals (Teecce, 2017). The field of strategic decision-making has evoked the development of several useful tools that can assist decision-makers to conceptualise plan and enact their chosen strategies. One of these is strategic audit, and this is discussed below.

V. STRATEGIC AUDIT

One effective means of putting the strategic decision-making process into action is through a technique known as the strategic audit. A strategic audit provides a checklist of questions, by area or issue, that enables a systematic analysis to be made of various corporate functions and activities. A strategic audit is a type of management audit that is extremely useful as a diagnostic tool for pinpointing corporate-wide problem areas and highlighting organizational strengths and weaknesses. A strategic audit can help determine why a certain area is creating problems for a corporation and can help generate solutions to problems. A strategic audit is not an all-inclusive list, but it asks many of the critical questions needed for a detailed strategic analysis of any business. Each question in a particular area of a strategic audit can be broken down into an additional series of sub-questions. An analyst can develop responses to these sub-questions when they are needed for a complete strategic analysis of a company (Wheelen et al., 2017).

Through the process of strategic audit, a board of directors can closely evaluate the job performance of the CEO and the top management team. The vast majority of American (91%), European (75%), and Asian (75%) boards review the CEO's performance using a formalized process (Mader et al., 2006). Objective evaluations of the CEO by the board are very important, given that CEOs tend to evaluate senior management's performance significantly more positively than do other executives. (Rosen & Adair, 2007). The board is concerned primarily with overall corporate profitability as measured quantitatively by ROI, ROE, EPS, and shareholder value. The absence of short-run profitability certainly can contribute to the firing of any CEO. The board, however, is also concerned with other factors. Members of the compensation committees of today's boards of directors generally agree that a CEO's ability to establish strategic direction, build a management team, and provide leadership are more critical in the long run than are a few quantitative measures. The board should evaluate top management not only on the typical output-oriented quantitative measures, but also on behavioral measures—factors relating to its strategic management practices. According to a survey by Korn/Ferry International, the criteria used by American boards to evaluate their CEO are as follows; financial (81%), ethical behavior (63%), thought leadership (58%), corporate reputation (32%), stock price performance (22%), and meeting participation (10%) (Mader et al., 2006). The specific items that a board uses to evaluate its top management should be derived from the objectives that both the board and top management have earlier agreed on. If better relations with the local community and improved safety practices in work areas were selected as objectives for the year (or for five years), these items should be included in the evaluation. In addition, other factors that tend to lead to profitability might be included, such as market share, product quality, or investment intensity. Performance evaluations of the overall board's performance are standard practice for 87% of directors in the Americas, 72% in Europe, and 62% in Asia. Evaluations of individual directors are less common. According to a PriceWaterhouseCoopers survey of 1,100 directors, 77% of the directors agreed that individual directors should be appraised regularly on their performance, but only 37% responded that they actually do such appraisals (Wheelen et al., 2017).

Even the most attractive alternative in terms of strategic direction might not be selected if it is contrary to the needs and desires of important top managers. Personal characteristics and experience can affect a person's assessment of an alternative's attractiveness. For example, one study found that narcissistic (self-absorbed and arrogant) CEOs favor bold actions that attract attention, such as large acquisitions, resulting in either big wins or big losses (Chatterjee & Hambrick, 2007). A person's ego may be tied to a particular proposal to the extent that they lobby strongly against all other alternatives. As a result, the person may have unfavorable forecasts altered so that they are more in agreement with the desired alternative. In a study by McKinsey & Company of over 2500 executives from around the world, (Garbuio, Lovallo, & Viguerie, 2007). 36% of respondents reported that managers hide, restrict, or misrepresent information at least "somewhat" frequently when submitting capital-investment proposals. In addition, an executive might influence other people in top management to favor a particular alternative so that objections to it are overruled. In the same McKinsey study of global executives, more than 60% of managers reported that business unit and divisional heads form alliances with peers or lobby someone more senior in the organization at least "somewhat" frequently when resource allocation decisions are being made (Wheelen et al., 2017).

VI. BARRIERS TO STRATEGIC DECISION MAKING: WHAT IS EGO?

The word ego has a long history. The English word ego is in fact the Latin word for "I". Ego theory was first presented by Freud (Freud, 1952). In Freud's theory, the ego represented a bridge between our primitive desires and the restrictions imposed by society. The ego is the only part of our personality which is conscious. The ego works out feasible ways of satisfying our demands. For some authors, ego or egoism is perceived in a negative way. An alternative way of viewing ego is that it is a necessary part of the human

condition and helps us to have the strength of our convictions; one could also think about experience-based intuition as a useful way of solving difficult dilemmas (Sinclair, 2020). However the question of the reality of our self-perceptions is still relevant. Collins (2007) posited five levels of leadership ranging from a person with individual skills who can make a productive contribution at the lowest level, through to a contributing team member, through to a competent manager with excellent management and organisational skills, through to effective leaders who can evoke commitment in pursuit of their clear vision, through to the highest level, 5. Level 5 leaders are the key to creating a great organisation through a combination of humility and determination. Rising to this level will require putting one's ego aside in pursuit of a greater goal.

VII. NARCISSISM IN DECISION-MAKING

One of the primary ways in which excessive ego expresses itself is through the trait of narcissism. Narcissism is a term associated with self-love, self-serving bias, and entitlement (Rohmann, Neumann, Herner, & Bierhoff, 2012). Narcissism means having a very elevated self-concept, out of kilter with reality. Narcissism and an unrealistic self-concept are predictors for anger, depression and verbal aggression following a threat to the ego (Stucke & Sporer, 2002). In fact, narcissism occurs along a spectrum (Krizan & Herlache, 2018). People who score high on narcissism and have a lack of clarity about the limits to their self-concept are more likely to react with anger and aggression following failure. As well as occurring on a spectrum, there are various types of narcissism and the type that is most associated with dysfunctional organisational behaviour is that of the grandiose narcissist. Grandiose narcissism is evident through admiration seeking, exhibitionism, aggression, dominance, entitlement and exploitiveness (Brookes, 2015). While initially being perceived as charming and popular, the negative correlates of this personality may become more apparent over time (Leckelt et al., 2018) and the exploitative nature of such people may be observed (Morf & Rhodewalt, 2001). People displaying high levels of narcissism do not actually think rationally: they are unable to step back and put their own needs aside (Sifferd & Hirstein, 2013). Highly narcissistic people abuse their power and focus on their own self-image, serving their own personal needs. A strong narcissist is driven by unconscious needs to protect their ego. This style of thinking is in fact quite incompatible with strategic thinking. Narcissistic people at the extreme level are actually not able to consider the needs of other people. Narcissistic people can come across as highly confident, but they are also likely to be incapable of and disinterested in comprehending anyone else's perspective.

Grandiose narcissism, with its strong feelings of control and agency, may be highly adaptive under certain conditions. Such narcissism has often been examined within CEOs. A theoretical perspective called the upper echelon perspective (Hambrick & Mason, 1984) suggests that the personal characteristics of CEOs and other senior managers will have a significant effect on a firm's strategic behaviour. There is quite a large body of recent work here. Cragun, Olsen, and Wright (2020) presented a review and meta-analysis on this topic and concluded that CEO narcissism is significantly positively correlated with firm financial performance. These authors concluded that narcissistic CEOs influence their companies in five major ways: firm performance, innovation and growth, policies and risk, financial leverage, and questionable behaviour. Others have also investigated these issues. Olsen, Dworkis, and Young (2014) found that firms with narcissistic CEOs have higher earnings per share and share price and that this result occurs through the executive decisions and influence over the firm's operational activities. On the other hand, Ham, Seybert, and Wang (2014) reported that CEO narcissism had a negative effect on profitability. The question of the financial implications of having a grandiose narcissist as a decisionmaker is not yet settled.

There can be some positive effects associated with senior leadership narcissism. In terms of innovation and growth, CEO narcissism has also been found to be related to new product innovation; for example, Kashmiri, Nicol, and Arora (2017) reported that narcissistic CEOs lead firms who are likely to have a higher rate of new product introductions and a larger proportion of radical innovations. However there are likely to be significant downsides. Firms led by narcissists are also more likely to encounter crises caused by harmful products. Part of the reason for this relationship is a significant level of competitive aggressiveness. Due to overconfidence, narcissistic CEOs are likely to increase their firm's financial leverage through risky decisions or influencing accounting numbers. Considering questionable behaviour, CEOs who are narcissistic are often characterised as being unethical, deceitful, illegal, reckless or just selfish. There may well be bullying, as well as fraudulent behaviour in distorting financial information. When a narcissistic CEO identifies strongly with the organization, they are more likely to see it as a personal extension of themselves. CEO wrongdoing will increase when there is pressure and opportunity, and if there are not enough controls in place then narcissistic CEOs can cause a great amount of harm. Regnaud (2014) reported

bullying by CEOs, and Capalbo, Frino, Lim, Mollica, and Palumbo (2018) reported the tendency to distort financial information.

This style of thinking is actually the antithesis of a structured rational strategic management approach. At a lower level of narcissism, people may be a little more controlled and be unconscious of the damage they are doing to others through their behaviour of protecting their ego. However a full-blown narcissist knows exactly what they are doing and consciously uses deception and manipulative tactics to get their own way (Post, 1997). A deceptive narcissist can use others to make it appear that their decisions are correct. However they will not accept any approach that is different from what they desire, often through covert aggression tactics: “Using calculating, underhanded means to get what they want ...while keeping their aggressive intentions undercover.” (Simon & Foley, 2011). There is a disconnect between the concept of rational strategic management processes being used by a person at the high end of the narcissist spectrum with their highly ingrained and disturbed thinking pattern. It’s quite possible that a highly narcissistic person has followed no strategic process at all. A narcissist who believes that they are correct is likely to be highly reckless in their decisions (Ramamoorti & Epstein, 2016). Their sense of entitlement and self-serving views means that they need to protect their ego and status at all costs, or they will become dangerous (Zeigler-Hill, Sauls, Ochoa, Kopitz, & Besser, 2021). Once such people are in an organisation it may be quite difficult to get them out. Narcissists conceal their identity very well (Zeigler-Hill, 2006) and some qualities of leadership that are reinforced in business may encourage a narcissist to step into a senior role without revealing their disturbed thinking patterns.

At the same time, a very high level of self-confidence, sometimes called hubris, is occasionally promoted within the Western world as a desirable trait. Studies of hero leaders such as Mark Zuckerberg and Jeff Bezos suggest an image of successful CEOs holding very strong self-confidence, almost to the point of hubris. As noted by Malmendier and Tate (2015): “A substantial share of top corporate executives exhibit symptoms of overconfidence in their decisions.” Hayward (2007) points out that hubris is often a driver for failing business decisions and in particular overpriced acquisitions. This approach to decision-making leads to people making decisions on their own based on ungrounded judgements and not considering the consequences. Apple, Vivendi, Segway, Enron and Dell are all firms that were harmed through excessive confidence in their senior leader decision-makers. The remedy for this would include consulting other people and listening to their cautionary feedback. Others have also investigated the role of hubris in famous people. A study by Russell (2011) investigated “the hubris syndrome” in politicians including former US Presidents John F. Kennedy, Richard Nixon and Lyndon Johnson. A key driver here is power; in particular intoxication with power. The word “hubris” comes from the Greek language and means inviting disaster and arrogance. The hubris syndrome is based upon behaviours such as excessive self-confidence, contempt for others, loss of contact with reality, restlessness and impulsiveness, and incompetence in policy-making because they disregard the process. There is a clear link here with narcissism. A lack of insight such as that associated with hubris will likely lead to impaired decision-making.

A well-known example of the costs of hubristic decision-making is presented in the case of the Volkswagen diesel emissions scandal or “Dieselgate” (Mujkic & Klingner, 2019). This study reports on attempts to manipulate regulations by Volkswagen company which led to financial damage of US \$20 billion. The decision to cheat was driven by the objective of becoming the world’s largest manufacturer of automobiles and this involved seizing a larger share of the US market. Poor decision-making undertaken by unethical leaders was followed by poor public relations and damage control. A culture of cover-ups and false advertising enabled the disastrous decision to install a defeat device that would mask regulatory tests. This was deemed to be the only way to catch up with competitors in the US market. The results of this decision are now well-known.

VIII. CROSS CULTURAL ASPECTS OF NARCISSISM

Recently authors have started to investigate cross-cultural differences in this trait of narcissism. Wetzel et al. (2021) note that Americans tend to be perceived as being more narcissistic than people from other countries and many authors have confirmed this finding. A study by Foster, Campbell, and Twenge (2003) considered narcissism against factors of age and world region in a sample of some 4000 respondents, and found that the older people get, the less narcissistic they become. Males were more narcissistic than females, and individuals from more individualistic societies reported more narcissism than people from more collectivist societies. The dimension of individualism versus collectivism is often used in cross-cultural studies and derives originally from work by Hofstede (Hofstede, 1984). This dimension assesses the extent to which people are integrated into social groups. Individualistic societies are those in which people prefer loose social frameworks and less obligations, whereas people living in collectivist countries live in tight knit social groups in which highly integrated relationships tie people together. In the study by Foster et al.

(2003), American respondents reported the highest levels of narcissism, followed by Europeans, Canadians, Asians, and Middle Easterners. However the link between narcissism and individualism is not always found. Fatfouta, Sawicki, and Žemojtel-Piotrowska (2021) re-examined this association between individualistic culture and narcissism as they investigated five world regions in this context and failed to support the usual conclusion that grandiose narcissism is more likely to arise in individualistic cultures. It is possible that the choice of samples that is either the general population or senior decision-makers has an influence on these research outcomes. Ways of understanding how to identify narcissists are not yet fully developed, although there are a number of scales which have emerged for this purpose.

IX. CONCLUSION

Strategic management has gained more weight as competition grows in the market. Strategic thinking and strategic planning have become critical for the survival and success of businesses in such a Volatile, Uncertain, Complex and Ambiguous (VUCA) world as we now experience (Asobee, 2021). This paper has explored the disconnect between a rational strategic management approach to decision-making, the strategic audit, in the face of an ego driven approach present in the decision-maker. Clearly decision-makers at the high end of the narcissism spectrum, focused as they are upon their own agenda, may be a significant impediment to the rollout of a rational SM process. Strategies are needed to protect organisations from the very serious danger that a highly narcissistic person can wreak. Some literature has indicated that people from individualistic societies such as US, UK and Australia are more likely to spawn highly narcissistic individuals. There is also some suggestion in the literature that such people may go unnoticed because they are skilful at hiding their actual motivations. Enhanced processes at the hiring stage may be a start in dealing with this problem. Once a narcissistic person is within the organisation it may be quite difficult to dislodge them. Unfortunately, many top managers may be unwilling to admit that their company has serious weaknesses for fear that they themselves may be personally blamed. Even worse, top management may not even perceive that crises are developing. When these top managers do eventually notice trouble ahead, ego driven people may be tempted to attribute the problems to temporary environmental disturbances and tend to follow profit strategies. Even when things are going terribly wrong, top management is greatly tempted to avoid liquidation in the hope of a miraculous recovery. Top management can enter a cycle of decline, in which it goes through a process of secrecy and denial, followed by blame and scorn, avoidance and turf protection, ending with passivity and helplessness. Thus, a corporation needs a strong board of directors who, to safeguard shareholders' interests, can tell top management when to quit (Kanter, 2003). Strategic decision-making under conditions of international crises will be high-value and high risk. Such decisions are in no way immune from ego driven decision-making of various types. It is likely that the underlying trigger is fear. Further research will explore the relationship between narcissism, hubris and fear. It will also be important to research and refine management tools that can assist companies in neutralising ego-based decision-making and instead catalyse strategic thinking.

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İstanbul Technical University & Bahçeşehir University

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Emerging Methods and Future Applications of Contemporary Knowledge Representation: A Literature Review

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Abstract— The development of knowledge production and storage technologies has accelerated the need for more advanced ways to efficiently process knowledge, using reasoning methods which prevent ambiguities. The accurate and unambiguous representation and interpretation of knowledge for both people and machines requires a common language based on a well-defined concept of knowledge, a task which people have been attempting since well before the modern era. Here knowledge is defined as propositions which include judgments about the way the world is and works. Knowledge Representation is the field that studies the representational options that enable computational reasoning. This paper reviews the literature on Knowledge Representation as a field and KR's contemporary uses in the management of knowledge, especially in organizations, and evaluates, for future applications.

Keywords— Knowledge, Representation, Knowledge Representation, Knowledge Management, Fuzzy Petri Net, Answer-set Programming, Dynamic Uncertain Causality Graph

I. INTRODUCTION

Knowledge is currently considered as a key resource and must be managed like other key resources [1]. For this purpose, a field of study has emerged, viz. Knowledge Management, defined as a “process of creating value from an organization’s intangible assets” [2], with subfields focusing on knowledge acquisition, the interplay of tacit and explicit knowledge [3], and efficient knowledge flow in and between organizations [4], amongst others.

For knowledge to be managed as a resource it must be captured and recorded in a storable, transferable, and interpretable format, which, with the ever-increasing amount of information, has created a need for automated management tools [5]. The field of Knowledge Representation and Reasoning studies human intelligence as a means of understanding how to endow computers with a human-like reasoning capability [6], practical applications of which are Knowledge-Based Systems or Expert Systems.

Knowledge Representation (KR) studies the methods used in the transmission of knowledge from one agent to another. Here we consider AI applications in KR. Recent developments in reasoning algorithms and computing have meant that KR has become more focused on the transmission of knowledge between human agents and computers, or between computers with little or no human involvement. KR encompasses a range of different disciplines as a tool for optimizing knowledge flow, due to which the KR literature is dispersed, lacking a recent, structured literature review. In this paper we aim to contribute to closing this gap. In what follows, we briefly outline the methodology for selecting papers to review, followed by definitions of main concepts used. Then a brief history of the development of KR leads to a structured discussion of recent literature.

II. METHODOLOGY

A keyword-based method was used to review the literature. First, an extensive literature review was conducted to specify main concepts and definitions of the field. Then, using these concepts as keywords, literature was reviewed to gain a historical perspective on development of KR. Finally, literature of last 5 years was reviewed for recent development and applications.

The review of recent literature used a keyword-based method and focused on papers written in the last 5 years. Papers with the keyword “knowledge representation” were selected using the Keyword Plus feature

of the Web of Science, which returned 52 results. After a review of the abstracts, one paper was excluded as irrelevant to the topic, and a second as not being in English, which left 50 papers for review. Out of these 50 papers, 22 of the studies development of current KR methods which are more relevant to the main goal of this paper. From these 22 papers, 21 of them were found to focus on 3 KR methods in total, thus, these methods were selected as the focus of the review of recent literature. 1 of these papers was a tutorial on one of the methods and 1 of these papers was on results of a programming competition about the method, so they were excluded. Finally, 19 papers were selected for literature review.

III. KEY CONCEPTS AND DEFINITIONS

We define four main concepts in this paper, viz. knowledge, knowledge representation, ontology, and reasoning, as follows. For ‘Knowledge’ we borrow from Brachman and Levesque [7], ‘propositions that include judgments we come to about the way the world is and works’ Representation is matching items in a domain with other items in another, representation domain; and using the second domain instead of the first, represented domain. We can expect that the representation domain is more accessible, efficient, and interpretable than the represented domain [7]. Knowledge Representation, at its core, symbolizes how the world works or phenomena about what’s happening in the world, with the purpose of communication [8]. KR is naturally related to reasoning methods studied under Artificial Intelligence for knowledge extraction. Yet, as the expressiveness of the representation language increases, the computation required for the knowledge extraction increases as well, which forces a trade-off between expressiveness and computer-interpretability. Thus, KR can be considered as a field of study on representation methods that provide computational reasoning flexibility.

Sanchez [9] describes ontology as “formalism of knowledge representation”. Ontologies contain domain-specific concepts and their properties, relations, and restrictions [7]. The process of creating an ontology is called Knowledge Engineering [7, 10]. Ontologies are important when structuring a knowledge base. Ontology can be considered as a domain-specific dictionary to define a common language.

According to Leibniz, Reasoning is a computation, but instead of numbers, it is made with symbols representing propositions [7]. Brachman and Levesque [7] exemplify reasoning as such; from the “John loves Mary. Mary will come to the party.” set of sentences, making the “Someone that John loves will come to the party.” inference is an example of logical inference type reasoning. Reasoning can derive symbols that represent new propositions that are deduced from previously defined symbols that represent a group of true propositions [7].

IV. HISTORY OF KNOWLEDGE REPRESENTATION

In the 1970s when KR has gained popularity, two approaches were prominent, Logical and Non-Logical formalization. Logical formalization aims to treat phenomena about the world with a first-order logical approach. Non-Logical formalization, on the other hand, prefers a cognitive understanding approach when processing these phenomena. The non-Logical approach aims to achieve this by replicating human memory and reasoning mechanisms [11].

In Logical formalization, representation is done with first-order logic and reasoning is a logical inference. Non-Logical formalization represents knowledge using specialized data structure and is processed by specialized reasoning methods. Quillian’s semantic networks and Minsky’s framework system are examples of specialized knowledge representation. A semantic network aims to form a relational network of knowledge “atoms” and the relations are created according to the context [12]. Similarly, Minsky’s frameworks groups knowledge by their meanings and context and represents inter-framework relations [11]. Since both methods rely on a network approach, knowledge-storage methods based on these approaches are called network-based structures [11].

Following the success of earlier attempts, knowledge management systems started to emerge in the 1980s [13]. The integration of these systems into organizations’ knowledge management operations and the impact of this integration has been the topic of many papers in the literature [14-17]. These systems help to create a knowledge base by recording the solutions to previously solved problems. When a new problem is encountered, with the help of semantic network-based computer reasoning, these systems find the solution of the most similar previous case [4]. Thus, it became possible to transfer the experience and expertise of an expert, which can be considered as tacit knowledge, to another less experienced expert. The most common example of such systems would be the business process solution systems of SAP.

From the late 1990s to the early 2000, significant progress was made in the field of KR. Standardizations for common knowledge representations to merge, combine and reason with the knowledge accessible over Internet Web, are conducted by W3C. In this context, an extensive ontological dictionary of basic data,

classes, and types is defined using “Resource Description Framework” (RDF), “RDF Schema” and Web Ontology Language (OWL) [18]

As the computation power of computers increased and as it became possible to transfer high amounts of data with high speed over the internet; relatively easier and simple Machine Learning started to become a popular inference method. Machine learning (ML) is a brute force solution that serves the very specific goals it’s trained for. Machine Learning provides solutions in many cases; however, it can’t be expected to solve previously unsolved problems, with the methods used for past problems. Even though machines excel at detecting patterns in large data, combining knowledge from a big and diverse set of knowledge base to decide the way to solve a complex problem, is a different and certainly more difficult task. It’s probable that the correlation detection method used by machine learning that provides solutions in many fields, is unsuitable for all applications and different approaches must be found. ML relates Input and Output via a weight network. The Semantic modelling approach, which differs from ML, relies on a representation method that clearly and accurately defining the concepts, relations, and rules of the relevant field and is interpretable by humans. Knowledge-Based Systems output more interpretable results when compared to the Machine Learning method. Machine learning methods process the input in a way we can’t inspect. This makes machine learning models harder to adapt to changing conditions.

V. APPLICATIONS OF KR

Knowledge Representation is the method used for storing, transferring, and processing knowledge. The amount of knowledge that needs to be processed is continuously increasing. However, the challenge of KR is not only the size of captured knowledge but also being able to capture it in a transferable and processable way as well.

A. Knowledge Capture and Retrieval

Captured past knowledge within an organization forms the institutional memory [2] and it consists of what is known about customers, products, processes, mistakes, and successes [19]. And this knowledge isn’t always clearly expressible, therefore, is tacit knowledge. Usually, knowledge acquired in time with experience is tacit. Thus, the extraction of tacit knowledge is a significant and complicated process, and KR must be suitable for this purpose. Further, as computer technology has become a part of almost all processes in organizations, KR methods should also be suitable for computer interpretability. Digital documentation of a firm’s knowledge can prevent loss of opportunities [20]. Additionally, considering the amount of knowledge firms must manage today, the desired knowledge should also be retrievable from the large mass of total knowledge stored.

Ontologies and taxonomies are at high significance to increase knowledge retrieval efficiency. Structuring a knowledge base with an ontology enables categorization and establishing inter-knowledge relations to reach to the needed record. To establish this system, ontologies must carry two important characteristics: common usage within the organization and computer-interpretability. Examples of studies that are concerned with creating a computer-interpretable common language/ontology is especially common in the medical field [21-24]. Attempts and studies to structure or extract knowledge from unstructured data [5, 25-28] is also common.

B. Expert Systems

Expert Systems are Knowledge-Based Systems that aim to support the decision-making process in a domain by offering solutions or advice to domain-specific problems at an expert level [29]. Earlier Expert Systems relied on high-level programming languages, which required significant efforts to implement the system and to update or change the knowledge defined to the system. Due to the dynamic nature of expert knowledge, this led to the separation of knowledge base and inference engine of the expert systems. A knowledge base is the expert system component that captures the domain-specific knowledge, and an inference engine consists of algorithms for manipulating the knowledge represented in the knowledge base [29]. With this separation, knowledge base is aimed to be easier to change and update for the domain experts. Thus, the KR method used for defining new knowledge to the knowledge base must satisfy some prerequisites which are defined by Lucas and Van der Gaag [29] as such;

- Have sufficient expressive power for encoding the particular domain knowledge,
- Possess a clean semantic basis, such that the meaning of the knowledge present in the knowledge base is easy to grasp, especially by the user,
- Permit efficient algorithmic interpretation,

- Allow for explanation and justification of the solutions obtained by showing why certain questions were asked of the user, and how certain conclusions were drawn.

1) *Explainability*: Nowadays knowledge-based systems based on Machine Learning (ML) methods are commonly used. The black-box nature of these methods tends to obscure causes of misinterpretations [30]. Goebel et al [31] explain explainability as matching features that the inference algorithm describes, with definitions pre-defined to the knowledge base. According to Goebel et al. [31], the explanation is needed for interfering with the understanding and beliefs of the reasoning system. When an ML-based system makes a mistake, the solution to prevent that mistake is usually to increase the training data with similar cases so that the system recognizes differences between the description it makes and the features it analysed. Yet, there are two main issues with this approach. The first one is to find such data that clearly show the different iterations of the case. The second one is that this solution is very case-specific, meaning that solving the faced problem doesn't necessarily mean when a similar case is encountered, the misinterpretation won't be repeated. Explainable AI (XAI) provides an explanation of the reasoning behind its decision. Thus, we can identify which feature or features are involved in the misinterpretation, to see the main cause that led to misinterpretation. Goebel et al [31] exemplify this case with a visual explanation, where AI analyses an image, (extracts its features to) describes the visual in the image and tries to output what is in the image as a *description*. This requires the AI to be able to accurately extract the features of the image and match them with the previously coded *definitions* in the knowledge base. Therefore, KR is significant for XAI since definitions in its knowledge base must be in the same representation format with the format of the AI description output, and still be understandable by a human.

VI. A REVIEW OF RECENT LITERATURE

Recent studies in the related literature focuses attention on three methods of knowledge representation: Answer Set Programming (ASP), Fuzzy Petri Nets (FPN) and Dynamic Uncertain Causality Graphs (DUCG). Out of the 19 reviewed articles, 6 articles study on ASP, 8 on FPN and 5 on DUCG. The summary of reviewed studies is given in Table 1. These methods are utilized to enhance decision-making processes with either automizing the process or assist the expert in utilizing a larger set of knowledge, faster. These three KR methods essentially rely on a previously defined knowledge-base that consists of rules put together by experts and triggering of these rules according to given or measured inputs.

ASP is a powerful declarative formalism for solving search problems KR [32] introduced by Gelfond and Lifschitz [33]. ASP contains a previously defined set of solutions as an answer set and from this set of solutions, provides the most fitting ones for a given problem via an answer set solver.

Petri Nets are powerful formalism tools for graphically and mathematically modelling processes using places, transitions, and tokens to represent changes in a system, especially for control and analysis of discrete manufacturing systems [34, 35]. Petri nets are widely utilized for fault diagnosis or safety analysis [34]. Fuzzy Petri Nets are an improved version of Petri Nets which are modified to process imprecise, vague, or fuzzy information [34-36]. Combining the graphical representation of Petri Nets with the benefits of fuzzy reasoning made Fuzzy Petri Nets a viable KR method which has drawn attention of researchers.

Finally, DUCG is a more recent method to model complex causality relations and their evolutions. DUCG represents events and causalities between events, explicitly and graphically with uncertainties and can be utilized for probabilistic reasoning, outputting results as conditional probability and illustrate the results graphically as well [37-39].

Table XII

KR Method	Article	Topic	Contribution to the literature
ASP	[40]	Medical diagnosis	Suggesting an ASP algorithm for cause identification to support diagnosis of neurological disorders
ASP	[41]	A survey of aggregate semantic for propositional ASP	Present and compare suggested implementation of aggregate semantics in ASP
ASP	[42]	Enable external input of atoms	Implement an evaluation technique for external atoms manually described to ASP
ASP	[43]	Stream reasoning	Suggests a new extension to ASP to cope with rapidly changing data and reduces circular justifications

ASP	[44]	A survey of forgetting (variable elimination) studies for ASP	Present a systematic review and comparison of state-of-the-art and novel studies on forgetting in ASP
ASP	[45]	Debugging for ASP	Introduce a stepping technique for debugging and analysis of ASP.
DUCG	[39]	Classification	Develop an outpatient triage system based on DUCG to help triage nurses and enhance the triage accuracy
DUCG	[46]	Medical diagnosis	Presents a sampling-based algorithm to improve computation efficiency even in high sample sizes.
DUCG	[38]	Medical diagnosis	Suggests a new DUCG algorithm that includes non-causal relationships to execute diagnoses with previously not classified input.
DUCG	[47]	Fault diagnosis	Develops a time-series-based industrial fault diagnosis platform based on cubic DUCG theory.
DUCG	[37]	Medical diagnosis	Suggests a DUCH method to work with intricate and confounding disease factors, incomplete clinical observations, and insufficient sample data.
FPN	[48]	Reduce complexity for fault diagnosis FPN	Presents an algorithm to reduce complexity of fault diagnosis process via removing irrelevant places and transitions of the large-scale FPN
FPN	[34]	Fault diagnosis	Presents an FPN that focuses on factor influences.
FPN	[49]	Reachability tree generation	Presents a method to automate and improve reachability tree generation for FPN to include dependence relationships among the places in the neighbouring layers.
FPN	[35]	Real-time data processing for automated decision making	A control method is suggested for energy saving by decreasing idle times of machines.
FPN	[36]	Fault diagnosis	A method is presented to improve the flexibility of conventional FPNs in dealing with fuzzy and linguistic knowledge as well as enhance the capability and accuracy of the knowledge representation.
FPN	[50]	Reliability evaluation	Develops a dynamic reliability evaluation method based on FPN which also increases efficiency.
FPN	[51]	Fault diagnosis	Suggests a method to improve the accuracy and adaptability of FPN for complex systems.
FPN	[52]	Route Optimization	An FPN algorithm is presented to find an optimal route with respect to trust and distance, to maximise QoS.

As the table shows, many studies with different approaches have been conducted to improve previously suggested KR methods. These approaches share somewhat similar purposes which are to increase the applicability of the method [36], increase efficiency [50, 51] or boost accuracy [36]. Further, we see that DUCG is usually preferred in medical diagnosis studies, whereas for fault diagnosis FPN is the preferred method. DUCG can be considered as a KR method for relatively more complex causal relationships, thus is more fitting for the complexity of symptom-disease matching. FPN, on the other hand, has a more fitting structure for modelling manufacturing systems by having simpler yet more scalable approach to graphical KR. ASP, compared to other two methods, lacks a graphical aspect, yet the main principle behind how it functions allows it to have a wider range of application.

VII. CONCLUSIONS AND DISCUSSIONS

Knowledge Representation was born with philosophy before the Common Era and it studies concepts that we still haven't fully defined to this day. KR studies that aim to replicate human cognition and memory, gained speed as the computation power of computers increased and artificial intelligence algorithms improved. Knowledge representation has played an important role in the emergence of knowledge-based structures, and the development of AI systems helped utilize these structures to support the knowledge management processes in organizations.

KR applications extend to a vast number of fields. Recent applications of KR in Internet of Things (IoT) attract special attention as IoT is emerging trending study field. Since IoT aims to track and record actions within the connected environment [53], it is argued that the recorded data can enable extraction of knowledge, specifically experience-based knowledge. Current state of the studies shows that there are many attempts to expand the applicability and scalability of KR methods. Advancements in more efficient processing of continuous real-time data with an explainable inference method can further popularize

knowledge-based systems, and even make knowledge-based systems a substitute, or preferably a complement, for currently widely utilized ML methods. The elaboration of the information circulating on the internet and preserving their processibility despite being detailed is a candidate to be the subject of studies in this field.

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Evaluation of Apps' Usage in Humanitarian Sector: A SWOT Analysis and Decision-Making Framework Development

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Abstract— Operating mobile applications in humanitarian world provides the target audience with numerous benefits in terms of delivering an effective service. In addition, mobile applications are significant tools for institutions in terms of offering highly efficient data collection and analysis opportunities. The need for mobile applications in the humanitarian aid sector is increasing steadily and many mobile application technologies are emerging accordingly. Each of available mobile tools carry out many different main and sub different criteria as well as diverse content. Therefore, the selection of a mobile application tools is critical for humanitarian organizations as increasing the effective usage of resources and feeding positively the corporate culture is enormously essential for them. In this study, first of all, a SWOT analysis of one of the most important mobile applications of the humanitarian aid sector, namely Commcare, will be carried out and following that a framework of decision-making process will be designed for the "selection of the best mobile application in humanitarian sector" from a wider perspective. In the future, it is aimed to test apply and validate the framework through actual practice.

Keywords— Humanitarian aid, mobile apps, decision making, technology selection, SWOT

I. INTRODUCTION

Recently developed information and communication technologies have a key role to facilitate an effective and rapid humanitarian response. Mobile applications (apps), in particular, are promising and powerful tools that enable humanitarian actors to take the advantage of utilizing widely applied mobile phones and tablets to ease their interventions in the field. As simple and publicly available tools, humanitarian apps make data collection and management activities neat as well as easy to follow.

Mobile apps have various of fractious features in project design and monitoring such as creating survey forms, collecting, analyzing, visualizing and managing data etc. Owing to all these facilities offered by the apps, humanitarian organizations are able to advance their interventions, generate robust statistics and deliver a better effective response to beneficiaries eventually. When it comes to using an app, decision-making processes may involve some risks and challenges although these apps are extremely useful. Therefore, it is substantial to know the strengths and the weaknesses, as well as opportunities and threats of apps for humanitarian actors that plan to utilize them.

To effectively neutralize the risks and challenges of utilizing an app, humanitarian actors can resort to effective decision-making methods. In compliance with this, the aim of the existing study is to propose a SWOT analysis for one of the most common technologies, and propose a framework of decision-making model that will contribute to the selection process of apps for the interventions that humanitarian sector delivers to persons of concern. By doing so, existing paper reviews one of the available technologies, namely Commcare, conducts a SWOT analysis of the platform and finally offers the general principles of a decision-making model to propose a guide and supportive tool to the managers who aim to make an effective selection among alternative technologies by considering both of qualitative and quantitative criteria.

II. BACKGROUND AND MOTIVATION

Mobile data collection technique enables field works to compile qualitative and quantitative data with the support of electronic devices such as mobile phones, tablets etc. Mobile data collection process

increases rapidity and accuracy of the collected data as the method makes possible to enter the information directly into a device that has capacity of exporting data into an associated database [13]. The connected database in return offers the facility of data retrieval as well [13].

The rapid and accurate data collection process mostly enables aid workers to get and store the actual-time data regarding the impact of the disaster, population movements etc. [13]. However, as the number of apps/tools gradually increases, it becomes difficult to indicate the most effective tool for data collectors or data managers [3]. The information is limited on adoption patterns of mobile technology by humanitarians albeit the tools are widely used [7]. It matters much to develop a model to assist decision-making processes in selecting the most appropriate app as the humanitarian workers should use to provide clear, accurate and substantiated information [7]. Therefore, this study takes the example of the Commcare that an app widely applied by humanitarian organizations and independent from this, it proposes a decision-making model to assist humanitarian workers/managers in the process of choosing the most appropriate tool for their interventions.

III. SWOT ANALYSIS OF THE COMM CARE TECHNOLOGY

CommCare is a well-known open-source mobile technology platform that provides field workers with various data gathering and managing facilities [7]. Numerous humanitarian projects have been supported by CommCare's cloud server. Projects that utilize CommCare for data management have one or more modified mobile applications (apps) programmed to support the project's workflow. CommCare apps are able to run via a smartphone, web or SMS. Each app can be accessed by several users, and in the using process of Commcare technology the caseworkers fill out forms that are eventually submitted to the CommCare cloud server [7].

Having thousands of registered mobile users across 80 countries in its cloud environment and over 37 million forms submitted per month, CommCare is one of the most extensively applied mobile platforms [6]. More than 75 peer-reviewed publications studied to analyze CommCare's Evidence Base measuring feature, its impact on frontline programs, frontline users, and client outcomes [18]. In addition, CommCare has been evaluated by third parties in comparison to other digital systems across a variety of factors - including its product capabilities and reach [18]. In light of all these works, following chapter of this article will provide a SWOT analysis of the platform.

A. Strengths

Capabilities: CommCare has been evaluated by different research groups against other digital systems for specific sector uses, focusing on its feature set. In comparison to other platforms, CommCare has come out as a top 1 or 2 tool for agriculture (compared with 17 tools in total), Ebola response (58 tools in total), and COVID-19 (9 tools in total) [18].

Reach: Some different researchers have assessed the reach of tools in a broader context to analyze and understand better overall industrial dynamics regarding the reaching capacity of tools. The findings revealed that CommCare is both the most widely used tool for nutrition-related digital interventions (16 out of 53 programs) and, in developing countries, the most accepted mobile platform among frontline workers in health sector (out of 140 studied programs) [18].

Maturity: A research found that CommCare is the 53rd most valuable open-source data storage platform on GitHub (out of 96 million). A different analysis found that CommCare was one of two tools graded 100% for Product Maturity (out of 24 tools by the time the analysis has been done) [18].

Cost Savings: Besides its technical competencies and reach, a subset of studies has analyzed the impact of CommCare's on program costs. Two distinct studies revealed that initiating CommCare would save the state of Colorado \$15 million over 3 years, and the platform would enable Burkina Faso government saving between \$830,000 and \$1.7 million a year for a government program [18]. Commcare makes the data collection and management process cost efficient. The platform supports researchers in reducing the expenses for data collection and entry [13].

B. Weaknesses

Technical challenges: One of the pitfalls of the Commcare platform consist technical difficulties. More than a few studies defined challenges with applying CommCare and mentioned specifically technical challenges, such as broken phones that remained unsettled, absence of convenient chargers for the devices, and lack of consist connectivity which leads limited data sharing and synchronization between the field teams [10].

Programmatic issues: Quite a few studies also revealed programmatic matters that cause limitations the utilizing CommCare. To illustrate, limited IT capacity of adopting organizations brings together the technical issues in maintaining the technology [10]. The ‘novelty effect’ of new technology that has been generally detected with low adoption rates between users, or the decline in utilization by time has also observed in projects that apply CommCare in implementation [10].

Labour demanding: The study conducted by Mathematica stated that the CommCare technologies, even if they have since been improved, had several challenges in supporting supervision; therefore, CARE International needed to provide their staff with very high level of training sessions to reach the expected impact level of the tool [10]. Other underlined programmatic issues in CommCare projects contain overdue top-up payments to field workers [10] and the inaccuracy risk in self-reported data [10].

C. Opportunities

Speed and Efficiency: Commcare has the opportunity of using mobile devices in data collection that extremely helpful specifically in gathering longer and more complex surveys data. Thanks to this rapidity, high volume of data can be ready for analysis in a very short span of time as this facility does not require a separate data entry process [13].

Quality data: In general, digital data platforms offers the opportunity of creating data sets, filtering options, special customization facilities and tools for quality check [13]. These advantages tha Commcare also holds improves data quality.

Control and flexibility of fieldwork: Electronic data collection tools allow users easily correct possible typographical errors as well as incomplete or incorrectly expressed questions in surveys. These user-friendly possibilities increase the reliability of data collection. In addition, there is no need to carry large survey materials when collecting data with the help of mobile devices, reducing the difficulty and burden of pen and paper methods [13]. Commcare have these listed opportunities and more in terms of offering effectively controlled and flexibly managed data collection process.

D. Threats

Usage difficulty: Providing data entry using mobile devices is challenging for those unfamiliar with electronic device use. Without customized tailor-made training sessions, using these tools will be difficult and this will disrupt the data collection process [13]. Therefore, both user-oriented designed training modules to develop electronic literacy and regular technical support are needed [11].

Competition in the market: Commcare is just one of dozens of platforms applied in the humanitarian sector. Although Commcare is an extremely trusted and widely used tool, there are many other platforms that can provide similar facilities and have capacity to compete with it.

Electronic devices are unreliable: As electronic devices operate relied on batteries they may run out at any stage of the process. Also, these devices are fragile and in a case of this the process of data collection may be disrupted. These pitfalls make them unreliable from some aspects [13].

Too expensive: Using electronic data collection tools naturally requires purchasing expensive equipment. In other words, there is a need to ensure the use of appropriate tools in order to obtain clear and grounded results [13].

Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths?	Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses?
Opportunities What opportunities are open to you? What trends could you take advantage of? How can you turn your strengths into opportunities?	Threats What threats could harm you? What is your competition doing? What threats do your weaknesses expose to you?

Fig. 1. SWOT Matrix [15]

IV. A FRAMEWORK FOR THE SELECTION OF THE BEST MOBILE APP FOR HUMANITARIAN SECTOR

As given in previous part, the strengths and weaknesses of a technology are depending on both of quantitative (cost, technical features etc.) and qualitative (flexibility, reliability etc.) criteria. Because it is very hard to reverse, top managers tend to apply an efficient procedure for selection of the best technology. As they clearly know, if the decision will fail, they will not only lose money and time; also, their reputation will also be damaged.

In the relevant literature, there are many studies handling technology selection problem such as [9], [12], [16], [5] etc. In especially humanitarian sector, most of studies proposed decision making methodologies for warehouse location selection problems, and logistics-based technologies/methods selection problems ([1], [4], etc.). Different from the others, in this study, mobile app selection procedure will be designed specifically for humanitarian sector.

For this aim, the main and sub criteria list that affect the selection process is emerged by inspiring from some studies such as [17], [19], [8], [2]. All criteria are given in Figure 3 within hierarchical structure.

By considering these criteria, a decision-making approach should be carried out by utilizing some novel approaches. Multi criteria decision-making (MCDM) is beneficial for problems including both of quantitative and qualitative criteria. In the MCDM procedure some main steps should be conducted as given in Figure 4.

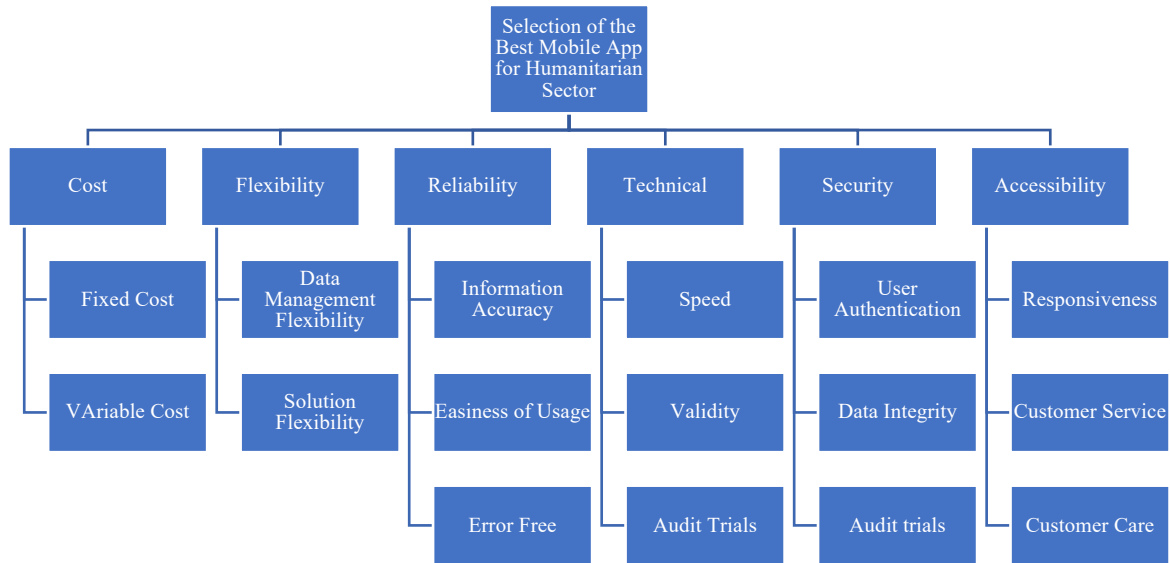


Fig. 2. Criteria List for Selection of the Best Mobile App for Humanitarian Sector

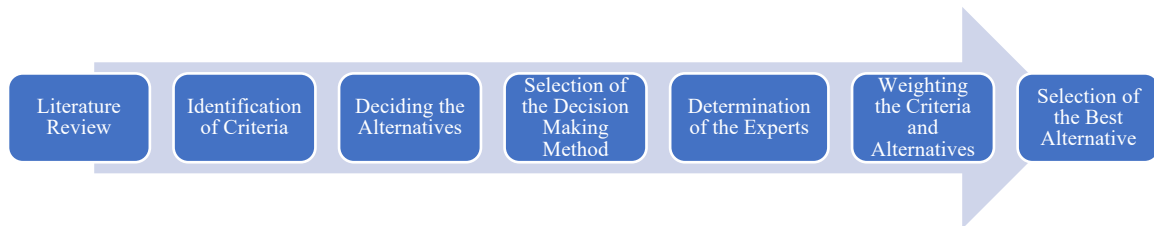


Fig. 3. Methodological Steps

In recent years, it is very preferable to adopt fuzzy approaches to traditional multi criteria decision-making approaches such as Analytical Hierarchy Process (AHP), Technique for Order Preference by Similarity to An Ideal Solution (TOPSIS), The Decision-Making Trial and Evaluation. Laboratory (DEMATEL) etc. Because high uncertainty and vagueness occur in humanitarian sector, some novel fuzzy MCDM methods such as Hesitant Fuzzy AHP and/or Hesitant Fuzzy TOPSIS are recommended.

V. CONCLUSION

In recent years, the rapid spread of humanitarian interventions has made inevitable using the technology in the management of activities within it. Technological advancement in humanitarian sector helps using resources effectively, saving time, and providing and efficient assistance. Mobile applications are at the forefront of these technologies and there are various mobile applications regularly utilized in this field. In current study, the strengths and weaknesses of a highly preferred mobile application, Commcare, in the market is evaluated in terms of several quantitative and qualitative criteria. Following, these criteria are expanded by reviewing the literature, and they are used to develop a procedure for selecting the best mobile application. While doing this, cost, flexibility, reliability, technical, security and accessibility are figured out as main criteria. The proposed framework can be a supportive tool for technology investors and strategic managers in humanitarian sector. In future studies, a real application should be conducted in order to see to what extend the proposed methodology can be applied in practice.

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Examining the aspects impacting the engagement of volunteers on volunteering match platforms

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Abstract— Online services that bring together those who want to take part in volunteering projects and volunteering opportunities are called volunteering match platforms. To increase volunteer engagement these platforms need to reach more people. Therefore, it is necessary to determine the expectations of users from these platforms and design and manage the platforms accordingly. This study aims to examine the main aspects impacting the engagement of volunteers in volunteering match platforms. For this purpose, 8 potential users of a newly established volunteering match platform in Turkey, Köprü Project, were interviewed. As a result of the study, it was found that the most important aspects of volunteering match platforms for potential users are gaining trust both for the projects and the platform, providing social media information of the projects on the platform, and communication with its users.

Keywords— Volunteering, online volunteering, volunteering match, social responsibility, volunteering intention

I. INTRODUCTION

With the development of technology, the use of the Internet is growing in almost every area of life and the number of internet users is increasing day by day [1]. Internet is used not only for running business or for entertainment purposes but also for meeting daily needs in many areas. Especially as a result of COVID-19 pandemic, opportunities have increased in areas such as remote working, food and groceries shopping, e-commerce/export, online/distance education, and remote payments, and thus access to resources has become easier than before [2].

One of the areas where reaching more people and increasing resources is most important is social responsibility activities and volunteering projects [3]. When the internet was not widespread and online systems were not developed enough, finding, identifying, and reaching people and organizations for volunteering/social responsibility activities were difficult [4]-[5]. Social responsibility projects were mostly carried out through certain institutions and organizations only or they were carried out through people who could only reach their circle of acquaintances [6]. However, especially with the opportunities provided by the internet, it has become quite easy to learn about volunteering projects, take part in them, reach people who may be interested in your project ideas, and provide social benefits to areas far from your location [7]-[8].

Platforms providing details of volunteering projects and aiming to bring together volunteering opportunities and people willing to volunteer are called volunteering match platforms/applications [9]-[10]. There are several volunteering match services around the world, and their numbers are increasing day by day. VolunteerMatch, Catchafire, Nomads Giving Back, Match Maastricht, and Volunteering Matters can be given as examples of such services. Köprü Project is also an example of these platforms. It was established in the last year and provides its services online in Turkey. It aims to increase volunteers' engagement to create social benefits by bringing organizations and individuals together, who otherwise may not be aware of each other. Although it has just been established, it has been increasing its services and the number of users gradually. For volunteering match platforms to reach more people and increase their resources, it is of great importance to identify the common needs, concerns, and expectations of potential users of these platforms.

This study was conducted as part of preliminary user research done for Köprü Project and it aims to determine the aspects impacting the engagement of potential users of Köprü Project so that once they are addressed in the platform design and management, users' engagement intentions in volunteering should be positively affected.

II. BACKGROUND

Social responsibility projects and volunteering activities are increasing day by day with the help of technology. Likewise, the research literature focusing on that area is expanding. When the existing literature is examined, it is seen that there are studies on online and virtual volunteering, aiming to identify the factors that motivate potential volunteers in different contexts. For example, in one study, where it is aimed to enable university students to participate in volunteering projects, students used volunteer-match websites to make participation decisions in volunteering activities. It has been observed that students prefer projects where the use of social media is up-to-date on the websites they visit and they also prefer to get information online by using their websites instead of going to non-governmental organizations and meeting face-to-face. In addition, as a result of interviews with non-governmental organizations, it has been observed that more people can be reached with the correct use of technology and the internet, and the use of internet sites is very important in raising awareness [11]. In another study, the VolunteerMatch website, which provides online volunteering match service, was examined in various aspects by experts in the field. In addition, as of the year the study was conducted, it was determined that although there were only 25 employees in the company, they were able to assist 31,000 people and more than 1.5 million people visited the website every year [12]. Another study was related to volunteer work done during the COVID-19 crisis. In the study, people in need, relatives of patients, or people in quarantine at the time of the COVID-19 crisis were helped by online volunteering platforms, and people continuously assisted sick people and their relatives voluntarily. It has also been shown that crises can be permanent and that volunteering-match services may be used more frequently by people to reach those who need help more easily in such situations [13]. Another study examined online volunteering and internet use, deficiencies in traditional volunteering practices, and the advantages of online volunteering. The study found that online volunteering is both a remedy for existing inequalities in volunteering and a way to strengthen existing patterns of social participation in increasingly digitalized societies [14]. In another study advantages of online volunteering services were examined. In the study, it was seen that people prefer online volunteering services because of their advantages such as ease of accessing information, freedom to search for information, and overcoming disabilities. In the interviews conducted in the study, the participants emphasized that through online volunteering accessing leaders was easier, and a more organized and planned life was possible, and that these services should have features that can appeal to all people [15].

III. METHOD

To increase volunteer engagement in social responsibility projects via volunteering match platforms, aspects impacting potential volunteers' engagement decisions should be determined and later incorporated into the platform design. To determine those aspects, interviews were held with 8 people who are actively volunteering. To be able to gather different views and opinions, interviewees were chosen so that their backgrounds and volunteering roles are different. Some are project leaders, some provide financial support, some provide mentorship, and some provide workforce as volunteers. The participants live in Turkey and carry out their volunteering activities here.

All interviews were conducted via Zoom. All interviewees gave consent to the interview being recorded. After an introduction and background information, guiding questions prepared before the study has been asked to understand users' experiences in online researching about volunteering projects and the aspects impacting their engagement decisions about the projects on the volunteering match platform. Although the interview questions were prepared before, some variations happened between individual interviews. The necessary information was obtained by recording the answers given by the participants. The recordings were re-watched by 2 researchers individually, and common themes determined by each researcher were then analyzed.

IV. RESULTS

In this section, the results of the interviews with the participants will be given in detail.

A. Trust

As a result of the analysis, it is seen that all participants define trust as the most important aspect in making volunteering decisions in the projects. According to the comments of the participants, trust cannot be built if information regarding certain topics is not presented on the platform. These are information about the owners of the project presented on the volunteering match platform, information about the founder/founder organization of the volunteering match platform, information about the supporting organizations behind the project, and financial transparency.

1) Information about the owners of the project

In the interviews, the participants indicated that they would want to see the information about the project owner before taking part in the volunteering projects in order to be able to decide that the project is trustworthy. The project owner may be a person or an organization. Participants emphasized that it is extremely critical to be informed about project owners' past volunteering experiences, their previous completed volunteering projects, and what was accomplished at the end of previously owned projects. Participants said that in this way, trust will be created due to the fact that there is a reliable, experienced person/organization running the project, and thus their probability of participating in the project will increase.

2) Trusting the platform

In the interviews, the participants want to see the information of the founders of the platforms that provide volunteering services in detail on the website. It is requested to see information about their past experiences in volunteering and social responsibility, their connections in the volunteering ecosystem, and what their motivation and aim are to build this platform. It was stated by the participants that this information should be presented comprehensively to increase trust in the platform. Participants also consider it to be extremely necessary not only to trust the platform founders but also to trust the platform itself. It has been said that the recognition of the name of the platform as a reputable network where volunteering projects and social responsibility activities are carried out would help with trusting the platform. Also, presenting the story of the emergence of the platform would be again helpful to build trust.

3) Supporting organizations

Another aspect identified in building trust towards the volunteering projects was presenting the information about the supporting organizations behind the projects. After the interviews with the participants, it was obvious that potential users of the volunteering match platform would like to see which organizations are supporting the project they are interested in. Participants indicated that they believe that projects which are supported by organizations financially, or through other services are more successfully maintained and more easily achieve intended outputs. However, their preference about the type of the supporting organizations may differ; while some participants thought that this support should be provided by non-governmental organizations, others said that it would also be beneficial to be supported by university clubs, local organizations, and various companies. Nonetheless, all interviewees indicated that seeing a reputable organization supporting a project would positively impact their trust towards the project.

4) Financial transparency

Another aspect that contributes to the trust problem is financial transparency. It is important that volunteering projects follow legal standards for financial transparency. The participants indicated that it is also ethically important, that the stakeholders of the volunteering projects are informed about how the finances are managed and where the expenditures are made. For example, some participants indicated that they would definitely want to be informed when the provided financial support is delivered to the people in need in case of projects fighting poverty. It was emphasized that it is critical to see the financial information of the projects on the platform in a transparent manner, especially for an unknown and newly established volunteering match service. If detailed financial information cannot be provided on the platform, then at least a link to the proper information resource should be provided with other project information on the platform. The participants think that if financial transparency is ensured, more people can participate in the project and thus the project can reach more people in need, or create more good.

B. Usage of Social Media

The second aspect that impacts the engagement decisions of potential users is the active use of social media. Especially today, social media is actively used not only by people but also by companies and governments. A total of 7 participants said that the use of social media is indispensable for increasing the recognition of volunteering projects and reaching more people. Through social media projects can share their messages

and activities not only locally but also globally. It has been emphasized by the participants that the social media accounts of projects should be informative, and should have attractive content in detail. Also, almost all of the participants emphasized the very importance of presenting up-to-date information on social media, not only in text format but also in visual formats like photos or videos with proper explanations. Participants also suggested that if it is too much work to manage social media accounts for the project team, hiring professional help to manage them, despite it bringing additional costs, should be an option due to the great benefits social media marketing would provide for the wider recognition of the project. It was stated that all social media accounts related to the project should be visible on the volunteering match platform along with other important information about the project.

C. Communication

According to the comments of the participants, people have difficulty allocating time for volunteering projects, due to having other responsibilities demanding their time like work or family. It has been said that effective assistance and volunteering cannot be provided by the projects if the number of active participants is low. However, sending periodic reminders about ongoing volunteering projects may help motivate users of the platform to make time for volunteering in their busy schedule and increase the number of active participants in the projects, hence, project goals may be met more easily. Therefore, according to the participants, like volunteering projects, also for volunteering match platforms it is very important that they use their social media accounts effectively to get in touch regularly with their users to increase volunteer engagement. Participants also suggested that in addition to social media, to communicate effectively with their users, volunteering match platforms should provide up-to-date information on the projects through other mediums like blog posts, websites, weekly e-bulletins and sms. Participants also indicated that these communications should be tailored according to the platform users' interests, so that users can be informed only about the progress of projects conducted in their areas of interest. Customization of communicated messages is also important not to drown potential volunteers in unrelated information which in turn may lead to total ignorance of incoming messages and finally to losing interest in volunteering.

V. CONCLUSIONS

The internet has provided convenience to the field of volunteering, just as it has provided to other fields, and the concept of online volunteering has emerged. In this context, volunteering match platforms that bring together people who want to take part in volunteering projects and volunteering opportunities have emerged. Via using these platforms, people can help people they have never seen, provide financial support, and take part in volunteering projects in many fields. To help volunteering projects reach more people who want to volunteer or provide some type of support, so that they can meet their project goals more easily, volunteering match platforms should understand which aspects other than the project topic impact volunteers' engagement decisions, and they should design and manage the platform accordingly.

In this study, interviews were conducted with 8 potential users of the newly established volunteering match platform in Turkey, Köprü Project. It was seen that the most noted aspect impacting project preference was trust. People want to trust the platform and the project before they consider taking part in a volunteering project. To make people trust, comprehensive information about the founders of the projects, founders of the platform, supporting organizations behind the project, and links to ensure the financial transparency of the project should be accessible via the volunteering match platform. Another finding was on the use of social media, which was consisted with the findings in the literature [11]. Participants emphasized that active usage of social media is indispensable for volunteering projects to reach more people and increase recognition. The lastly indicated expectation was on platform's communication with its users. It has been determined that it is extremely important to update the platform users about ongoing events/projects or project outputs via multiple mediums to increase volunteer engagement. According to the results, it is believed that if newly established volunteering match platforms such as Köprü Project are to meet these expectations and aspects through their design and platform management, they can reach more volunteers, increase their resources, serve more people, and raise awareness in the field of volunteering.

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Food Waste and the Situation in Turkey

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Abstract— The aim of this article is to give information about the situation of food wastes in Turkey, which is one of the environmental problems that are getting more serious with the scarcity of resources in the world we live in, and to make suggestions about what sustainable steps can be taken regarding the recycling of these wastes. The food industry is an area that has a large share in every country, is constantly developing, and in this direction, its wastes and losses are increasing. For this reason, food waste is one of the most important issues that have come to the fore in the world recently and is among the seventeen sustainable decisions announced by the United Nations in terms of both reducing the hunger dimension to zero and waste management. Although Turkey has taken very recent steps in sharing of food waste rates and the recyclability of this waste, it was revealed in a previous study that the daily waste rate of bread, which is considered one of the basic foods, is approximately 5.9 million loaves of bread were wasted per day and 2.1 billion pieces of bread were wasted annually. While the increasing situation of these data poses an alarming danger not only in terms of individual but also in terms of environment and economy, the fact that hundreds of people are dealing with malnutrition and famine problems in many parts of the world also creates an ethical problem. It is seen that the Ministry of Agriculture and Forestry has started to cooperate with the United Nations Food and Agriculture Organization (FAO) on food waste in Turkey and is working for progress in this field with the sustainability targets in the food sector, which it has announced in its development plans. At the same time, institutions were established to serve this purpose with organizations such as Food Banks and Surplus Food, and in addition to all these, the National Strategy Document and Action Plan on the Prevention, Reduction and Management of Food Loss and Waste in Turkey was published in 2020.

Keywords— Food Waste; Sustainability; Turkey; Food Waste Management.

I. INTRODUCTION

In order to ensure the continuity of life on Earth, it is necessary for the environment we live in to be in balance and for human life. All living things live in their own ecosystems. Pollution of essential substances such as air, water and soil in these habitats or a disruption in their cycles makes all living things and living conditions in this ecosystem difficult [1].

The food industry is an area that has a large share in every country, is constantly developing, and in this direction, its wastes and losses are increasing. Every year, as much as China's land area is used to grow food that goes to waste, wasted food makes up 8% of global greenhouse gas emissions, placing it in the second place after road transportation in this area. The increasing amount of waste in our world not only restricts our living space, but also causes damage while narrowing this space. This means that it causes more damage and destruction to ecosystems day by day [2]. Food waste, which is called and evaluated as solid waste, has become a global problem today [3]. Food waste poses a direct threat to environmental, social and economic sustainability. For this reason, food waste is one of the most important issues that have come to the fore in the world recently [4] and is among the seventeen sustainable decisions announced by the United Nations in terms of both reducing the hunger dimension to zero and waste management. Many countries, businesses and non-governmental organizations are working in different areas related to food waste because this topic creates both an environmental and an economic problem and creates many ethical problems for every institution and person [5].

II. CLASSIFYING AND DEFINING WASTE

Waste is the whole of outputs that are formed in every area where consumption is made and differ from garbage. UNEP defines waste as a: "Wastes are substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law" [6]. The concept of waste is different from garbage because garbage is the residual material that cannot be recycled or recycled in any way.

When it comes to food, we must first define food loss and food waste. Food loss refers to the reduction in the mass of edible food along the portion of the production chain that makes up food produced for human consumption. Food losses in different sizes can occur in the production, post-harvest and processing stages in the food supply chain [7]. The surplus that arises due to the behavior of retailers and consumers, which constitutes the end of this production chain, is more commonly referred to as "food waste". Although it is used for purposes such as feed, bioenergy, etc. after the losses in the food production chain, it continues to be called food waste. According to the Council of Europe, waste is substances or objects that are disposed of or intended to be disposed of in accordance with the provisions of national law. We can classify food waste, which is considered as solid waste, as edible food waste and inedible food waste. Edible food waste can be expressed as waste from the kitchen (in the food preparation stage) and waste from the customer (plate waste) of the enterprises in the food and beverage service sector. Non-edible food waste, on the other hand, is the expression used for wastes such as bone, eggshell, coffee grounds that cannot be consumed by humans [8].

The Food and Agriculture Organization [9] reported that approximately 30% of the food produced for human consumption in the world each year is considered lost or disposed of by being thrown away [10]. FAO reports that 1/3 (1.3 billion tons) of the total amount of food produced in the world every year is wasted and its economic value corresponds to 990 billion dollars. While the total amount of solid waste produced in Turkey in the 1960s was 3-4 million tons per year, the amount of solid waste collected by municipalities increased to 25,845 million tons according to 2012 data [11]. In the statement made by the Chairman of the Central Council of the Turkish Veterinary Medical Association (TVHB), Ali Eroğlu stated that approximately 25 thousand people die every day in the world due to hunger. It has been announced that approximately 600 million people become ill every year due to consuming unsafe food, and 420 thousand people out of this data have lost their lives because of this [12].

III. DRIVERS AND REASONS FOR FOOD WASTE

Food waste is an issue that needs to be addressed both individually and industrially. Areas such as hotels, restaurants, production facilities cause many food wastes due to overproduction, unnecessary storage, not being able to be used on time, bad raw materials and similar reasons. Minimizing food waste or being able to evaluate the waste is a versatile and important concept that can be addressed in terms of both quality and production, especially in mass production facilities. In the research conducted by Kılınc and Bekar [13] on waste generated in five-star hotels in Turkey in 2018, it was determined that approximately 180 tons of food waste was produced per month and the ratio of total food waste generated in a day to other wastes was as follows. about 70% (or 7/10) in calculations. When we examine and exemplify the main causes of food waste under headings, throughout the food supply chain (from farm to fork), we can list them as follows:

- Agricultural production
- Manufacturing: Loss of quality and product due to contamination and improper production in the production process
- Distribution and wholesale/retail: Not displaying the products whose expiry date is approaching on the shelves or creating an excess of products by overstocking may cause waste and losses.
- Hospitality industry and catering: Cooking more food than demanded, increasing the number of foods that goes to waste with an open buffet style approach may cause an increase in food waste.
- Households: Reasons such as not doing planned grocery shopping, not reading labels such as the consumption date, not doing a good storage, not knowing how to evaluate the leftover food can cause an increase in household food waste.

The amount of solid waste produced per capita is affected by many factors such as living standards, habits, industrialization, urbanization, customs and traditions, seasonal variables and the education level of individual [14]. For this reason, the prevention or reduction of food waste as much as possible, its correct disposal and recycling, if possible, are among the most important issues in the food chain [15].

IV. SUSTAINABLE STEPS FOR REDUCING FOOD WASTE

There has been an increasing interest in the sustainable management of food waste in the world in recent years. The European Union (EU) increased consumption of natural resources and the linear economy to prevent environmental damage; In 2019, it announced the Green Deal, which has a comprehensive approach. This agreement contributes to studies on recycling and recycling technologies for food waste by developing an intersectoral integration in one branch of the food chain in all countries.

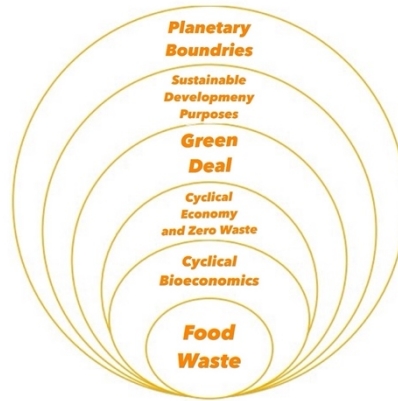


FIGURE 1

THE GREEN DEAL, BIOECONOMY AND ZERO WASTE RELATION

(Fig.1. was taken directly from Maçin K.E., 2021)

As a result of the study called "Resources, Conservation and Recycling" conducted by Priefer et al. in 2016, they made some suggestions for the prevention of food waste. Some of them are as follows;

- Setting national, regional and local level food waste reduction targets and agreeing on voluntary commitments for key industries such as manufacturing, retail and hospitality.
- Establishing Integrated Supply Chain Management to reduce food waste and increase coordination throughout the food supply chain and review existing food safety regulations and practices to identify causes of food waste.
 - Giving information to increase awareness of expiration dates and reducing individual food waste and increasing the channels where household surplus food can be donated or evaluated.
 - By opening new marketing channels to create direct connection channels between producers and consumers, waste generation can be prevented.
 - Individual and industrial food waste can be reduced by restructuring both national and regional taxation and obligations regarding waste food regulations.
 - Standard portion sizes per person, careful menu planning and improvement can be done to combat food waste in the tourism and entertainment industry [16].

In order to reduce and recycle food waste at every point of the production chain, the concept of waste management must be understood and applied. Waste management should offer solutions on how to design, improve and operate the process to minimize material and energy waste, while at the same time presenting a proposal on how to evaluate the remaining waste. With a suitable solution, the waste of one substance can become a valuable raw material for another substance [17]. What can be done to prevent or minimize the formation of these food wastes, respectively; preventing wastes before they occur at the source, delivering wastes suitable for human use to those in need, recycling wastes suitable for animal consumption

(e.g. food scraps, etc.) that are not suitable for human consumption, composting and correct evaluation of unused food wastes. The last option is the appropriate incineration or storage of food waste, which cannot be recycled, without harming the environment.

V. FOOD WASTE SITUATION IN TURKEY

To better understand the food waste nationwide, we can look at the results of the "Bread Waste in Turkey Research" conducted by TMO in our country. As a result of this research, it was revealed that approximately 5.9 million loaves of bread were wasted per day, and 2.1 billion pieces of bread were wasted annually. It was added to the report that the monetary value of the bread wasted annually is 1.5 billion TL, 500 schools and 80 hospitals can be built with this money. When the data in the same study is compared with the data obtained in 2012, while 2% of the total bread production was wasted in 2008, this rate unfortunately increased to 3.1% in 2012. In order to minimize this waste and to ensure the recycling of this waste, institutions such as food banks operating in many countries in our country have started to work. food bank; They are organizations formed by associations, foundations or associations that store all kinds of donated or surplus food under appropriate conditions and deliver these products to people in need of food aid, either directly or through charity organizations [18].

Under the coordination of the Ministry of Commerce, a working group was established with the participation of the Ministry of Transport and Infrastructure. Turkey Green Reconciliation Action Plan includes 8 main headings. Three topics in this study and the details of the plans were shared:

- Carbon Border Adjustment (CBAM)
- A green and circular economy
- Green financing and Diplomacy
- Clean, economical and secure energy supply
- Sustainable agriculture
- Sustainable smart transportation
- Combating Climate Change (including being carbon neutral)
- European Green Deal information and awareness activities.

In Turkey, food waste is mostly formed at the "production" stage of the production chain. Although the importance of the agricultural sector and food waste is known, the exact numerical data on the amount of waste and its management in Turkey are unfortunately still unknown [19]. Attention is drawn to the importance of raising the awareness of the producers with Good Manufacturing Practices (GMP) in order to prevent and reduce the losses that occur during production, harvest and post-harvest in fresh fruit and vegetable products where food waste is the highest [20].

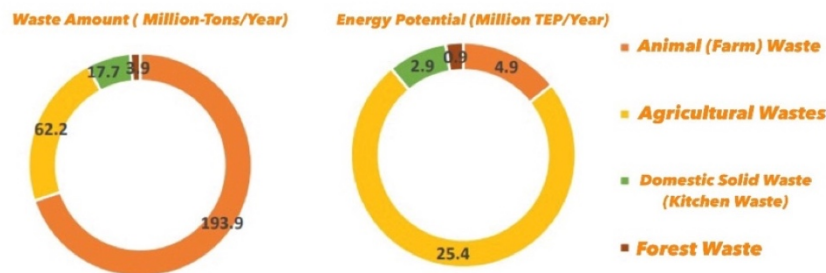


FIGURE 2.

AMOUNT OF WASTE AND ENERGY POTENTIAL PRODUCED IN TURKEY (BEPA, 2020)

(TEP: Tonne equivalent oil: 10 million kCal) (Fig.2. was taken directly from Maçin K.E., 2021)

VI. CONCLUSION

In this article, the concept of food waste was examined closely and general information about the situation of food waste in the world and in Turkey was shared. In the food waste scheme, it is very important to prevent food waste, if possible, before it occurs at its source, or to try to reduce it to a lower rate. Today, food waste has become a global problem that carries risks in many aspects affecting humanity in our world, which is changing and developing in terms of technology and industry. In order to combat this situation, it is seen that national, regional and worldwide legal authorities and non-governmental organizations are taking action with more definite and big steps. It is obvious that the disposal and recycling of food waste has a more important and complex structure than is thought. Today, it is understood that the food waste rate and the factors affecting this rate do not depend on only one variable and should be examined in many ways. As a result, it is seen that there are many steps to be taken in the fight against this issue, both in the individual and industrial fields, and this can be achieved with the necessary regulations by raising the awareness of the society.

It is necessary to ensure regular controls of these steps taken nationally, to impose industrial-level obligations, and to increase efforts to minimize waste before it occurs. However, Turkey should take more constructive and definite steps for both individual and sectoral awareness in terms of recycling. Although waste management remains mostly at the level of domestic and individual volunteering in practice in today's Turkey, this situation needs to be brought to sectoral levels as soon as possible with a fast and effective planning, making it a necessity.

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Global Advances in Engineering Management

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Abstract— This paper starts with providing an overview of Engineering Management principles, practices, standards and body of knowledge. Contributions to the discipline of Engineering Management are compared in terms of geographical regions. Global advances in the discipline are considered by exploring Engineering Management education programs around the world, as well as publications in the field of Engineering Management globally during the two time periods of 2002-2011 and 2012-2021. The number of certified engineering managers in different geographical locations is also presented. Comparisons are made between different regions. As a way of assessing where the contributions are coming from versus where the opportunities are for expansion, we propose a ratio of Engineering Management effort to contribution. This ratio could consider the number of registered engineering companies in a region versus the number of education programs and the number of certified practitioners. In Australia, for instance, there are a large number of engineering endeavours, but the discipline of Engineering Management does not have a high profile. This ratio is proposed as a way of ascertaining where there are disparities and consequently opportunities for growth.

Keywords— Engineering management, global advances, past and current trends

I. INTRODUCTION

Engineering Management (EM) applies the principles of management to the domain of engineering practices and endeavours: that is, the business application of engineering. Engineering managers are trained to combine technological problem-solving capacity with organisational and management abilities to oversee complex engineering businesses. EM education covers a wide range of topics across finance, systems, modeling, quality, intellectual property, operations, human resources, psychology, and organisational health and safety. The oldest EM department is generally believed to be located at the Stevens Institute of Technology and was established in 1902 [1]; at that time it was called the Department of Business Engineering. Kocaoğlu [2] asserted that EM has been offered as a formal degree since the mid-1940s, but that courses in business and management aspects of engineering were offered before that time, from the early 1900s. The first academic department of EM was established in 1967 at the Missouri University of Science and Technology [3], and the first PhD was awarded there in 1984 [4]. Elia, et al. [5] point out that EM expanded rapidly in the 1960s and 1970s, following expansions after World War II, when many other programs were focusing upon operations research, whereas EM was attuned to decision-making for strategic and operational leadership, given emerging technologies.

There have been various attempts to define the domain. Elia, et al. [5] comment that the historic focus of the domain has been upon "...integrating scientific, engineering, and management know-how to contribute effectively to the functioning of organizations and industries." These authors highlight the need for what they call "management engineering" due to the major transformations we are now experiencing concerning the technological, geopolitical and social landscape, and promote the usefulness of this discipline combining engineering and management as a cross disciplinary area, in promoting innovative solutions for the wider benefit of people, organisations and societies. They suggest that the new name of management engineering, which was first introduced in the 1950s, was taken up in health systems operations and in particular the designing of systems to support change within such structures. Others have also posited the name management engineering [6]. The interdisciplinary nature of the field combines technical knowledge, management knowledge and planning capabilities, and the application of the field is broad, based upon the pillars of managing the technological life-cycle and managing a system through its constituents of people, projects, organisation, resources, strategy and technology [7]. The conceptual basis of the discipline arises originally from industrial engineering [4].

It is becoming increasingly clear that interdisciplinary approaches such as that represented by EM provide significant benefits. A retrospective by Allen and Sosa [8] examined the previous 50 years of the Journal

IEEE Transactions, asserting the great benefit to the discipline accruing from its cross disciplinary nature, which attracts both academics and practitioners from many different domains, and can therefore address many questions of a general nature that have broad appeal. They forecast an increased trend towards such cross-fertilisation; a trend which has come to pass. Cunningham and Kwakkel [9] reviewed the evolution of knowledge in the field across 60 years of history and note a fivefold increase in papers in the field in the 1980s and 1990s, with EM emerging as a mainstream research field in the 1980s. They comment that in the 1990s and 2000s, there was increasing specialisation and professionalisation of the EM field. These authors conclude that EM is becoming more applied and giving increasing attention to business firms and industries.

The Handbook of Engineering Management (2nd Edition) lists the following topics in its index: Engineering Management, past, present and future/professional responsibility, ethics and legal issues/management theory and concepts/managing knowledge workers/types of IP/leading individuals and the engineering project team/managing the multigenerational knowledge based workforce/operations research/simulation/decision analysis/multi-criteria analysis/engineering informatics-state-of-the-art future trends/basic accounting and finance/engineering economics/project management role in EM/systems engineering/systems thinking/ risk management/quality management/strategic management/innovation and entrepreneurship/supply chain management. This is a very broad range of topics that could be categorized under the following subcategories: leadership and management challenges; technical/engineering challenges; and business challenges. The content in the domain of EM is particularly relevant in these times of significant disruptive change, transformations in decision-making, huge advances in technology and cyber physical systems characterised by ubiquitous digitisation, blending of the biological and physical, continuous reinvention, autonomous systems, mobile supercomputing, AI and robotics. As noted by Elia, et al. [5], EM is right on the border between organisation and technology, applying the practices and principles of management within the engineering domain, with the objective being to help strategic and operational leadership to make the right decisions in the face of current and emerging technology.

This paper considers the discipline of EM from a global perspective: where are the concentrations of EM effort in terms of publications, education, certified practitioners, and engineering companies? While one might expect that initial efforts would be concentrated in the US, the paper considers the spreading of this important discipline around the globe and where there may be shortages indicating a need for attention and growth.

II. PUBLICATIONS IN ENGINEERING MANAGEMENT: 2002-2011

Research was undertaken to identify the quantum of publications of various kind by region and country that had the words “Engineering Management” in the title. The first search was for the decade 2002 to 2011, using the database Scopus and the following string: TITLE ("Engineering management") AND PUBYEAR > 2001 AND PUBYEAR < 2012. Scopus was chosen for this search because it is the largest abstract and citation database of peer-reviewed literature and gives a comprehensive overview of global research output in the fields of science and technology, social sciences, medicine, and arts and humanities. During this decade there were a total of 373 publications of all kinds; and of these, 188 originated from the United States, 51 from China, 13 from the UK, 13 from Australia, 8 from Canada, 7 from South Africa, 4 each from Germany, Italy, and South Korea and 3 from Israel and Japan. Several other countries had 2 or fewer publications. Figure 1 displays the global origin of publications in this earlier decade, and clearly shows the dominance of the US at that time.

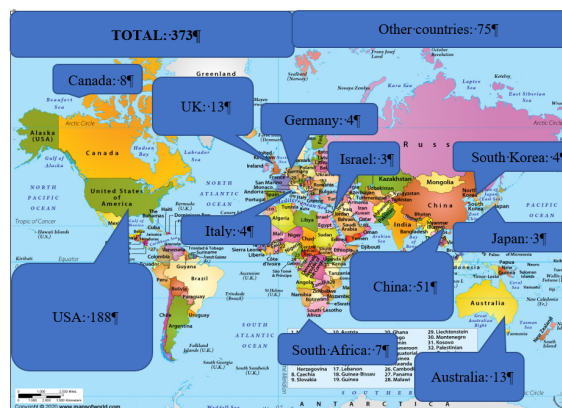


Figure 1. Publications with “Engineering Management” in the title, 2002 to 2011

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When seeking affiliation of these publications, the list is dominated by the Stevens Institute of Technology, Missouri University of Science and Technology, and Old Dominion University. In terms of source type, 256 were conference proceedings, 91 were journals, 14 publications were from book series, 11 from trade journals and there was one book.

When searching document type, there were 228 conference papers, 77 articles, 35 conference reviews, 15 editorials, 7 reviews, 5 retracted offerings, 2 book chapters, one book, one letter and one errata. Figure 2 below presents frequencies of the various kinds of publications.

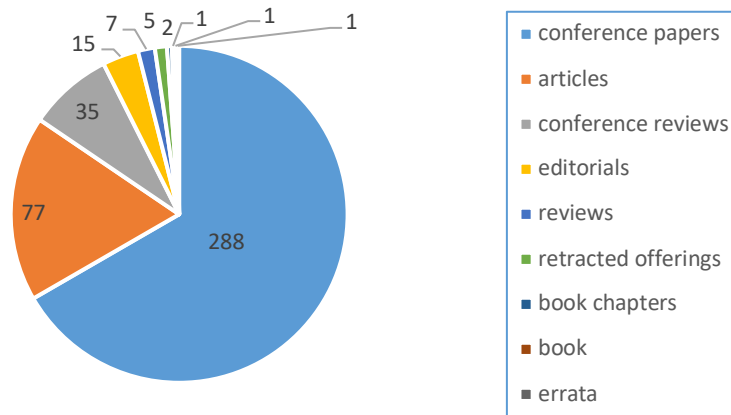


Figure 2. Frequency of types of publications in EM, 2002-2011

The number of publications per year is presented below in Figure 3.

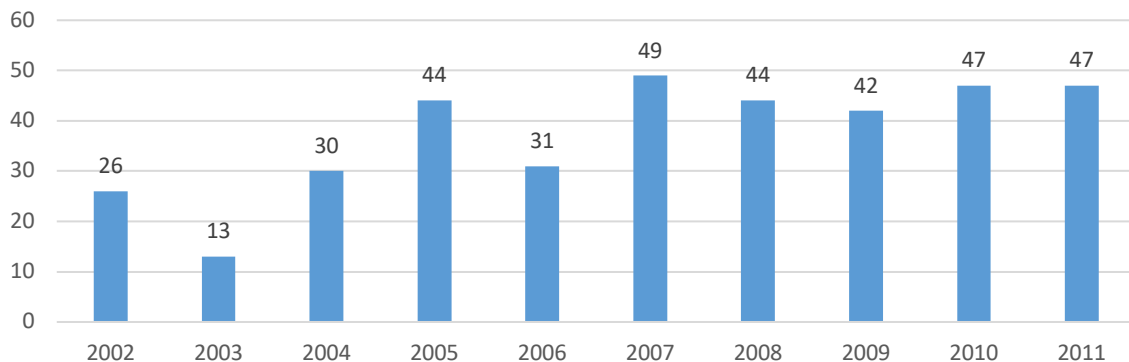


Figure 3. Number of publications in EM between 2002 and 2011

Of the articles published, 43 originated from the US, 5 from Australia, 4 from the UK, 3 from China, 2 each from Columbia, Iran, Italy, and Romania, and one from both Germany and Israel. The Engineering Management Journal was the publisher of 23 of the 77 articles and by far the biggest publisher. 72 articles were in the English language, 3 in Chinese, and one each in German, Russian, and Spanish.

III. PUBLICATIONS IN ENGINEERING MANAGEMENT: 2012-2021

Next, the decade 2012 to 2021 was searched using the string as follows; TITLE ("Engineering Management") AND PUBYEAR > 2011 AND PUBYEAR < 2022 This search revealed 458 document results in total. Of this total, 139 emanated from China, 105 from the US, 17 from Australia, 16 from South Africa, 13 from both Germany and the UK, 8 from the Russian Federation, 7 from both Italy and Portugal, and 6 from Canada. Figure 4 reveals a reduced dominance by the US and increasing numbers of publications from China and South Africa. Comparison of Figures 1 and 4 show that although US still accounts for a large number of publications, China is now in the lead. Russian Federation is a new joiner here, as are Netherlands, Portugal, Israel and South Korea.

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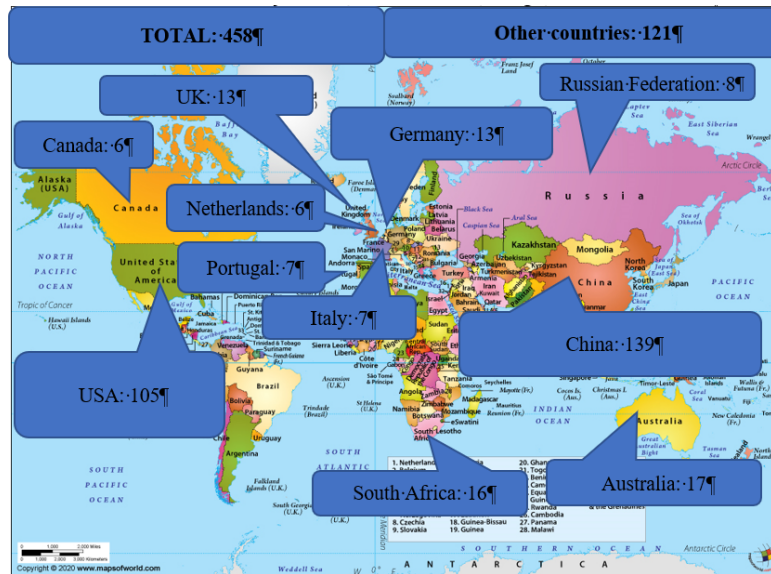


Figure 4. Publications with “Engineering Management” in the title; 2012 to 2021

Affiliations of these publications changed during this most recent decile: University of Johannesburg was the affiliation for 11 publications, Old Dominion University and Sichuan University produced 8 publications, and Stevens Institute of Technology produced 7. The source type of these publications were 276 conference proceedings, 112 journals, 54 book series, 13 books and 3 trade journals. In terms of document type, there were 254 conference papers, 84 articles, 71 conference reviews, 12 editorials, 10 errata, 9 book chapters, 9 reviews, 6 books, one letter and one note. Figure 5 shows the frequencies of the different types of publications. Comparison of Figures 2 and 5 indicate fewer conference papers, more journal articles, and more conference reviews in this later decile.

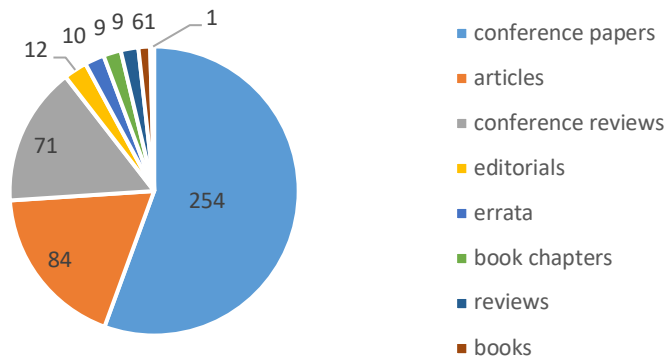


Figure 5. Frequencies of various types of publications in EM, 2012-2021

Figure 6 presents the total number of publications year by year. There seems to have been a drop in 2015, but there is clearly an expansion as we approach the current time, and no impact of the pandemic is evident here.

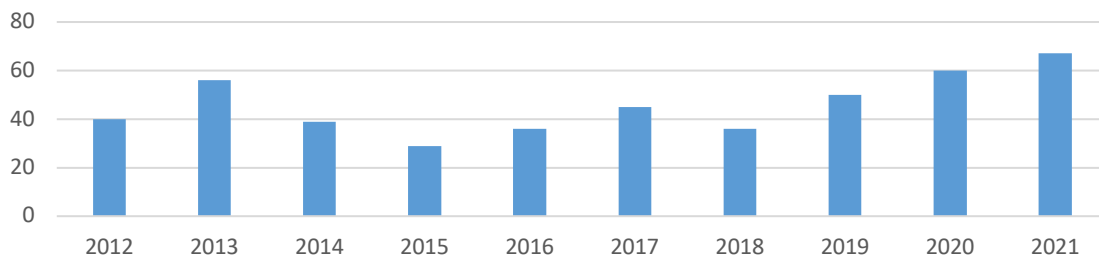


Figure 6. Number of publications in EM in each year between 2012-2021

Of the 84 articles published, 7 were published by the Engineering Management Journal, and 4 each by IEEE Engineering Management Review and Transactions on Engineering Management. 76 articles were in English and 8 in Chinese.

IV. EDUCATIONAL PROGRAMS IN ENGINEERING MANAGEMENT

A search was conducted to ascertain the number of education programs in EM in different countries around the world. A search of Google using the following string was conducted; "engineering management programs in country name". It is acknowledged that this search is somewhat limited; however, it does give a broadbrush indication of proportionate contributions. A total of 293 programs are offered around the world in EM. Of these, there are a total of 74 programs in North America. 62 are in the US: 2 doctoral programs (one at George Washington University and one at Stevens Institute of Yechnology), 27 masters programs, and 33 bachelors programs. Of the remainder, there are 14 EM programs in Canada: 3 bachelors programs, 9 masters programs, and 2 doctoral programs (at the University of Alberta and University of Waterloo). In South America, there are three programs in Mexico, 2 in Brazil, 4 in Argentina, 5 in Columbia, 2 in Peru and one in Venezuela. In the continent of Africa, there are 4 programs in Nigeria, 3 in Egypt, 2 in Tanzania, 9 in South Africa, and one each in Ghana and Cameroon. Within Europe, there are 11 programs in Russia (with 5 of these in Moscow), 14 programs in Germany (none at the doctoral level), 39 programs in the UK, 9 of which are bachelors and the remainder masters degrees, 8 programs in France, 17 programs in Italy, 5 in Spain and one in Cyprus. Within Asia, 10 programs are offered in Turkey, 16 programs in China (including 2 doctoral programs). There are 10 programs in Pakistan, 6 in India, 4 in Japan, 3 each in Indonesia, South Korea and Indonesia, 2 in both Thailand and UAE, one in Hong Kong, Kazakhstan and the Philippines. Within Australasia, there are 4 programs in New Zealand and 19 programs in Australia. Figure 7 presents the breakdown by country of educational programs in EM.

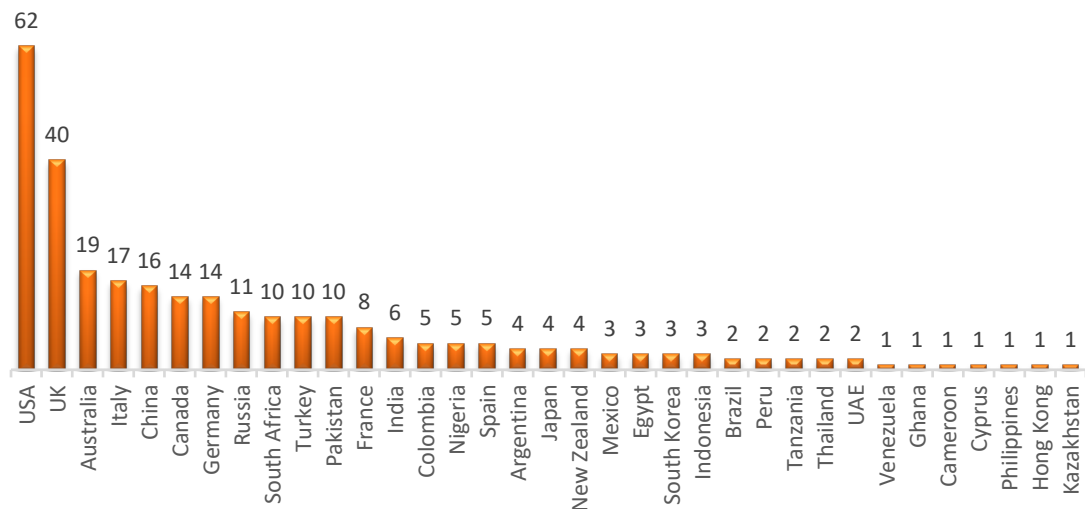


Figure 7. Offerings of educational programs in EM globally

V. NUMBER OF CERTIFIED ENGINEERING MANAGERS BY REGION

The location of certified engineering managers by country in alphabetical order is as follows (data provided by ASEM Head Office): United Arab Emirates, Australia, Bahrain, Belgium, Canada, China, Denmark, Egypt, Hong Kong, Indonesia, Ireland, Kuwait, Mexico, Namibia, Netherlands, Nicaragua, Nigeria, Pakistan, Peru, Philippines, Qatar, Saudi array, Singapore, Sweden, United Kingdom, USA. The issue of certification of EM professionals and the need for development here was noted by Kotnour and Farr [3], who made comparisons with the progress made by some other professions, for example Project Management Institute. As this author noted: “For the long-term health of the profession and practice of Engineering Management, there needs to be clarity and explicitness in the intent of the certification effort.” [3]. The issue of certification is picked up in the following section.

VI. RATIO: EM EFFORT VERSUS CONTRIBUTION: US VERSUS AUSTRALIA

In terms of a comparison between US and Australia, there are 297 current certified EM professionals in the USA and one in Australia. The total number of engineering companies in the US is 225,921 (BoldData). Of those, Los Angeles has a 3% market share with 6728 engineering companies. Chicago has 5233

engineering companies. The third largest number of engineering companies occurs in Santa Ana; 4422. A search for engineering companies in Australia from the same site reveals a total of 45,780 companies. Sydney, being the largest city, has about 25% of these: 11,489 engineering companies. The second largest city is Melbourne and it hosts some 9,600 engineering companies (21%). Brisbane also has a large number of engineering companies: 7200.

Taking the comparison of US versus Australia, the ratio of certified EM professionals to engineering endeavours in the US is about 753. Considering the ratio of engineering endeavours versus publications, the result is about 3500. The same ratio in Australia is so tiny as to be not worth calculating. However in considering this ratio of engineering endeavours versus the number of EM education programs, the situation is less stark. In the case of the US, the ratio of engineering firms to programs is around 3645. In Australia, the same ratio is about 2400. It is still possible to say, even given the number of programs in Australia, that there is room to expand.

CONCLUSION

The nature of our current society, with its rapid change and the increasing degree of interconnectedness between people and technology, offers a great future for the discipline of EM. Considering behavioural and social dimensions of the people working in engineering endeavours is becoming ever more important, given the complexities of globalisation, astronomical growth in technology, and greater involvement and expectations of stakeholders. As noted by Chang [10], practitioners of EM need to take on leadership roles to meet these challenges. Adding value, focusing on customers, and taking a business perspective, are all important and desirable competencies and mindsets. Engineering managers have access to the approaches and tools that can develop and sustain competitive advantage and assist firms to expand globally. Possessing broad-based perspectives and in-depth skills and knowledge equips engineering managers with strong leadership potential in the current dynamic environment. Practitioners of EM have just the right set of skills and tools to bring value to the success, organisational climate, and bottom line of EM endeavours. This paper has shown an increasing level of international spread of the discipline when considering publications and EM education programs. Certifications offered by ASEM have not kept pace. It is recognised that there are some limitations in the searches conducted in this paper. The search for publications was limited to Scopus and limited to publications which had the words “engineering management” in the title. Scopus does not include procedures of smaller conferences and symposia. The ratio of effort versus contribution was illustrated only by comparing US and Australia. There are other regions, especially China, where there is much engineering activity and the ratio of effort to contribution evident in the US may not be seen. The point of this paper is to give an overview and comparison of efforts in EM globally. There is plenty of room to advance the recognition of the EM profession worldwide and to educate professionals in this domain.

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IIoT Vendor Selection Framework Using Novel Hybrid CRITIC-ELECTRE Multi Criteria Decision Making Model

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Abstract— Industrial Internet of Things (IIoT) solutions become the backbone of manufacturing organizations. Investigating requirements to select the best solution is key for successful project lifespan. Selecting the best alternative among all options, with respect to multiple criteria is known to be multi-criteria decision making (MCDM) problem. In this paper, comprehensive literature review was done to identify the most critical technical IIoT system requirements for manufacturing organizations. Moreover, novel hybrid CRITIC-ELECTRE framework is introduced for the first time in literature to the best of the authors knowledge. The subjective weighting was replaced by structural CRITIC approach, combined with ELECTRE as a consistent framework to guide companies evaluating their solutions for the future. The aim is to improve competitiveness and efficiency, as well as providing support to organizational digitalization strategy. An industrial case study is demonstrated to verify the feasibility of the suggested method as well as providing guidance to the participating companies.

Keywords— Industrial Internet of Things (IIoT), Vendor Selection, Multi-Criteria Decision Making (MCDM), CRiteria Importance Through Inter-criteria Correlation (CRITIC), ELimination Et Choice Translating REality (ELECTRE)

I. INTRODUCTION

Since almost one and a half decades ago, the importance of Internet of Things (IoT) systems became vital in the world. IoT Systems interconnects physical and digital environments without the need of advance human interactions [1]. These systems are used in multiple areas such as transportation, smart homes, healthcare, smart-cities and smart-industries [1–3]. The usage area for IoT systems are covering but not limited to energy management, overall equipment efficiency analysis, asset tracking and facility management [2]. According to researches done by McKinsey, Goldman Sanch and others, one of the biggest usage will be on the industrial manufacturing plants and the wave of IoT is expected to be stronger than previous internet and mobile waves [4]. 50 billion predicted connected device by 2020, will surpass the entire human population. Machine to machine communication is expected to consume 45% of the total internet usage alone [3, 5]. The IoT systems used in manufacturing, for the purpose of smart-industries (industry 4.0) are called Industrial IoT (IIoT) systems. Considering that the production environments are very dynamic, the decision making happens regularly. These systems, which are accepted as the backbone of production, are responsible for giving critical human decisions automatically to avoid disasters and reshape the business models around the entire company [3, 4, 6]. IIoT systems consist of, sensors, computers and communication interfaces. They are using hardware, software and network infrastructures to optimize quality and production efficiency with massive volumes of data to be processed and stored in special form and shape [4, 7]. In order to gain insight of the shop floor, in order to improve and manage; scheduling, machine loads and quality, each machine needs to be tagged and status should be gathered constantly [8]. Information technology (IT) and operational technology (OT) systems need to be merged to improve added value. Such integration is known to be service oriented architecture (SOA). Due to utmost importance of IIoT systems, manufacturing companies are evaluating whether to implement their own systems or to buy out-of-the-shelf (OOTS) package solutions. Based on multiple studies, IT strategy suggests organizations to move from in-house development to purchasing. In order to save cost and benefit from long term partnership with the vendor [9–13]. Moreover, up to 80-90% of existing systems share a common implementation and only around 10-20% is customized for the specific needs [14]. Purchasing OOTS solution is assumed to be easier. However, the success of the project is determined not only by the

quality and ease of use of the software, but also by the vendor's communication and cooperation, implementation success and management of organization wide business processes [9, 15–17]. OOTS software purchasing not only saves time and budget. OOTS software helps companies gain significant advantages in terms of productivity, responsiveness and on-time, in-budget deliveries [11, 18]. Companies that decide to buy IIOT software need to form evaluation teams from experts, list potential candidates, define requirements and apply multi-criteria decision making (MCDM) framework to select solutions with analytical guidance [11, 14, 19]. As clearly seen, selecting software is a very challenging task due to three main reasons, those are, poor planning, changes in project scope, lack of management support [14]. The failure rates are as high as 85% [14, 20]. Forming a team of minimum six people to as large as hundred full time equivalent people requires number of sacrifices [10]. The bias of the team in defining criteria and subjective selection method could jeopardize the success of the company [12, 21]. On top of internal challenges, there are a number of external challenges that could cause additional bottlenecks such as, increasing competition, market related risks and customer demands [14]. Besides all, most organizations fail in their selection process. Because these companies directly rush into alternatives' comparison, forgetting the importance of structural information gathering and systematic comparison methods [15]. In most of the studies, benefits of implementing IIOT systems were discussed. Assessing the return of investment (ROI) is critical. However, success of ROI calculations are heavily dependent on assessing the technical needs which fit best to the organization stipulation. Our aim in this study is to identify a systematic technical IIOT vendor selection framework for manufacturing companies. In order to reduce the bias coming from the experts; systematic MCDM model is required. There are a number of MCDM models such as AHP, ANP, PROMETHEE, VIKOR, ELECTRE, TOPSIS and many others. All methods use different techniques to choose the best outcome or rank the alternatives based on their satisfaction. However, as the satisfaction to select certain alternatives is important, dissatisfaction based on a criteria is something to keep an eye on.

Therefore, ELECTRE (ELimination Et Choice Translating REality) method is selected. In most cases a MCDM model requires

- Decision Criteria
- Alternatives
- Expert Criteria Weighting
- Decision Maker Scores

In ELECTRE method, the weight of the criteria can be selected equally. Nevertheless, most companies have unique requirements and desire variable weighting. In most of the cases, the weighting was gathered from experts of the domain. On the one hand, finding experts on newly growing domains such as IIOT is difficult. On the other hand, providing both weighting and alternative scores by the same expert group creates a potential bias. In order to avoid bias and considering satisfaction as well as dissatisfaction among alternatives, systematic and objective weighting system called CRITIC (CRiteria Importance Through Inter-criteria Correlation) is selected to form novel hybrid CRITIC-ELECTRE MCDM framework. To the best of the authors knowledge, hybrid CRITIC-ELECTRE method has not been presented in the literature before. The remainder of this paper is organized as follows. Section 2 is devoted to the literature review which consists of two subsections. Subsection 2.1 is about CRITIC and ELECTRE methods' history and subsection 2.2 is about technical IIOT vendor selection criteria. Section 3 shows the methodology followed by suggested methods' case study application in section 4. Lastly, section 5 shows the result of the method and section 6 discusses the outcome, concluding remarks and future work suggestions.

II. LITERATURE REVIEW

A. Multi Criteria Decision Making

MCDM is a commonly used technique, in evaluating the multiple alternatives with respect to multiple decision criteria. Due to the fact that, criteria among each other has different importance, a weighting system should be used to differentiate their effect. After the criteria and alternatives are defined, CRITIC method is used to weight the criteria in order to objectively and efficiently define their values as suggested by Diakoulaki, Mavrotas, and Papayannakis. The beauty behind the CRITIC system is the power of objectively converting the intrinsic information into analytical weighting system [22]. The aim is to show the amount of information stored in each category. The method is based on correlation which shows the conflict between weights and standard deviation which shows the contrast intensity of criteria calculations [23]. The CRITIC weighting system is used in a number of studies. Software selection problem was addressed by Tus, and Aytac, Adalı [24], 5G industrial evaluation was done by Peng, Zhang, and Luo [25],

logistic provider selection was done by Ghorabae et al. [23], population vulnerability analysis was done by Miao et al. [26] and renewable energy system evaluation was done by Babatunde and Ighravwe [27]. Besides the weighting, the MCDM or Multi Criteria Decision Aid (MCDA) methods are required to evaluate the alternatives. Most well known MCDM methods including but not limited to AHP (Analytic Hierarchy Process), ANP (Analytic Network Process), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), DEMATEL (Decision Making Trial and Evaluation Laboratory), COPRAS (Complex Proportional Assessment), VIKOR (VIsekriterijumska optimizacija i KOmpromisno Resenje), MULTIMOORA (Multiobjective Optimization by Ratio Analysis plus Full Multiplicative Form), SIMUS (Sequential Interactive Model for Urban Systems), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), and ELECTRE [28–37]. In this study, the ELECTRE method is used. The method was first introduced by Bernard, ROY and Daniel [38] in 1965. ELECTRE ranks the alternatives on concordance and discordance analysis [37]. ELECTRE has multiple versions. Some models find the best outcome and others rank full alternatives in an order [39]. Besides other MCDM methods, ELECTRE considers vagueness and uncertainty in its calculations. Therefore, reduces the ambiguity related to decision makers bias and misjudgement. ELECTRE method is mostly used in energy, transportation, environment, healthcare, social, chemical, agriculture, software selection problems and so forth [40, 41]. ELECTRE was used in multiple papers, some examples are done by Sevkli [42] to select supplier, to rank energy sources by Lee and Chang [43] and to assess the cement vendor by Komsiyah, Wongso, and Pratiwi [41]. Most important drawbacks of using ELECTRE or any other MCDM methods is on the definition of all criteria. If there are missing criteria, the quality of MCDM approach can be questionable [41]. In order to avoid missing criteria problem for IIOT selection, technical requirements were analysed and detailed research review was done with this aspect. The next section explains the most critical IIOT technical selection criteria firms need to consider in the decision process.

B. IIOT Technical Criteria

The requirements for enterprise applications such as IOT and ERP (Enterprise Resource Planning) in general are identified in several studies [1, 2, 9, 44–47]. Based on the outcome gained from multiple papers, manufacturing oriented IIOT system requirements are identified. Comprehensive IIOT system should consist of three layers. These layers are categorised as perception layer, business layer and application layer [1–3, 8, 44, 48]. Perception layer is the lowest level where all the connection to sensors and databases happens. Business layer is responsible for the managing processes and logic of the system. Lastly, the application layer supports visualization and communication with the end users. To select an IIOT solution, manufacturing organizations can consider technical requirements (ex: security, connectivity, architecture) as well as nontechnical requirements (ex: ease of use, vendor market presence, total cost of ownership) [9, 45, 46]. In this study, only the tangible technical list of criteria is determined. “Table 1” shows the list of main and secondary technical criteria with their relevant references from literature. The aim of identifying the complete list of criteria is to help companies easily compare out of the box (OOTB), non-customized alternatives [15]. There is no doubt that enterprise systems will reshape broader organizations. The solution selection is not limited to the choice of software and should be considered as a long-term partnership with the vendor. Therefore, if the most comprehensive solution can be objectively selected, the amount of customization and total cost of ownership will be reduced in the long-run and the benefit would be maximized [47]. In the following sections, details of each main criteria category are explained to provide better understanding.

1) Connectivity

IIOT Systems are required to integrate with multiple IT Applications (PLM, ERP, CRM, etc.) and OT Systems (PLC, Scada, edge, etc.). The cyberphysical systems communicate through IIOT platforms [44]. Cross-functional organizational information needs to move bidirectionally through departments [9]. Without duplicating the data, standardized protocols are required to pull/push information. Strong IIOT System needs to support most common standards such as IEEE802.3, IEEE802.11, etc. and communicate with open protocols such as MQTT, HTTP-Rest, DDS, XMPP, etc. [1]. The connectivity is the main requirement for a comprehensive IIOT system. Instead of focusing on certain protocols, the secure and exposed bidirectional information sharing approach has to be prioritized by the vendor.

2) *Contextualization*

Once the data is linked and gathered, context-aware computations and reports become essential. Even if the same data is gathered, different users with various roles are required to utilize information for custom needs [1]. IIOT helps to create digital twin of manufacturing with several context specific requirements. Furthermore, for multinational manufacturers, localization of user interfaces is also considered critical.

3) *Insight*

Perhaps the most important feature of IIOT systems, is the capability of transforming data into knowledge to provide wisdom on daily operations. Strong artificial intelligence (AI) competence helps organizations differentiate within competition [3, 45]. Since manufacturing organizations are generally lacking skilful machine learning (ML) experts, automated ML becomes an exceptive component of the IIOT system [4]. These systems should handle bigdata. Application of automatic basic and advance analytic capabilities in real-time is essential.

4) *Architecture*

As the backend IIOT system plays essential role, architectural options to support high load of real-time information flow should be handled securely. IIOT systems empower the information to become available anytime and anywhere [1]. Since IIOT systems communicate with various systems, they are considered to support Service Oriented Architecture (SOA) [44].

TABLE I
IIOT Technical Decision Criteria

Code	Main Criteria	Sub Criteria	Reference
C1	Connectivity	IT — OT Integration	[1, 3, 5, 7, 8,
		Edge Machine Connectivity	10, 45, 46,
		ISA-95 Support	49–53]
		OPC Client	
C2	Contextualization	Digital Twin	[1, 5, 45,
		Localization	54]
C3	Insight	Analytic	[3, 5, 6, 8,
		Big Data	10, 45, 46,
		Automated ML	50, 52, 55]
C4	Architecture	Security (Blockchain)	[1, 5–8, 10,
		Real-Time Information	14, 17, 21,
		Accessibility	45, 46, 49,
		Compatibility	50, 52–54,
		Interoperability	56]
		Service Oriented Architecture (SOA)	
		Cloud — On-Premise — Hybrid Deployment	
C5	Democratization of Information	Self-Service Reporting	[5, 45, 46,
		Custom Dashboard	49, 50, 52]
		Codeless development	
C6	Visualization	Reporting	[1, 5, 7]
		Dashboards	
		Augmented Reality	

SOA Architecture reduces system to system integration. All applications connect to IIOT platforms instead of one on one communication between themselves. In case of replacing or upgrading part of a solution, only the IIOT integration interface needs to be considered. SOA organize the flow of coordination. It is mandatory to have compatible, accessible and interoperable systems that can be available both in the cloud or on-premise. Availability of advance deployment options such as software as a service (SAAS) or platform as a service (PAAS) is also beneficial. The nature of IIOT systems are different. Therefore, their security requirements are advanced to protect mission critical information from cyber attacks [53]. User and access management, edge device communication and real-time data needs to be encrypted and securely

stored. Strong IIOT solutions should support various aspects of deployment and are required to be flexible and scale-able to meet constantly changing organizational demands [7].

5) Democratization of Information

Various departments such as logistic, manufacturing planning, manufacturing execution, design and purchasing, benefit differently from accessing the IIOT systems. All employees need to use and customize the reports and dashboards for their specific desires. The system requires to be complete and integrated with other enterprise solutions [43]. In order to monitor real-time situations and transition of information, the system needs to be customized without the need of heavy coding. Self-service enterprise wide data democratization is a must on successful IIOT projects.

6) Visualization

Gathering data into IIOT system with a secure and flexible way is not enough as long as the information is re-shared with a new look and feel. Visualization can happen on real-time via dashboards or in colour coded, graphical reports. But the interaction with machines, using augmented reality based IIOT system not only improves the efficiency but also reduces the mistakes [1]. Embedded visualization capabilities, ease the use of system and provide guidance to non-experienced end-users to navigate effectively.

III. METHODOLOGY

This section shows the hybrid CRITIC-ELECTRE method steps and the mathematical formulations. The generic framework of MCDM is shown in “Fig. 1”.

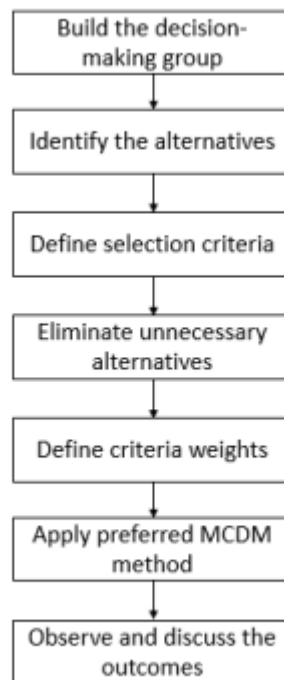


Fig. 1. Multi-Criteria Decision Making Overview

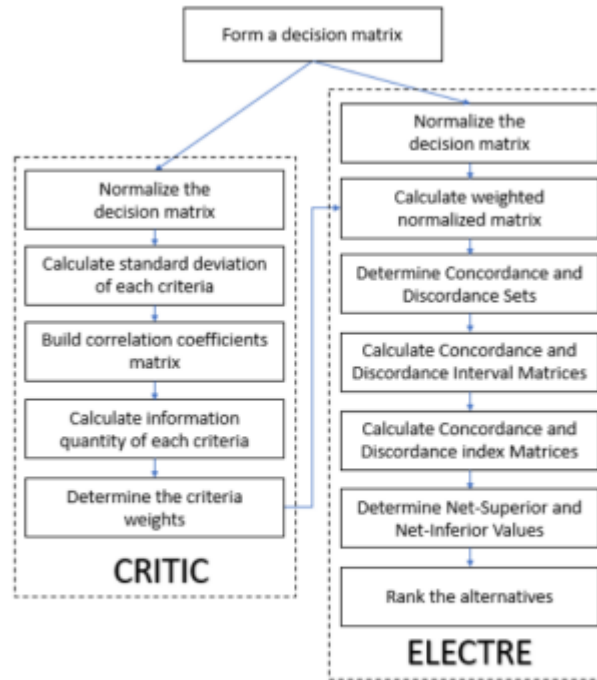


Fig. 2. Combined CRITIC-ELECTRE method

However, in the case of IIOT selection, after building the decision group and defining the alternatives, the rest of the procedure is defined to save time and reduce effort for companies. In order to initiate the process, first the evaluations are gathered to construct the decision matrix for each decision maker (DM) denoted by X_p . “Fig. 2” shows the novel hybrid CRITIC-ELECTRE method where the weights are calculated using CRITIC method and are used in the ELECTRE decision making system.

Decision Matrix: The decision matrix composed of multiple decision makers’ subjective evaluation of each alternative with respect to each criteria [26]. In order to achieve a single table, arithmetic average of all decision makers is used. If preferred, different decision makers’ matrices can be used separately and end results can be compared afterward

$$X = [X_1, X_2, \dots, X_n] = \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ \vdots & & & \vdots \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{bmatrix} \quad (1)$$

A. CRITIC Method Steps

CRITIC Normalization of Decision Matrix: In order to standardize and remove the effect of high values, normalization for positive (beneficial) and negative (non-beneficial) criteria can be calculated with the same formula shown below [24]. In case of cost attributes, the min and max are replaced.

$$X_{ij}^* = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \quad (2)$$

Standard deviation and correlation: The weight of criteria is dependent on the standard deviation within the columns and correlation coefficients of pairs [24]. The criteria with high standard deviation and low correlation contains strong explanatory information, therefore gets a higher weight

$$w_j = \frac{C_j}{\sum_{j=1}^n C_j} \quad (3)$$

$$C_j = \sigma_j \sum_{j=1}^n (1 - p_{jk}) \quad (4)$$

in which the standard deviation is calculated using “Eq. (5)” [25].

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (X_i - \mu)^2}{N}} \quad (5)$$

the correlation between criteria pairs is calculated using “Eq. (6)” [25]

$$p_{jk} = \frac{\sum_{i=1}^m (r'_{ij} - \bar{r}_j)(r'_{ik} - \bar{r}_k)}{\sum_{i=1}^m (r'_{ij} - \bar{r}_j)^2 \sum_{i=1}^m (r'_{ik} - \bar{r}_k)^2} \quad (6)$$

B. ELECTRE Method Steps

ELECTRE Normalization of Decision Matrix: All values of the benefit and cost requires normalization [42]. For the maximization (Benefit Attributes)

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (7)$$

For the minimization (Cost Attributes)

$$r_{ij} = \frac{1/x_{ij}}{\sqrt{\sum_{i=1}^m 1/x_{ij}^2}} \quad (8)$$

Weighted Normalized Decision Matrix: The normalized decision matrix is weighted with the previously calculated CRITIC criteria weights [42].

$$v_{ij} = r_{ij} * w_j \quad (9)$$

Determine Concordance Set: The preferred alternatives are grouped under concordance sets [42].

$$C(p, q) = [j | v_{pj} \geq v_{qj}] \quad (10)$$

Determine Discordance Set: All the unpreferred alternatives are grouped under discordance sets [42].

$$D(p, q) = [j | v_{pj} < v_{qj}] \quad (11)$$

Concordance Interval Matrix: The interval of concordance sets is the preferred suggestion of one over another [42].

$$C_{pg} = \sum_j w_j^* \quad (12)$$

in which the j^* shows the attributes in the concordance set

Discordance Interval Matrix: The interval of discordance sets shows the unpreferred suggestion of one over another [42].

$$D_{pg} = \frac{\sum_{j^+} |v_{pj^+} - v_{qj^+}|}{\sum_j |v_{pj} - v_{qj}|} \quad (13)$$

in which the j^+ shows the attributes in the discordance set.

Concordance Index Matrix: The measurement of satisfaction preference is calculated using the formula 14. The matrix (E) is a boolean concordance matrix

$$\bar{c} = \frac{\sum_{a=1}^m \sum_b^m c(a,b)}{m(m-1)} \quad (14)$$

$$\begin{cases} e(a,b) = 1 & \text{if } c(a,b) \geq \bar{c} \\ e(a,b) = 0 & \text{if } c(a,b) < \bar{c} \end{cases}$$

Discordance Index Matrix: The preference dissatisfaction is measured by discordance index matrix. The matrix (F) is a boolean discordance matrix

$$\bar{d} = \frac{\sum_{a=1}^m \sum_b^m d(a,b)}{m(m-1)} \quad (15)$$

$$\begin{cases} f(a,b) = 1 & \text{if } d(a,b) \leq \bar{d} \\ f(a,b) = 0 & \text{if } d(a,b) > \bar{d} \end{cases}$$

Net Superior Value: Net superior value shows the relative superiority of all alternatives. When the value gets bigger, the outcome is more preferred hence ranked higher

$$c_a = \sum_{b=1}^n c_{(a,b)} - \sum_{b=1}^n c_{(b,a)} \quad (16)$$

Net Inferior Value: Net inferior value shows the relative inferiority of all alternatives, and the smaller value indicates the more preferred outcome

$$d_a = \sum_{b=1}^n d_{(a,b)} - \sum_{b=1}^n d_{(b,a)} \quad (17)$$

IV. APPLICATION OF CRITIC-ELECTRE

In order to show the applicability of the proposed method, three companies were identified. The six criteria defined above were shared and their IIOT alternatives' rate was asked to be filled. All of the companies are currently investigating the IIOT solution to be used in manufacturing. In order to secure intellectual property, the name of the companies and participating individuals are kept confidential. The profile of these companies are listed in "Table 2".

TABLE II
Company Profiles

	Sector	Status	Year
A	Cleaning Paper	International	+15
B	Yarn Maker	International	+30
C	Employers' Assoc.	National	+60

Company A is part of a strong group and focuses on cleaning paper material production such as roll papers. The company operates in multiple regions outside of Turkey. There are multiple brands under both consumer and industrial product groups. Company aims to be the leader in its domain in the coming future. For that reason, the importance of vendor selection is prioritized.

Company B operates under one of the strongest holdings of Turkey. The company is known to be one of the top yarn makers in the world. The production is focuses on standard and functional yarns including polyester, cotton, elasthan, etc. There are between 5 to 10 production locations covering more than twenty thousand meter square area where the aim is to digitalize all factories using an IIOT solution.

Company C is actually an employer's association of a specific industry in Turkey. The history of the organization dates back to more than sixty years. The ecosystem contains of approximately two hundred member companies. The aim of the organization is to improve technical capabilities of Turkish manufacturers by providing them information about best in class solutions that are suitable for manufacturing. The association investigates all emerging and existing technologies such as IIOT solution, to be demonstrated in the digital factory for the member firms.

Among all three companies, multiple decision makers' evaluations were averaged to define the decision matrices. In order to conduct the study, one representative was selected from each organization. The profile of the contact persons are listed in "Table 3".

TABLE III
Representative Profiles

	Role	Education	Experience
A	IT Manager	Engineering	+25
B	Business Dev.	Engineering	+20
C	Consultant	Engineering	+20

As the number of alternatives changes from company to company, the decision matrix have different number of rows with same numbers of criteria. In this study, all the decision matrices and the end results will be shared. However, the step by step instruction of only one of the decision matrices will be shared in detail to save space. Nevertheless, the exact same method can be used to calculate the others.

TABLE IV
Rating System

Rating	Description
1 point	Very Low Capability
2 points	Low Capability
3 points	Decent Capability
4 points	High Capability
5 points	Very Strong Capability

Step 1: In the first phase, the alternatives and predefined criteria shown in "Table 1" is formed to create decision matrix as explained in "Eq. (1)".

The alternatives are shown as alternative 1 (A1), alternative 2 (A2) and alternative 3 (A3). Criteria C1, C2, C3, C4, C5 and C6 are used, for example, the criteria C1 is connectivity and C6 corresponds to visualization. 1 to 5 rating system is used as shown in "Table 4". In case of uncertainty the numbers between two integer values can be used.

TABLE V
 Company A – Decision Matrix

	C1	C2	C3	C4	C5	C6
A1	4.00	4.00	4.00	4.00	4.00	4.00
A2	4.00	3.50	3.00	3.00	3.00	3.50
A3	3.50	3.00	2.00	3.50	2.00	3.00
A4	3.00	3.00	2.00	2.00	3.50	2.50
A5	3.50	3.00	2.50	3.00	3.00	3.00

TABLE VI
 Company B – Decision Matrix

	C1	C2	C3	C4	C5	C6
A1	5.00	4.00	5.00	4.00	5.00	5.00
A2	4.00	4.00	3.00	3.00	5.00	4.00
A3	4.00	3.00	3.00	3.00	4.00	4.00
A4	3.00	4.00	3.00	3.00	4.00	3.00

TABLE VII
 Company C – Decision Matrix

	C1	C2	C3	C4	C5	C6
A1	3.00	4.00	3.00	3.00	2.00	2.00
A2	5.00	3.00	3.00	4.00	5.00	4.00
A3	3.00	3.00	5.00	5.00	3.00	5.00

Three decision matrix tables of “Table 5, 6, 7” were generated by each participating company.

In order to display the results, decision table from Company A “Table 5” was selected as an example to be demonstrated throughout the paper as it contains the biggest number of alternatives.

Step 2: The decision matrix is normalized based on maximum and minimum values (best and worst) as shown in “Table 8” using “Eq. (2)”.

TABLE VIII
 CRITIC Normalized Decision Matrix for Company A

	C1	C2	C3	C4	C5	C6
A1	1.00	1.00	1.00	1.00	1.00	1.00
A2	1.00	0.50	0.50	0.50	0.50	0.67
A3	0.50	0.00	0.00	0.75	0.00	0.33
A4	0.00	0.00	0.00	0.00	0.75	0.00
A5	0.50	0.00	0.25	0.50	0.50	0.33

Step 3: σ shows the standard deviation of each column. The “Table 9” is constructed using “Eq. (5)”.

TABLE IX
 CRITIC Standard Deviation for Company A

	C1	C2	C3	C4	C5	C6
σ	0.42	0.45	0.42	0.37	0.37	0.38

Step 4: The correlation coefficient values are calculated for each criteria using “Eq. (6)” shown in “Table 10”. The table is symmetric.

TABLE X
 CRITIC Correlation Coefficient for Company A

	C1	C2	C3	C4	C5	C6
C1	1	0.80	0.82	0.77	0.16	0.94
C2		1	0.97	0.64	0.64	0.93
C3			1	0.66	0.66	0.94
C4				1	-0.02	0.83
C5					1	0.38
C6						1

Step 5: The final C_j and w_j values are calculated using “Eq. (4)” and “Eq. (3)”. The result is displayed in “Table 11”. The weights shown here are carried over for ELECTRE calculations.

TABLE XI
 CRITIC Criteria Weights for Company A

	C1	C2	C3	C4	C5	C6
C_j	0.63	0.45	0.39	0.79	1.18	0.37
w_j	0.17	0.12	0.10	0.21	0.31	0.10

As a result of the CRITIC calculation, entire normalized weights for other companies are displayed in “Table 12”

TABLE XII
 CRITIC Criteria Weights for All Companies

	C1	C2	C3	C4	C5	C6
A w_j	0.17	0.12	0.10	0.21	0.31	0.10
B w_j	0.12	0.33	0.13	0.13	0.19	0.12
C w_j	0.13	0.12	0.33	0.10	0.10	0.22

Step 6: The first step in ELECTRE is to form Decision Matrix. The decision matrix shown in “Table 5” is reused. In order to apply ELECTRE calculations to other companies, corresponding decision tables need to be used.

Step 7: The normalization is applied to ELECTRE calculations using “Eq. (7)” as all selected criteria are beneficial (maximization) type. In case of cost (minimization) parameters, “Eq. (8)” needs to be used. “Table 13” shows the result of the calculations.

TABLE XIII
 ELECTRE Normalized Decision Matrix for Company A

	C1	C2	C3	C4	C5	C6
A1	0.49	0.54	0.64	0.56	0.56	0.55
A2	0.49	0.47	0.48	0.42	0.42	0.48
A3	0.43	0.40	0.32	0.49	0.28	0.41
A4	0.37	0.40	0.32	0.28	0.49	0.35
A5	0.43	0.40	0.40	0.42	0.42	0.41

Step 8: The normalized weights w_j (where the sum of all weights are equal to 1), are displayed already in “Table 11” are reused in “Eq. (9)”. The weighted normalized decision matrix is shown in “Table 14”.

TABLE XIV
 ELECTRE Weighted Normalized Decision Matrix for Company A

	C1	C2	C3	C4	C5	C6
A1	0.08	0.06	0.07	0.12	0.17	0.05
A2	0.08	0.06	0.05	0.09	0.13	0.05
A3	0.07	0.05	0.03	0.10	0.09	0.04
A4	0.06	0.05	0.03	0.06	0.15	0.03
A5	0.07	0.05	0.04	0.09	0.13	0.04

Step 9: The concordance set calculated using “Eq. (10)” and discordance set calculated using “Eq. (11)” are shown in “Table 15” and “Table 16” respectively. The discordance set is the opposite of the concordance set.

TABLE XV
 Concordance Set for Company A

	C1	C2	C3	C4	C5	C6
A12	1	1	1	1	1	1
A13	1	1	1	1	1	1
A14	1	1	1	1	1	1
A15	1	1	1	1	1	1
A21	1	0	0	0	0	0
A23	1	1	1	0	1	1
A24	1	1	1	1	0	1
A25	1	1	1	1	1	1
A31	0	0	0	0	0	0
A32	0	0	0	1	0	0
A34	1	1	1	1	0	1
A35	1	1	0	1	0	1
A41	0	0	0	0	0	0
A42	0	0	0	0	1	0
D43	0	1	1	0	1	0
D45	0	1	0	0	1	0
D51	0	0	0	0	0	0
D52	0	0	0	1	1	0
D53	1	1	1	0	1	1
D54	1	1	1	1	0	1

TABLE XVI
Discordance Set for Company A

	D1	D2	D3	D4	D5	D6
A12	0	0	0	0	0	0
A13	0	0	0	0	0	0
A14	0	0	0	0	0	0
A15	0	0	0	0	0	0
A21	0	1	1	1	1	1
A23	0	0	0	1	0	0
A24	0	0	0	0	1	0
A25	0	0	0	0	0	0
A31	1	1	1	1	1	1
A32	1	1	1	0	1	1
A34	0	0	0	0	1	0
A35	0	0	1	0	1	0
A41	1	1	1	1	1	1
A42	1	1	1	1	0	1
D43	1	0	0	1	0	1
D45	1	0	1	1	0	1
D51	1	1	1	1	1	1
D52	1	1	1	0	0	1
D53	0	0	0	1	0	0
D54	0	0	0	0	1	0

Step 10: The concordance interval matrix is calculated using “Eq. (12)” and discordance interval matrix is calculated using “Eq. (13)” are shown in “Table 17” and “Table 18” respectively.

TABLE XVII
Concordance Interval Matrix for Company A

	A1	A2	A3	A4	A5
A1	-	1.00	1.00	1.00	1.00
A2	0.17	-	0.79	0.69	1.00
A3	0.00	0.21	-	0.69	0.59
A4	0.00	0.31	0.53	-	0.43
A5	0.00	0.52	0.79	0.69	-

TABLE VIII
Discordance Interval Matrix for Company A

	A1	A2	A3	A4	A5
A1	-	0.00	0.00	0.00	0.00
A2	1.00	-	0.33	0.75	0.00
A3	1.00	1.00	-	1.00	1.00
A4	1.00	1.00	0.67	-	1.00
A5	1.00	1.00	0.33	0.75	-

Step 11: The concordance index matrix is calculated using “Eq. (14)” and discordance index matrix is calculated using “Eq. (15)” are shown in “Table 19” and “Table 20” respectively

TABLE XIX
 Concordance Index Matrix for Company A

	A1	A2	A3	A4	A5
A1	-	1	1	1	1
A2	0	-	1	1	1
A3	0	0	-	1	1
A4	0	0	0	-	0
A5	0	0	1	1	-

TABLE XX
 Discordance Index Matrix for Company A

	A1	A2	A3	A4	A5
A1	-	1	1	1	1
A2	0	-	1	0	1
A3	0	0	-	0	0
A4	0	0	0	-	0
A5	0	0	1	0	-

Step 12: The final step shows the net superior and net inferior values with the corresponding rankings. “Eq. (16)” is used to form “Table 21” where the net superior values and their corresponding rankings are displayed. The bigger value indicates, the more preferred (better) alternative.

TABLE XXI
 Net Superior Value and Ranking for Company A

	Net Superior Value	Ranking
A1	3.83	1
A2	0.62	2
A3	-1.63	4
A4	-1.81	5
A5	-1.02	3

On the other hand, the net inferior is calculated using “Eq. (17)” and shown in “Table 22”. The ranking here is opposite. The large inferior values indicate the unpreferred alternative. Therefore, the smaller value indicates better alternative.

TABLE XXII
 Net Inferior Value and Ranking for Company A

	Net Inferior Value	Ranking
A1	-4.00	1
A2	-0.92	2
A3	2.66	5
A4	1.18	4
A5	1.08	3

The superior and inferior tables for Company B are displayed in “Table 24” and “Table 23”.

TABLE XXIII
 Net Superior Value and Ranking for Company B

	Net Superior Value	Ranking
A1	2.16	1
A2	0.44	2
A3	-1.60	4
A4	-1.00	3

TABLE XXIV
 Net Inferior Value and Ranking for Company B

	Net Inferior Value	Ranking
A1	-3.00	1
A2	-1.00	2
A3	2.66	4
A4	1.34	3

Lastly, the superior and inferior tables for Company C are displayed in “Table 26” and “Ta

TABLE XXV
 Net Superior Value and Ranking for Company C

	Net Superior Value	Ranking
A1	-1.07	3
A2	0.02	2
A3	1.05	1

TABLE XXVI
 Net Inferior Value and Ranking for Company C

	Net Inferior Value	Ranking
A1	1.48	3
A2	-0.08	2
A3	-1.41	1

The suggested decision table for all companies is displayed in “Table 27”

TABLE XXVII
 Selection Suggestions

	Alternative Ranking
Company A	A1>A2>A5>A3=A4
Company B	A1>A2>A4>A3
Company C	A3>A2>A1

V. RESULT

The calculations were conducted using CRITIC objective weighting system. Weights were derived from decision makers’ evaluations using a systematic approach. Later on, these weights were used in ELECTRE instead of the subjective criteria defined by experts. Compared to other MCDM methods, ELECTRE method considers both satisfaction and dissatisfaction. For the three corresponding participating companies, decision is made based on superior and inferior tables. The ranking for all superior results are displayed in “Table 21, 23, 25” and inferior results are shown in, “Table 22, 24, 26”. For Company B and Company C, both superior and inferior tables provide the same ranking of the alternatives. Therefore, the selection is straightforward. But the result of Company A differs between the inferior and superior tables. If the superiority is more important than inferiority, a ranking from that table can be selected. On the other hand, as shown in “Table 27” the first three options were ranked and the last two options could be considered equal. As they appear last on the selection list, their importance is very low.

VI. CONCLUSIONS

Industrial revolutions are reshaping the world and the enterprises among all verticals. Manufacturing is one of those areas where the digitalization strategies decide the competitiveness and survival of organizations. In this manner, deciding on a long-term IIOT solution which becomes the backbone of the entire manufacturing processes is key. On the other hand, while dealing with daily work routines, arranging a large workforce to decide on IIOT selection criteria and building a custom framework is beyond acceptable limits. In this paper, most important six main IIOT criteria with their sub-criteria are defined

based on literature reviews. Those are “Connectivity, Contextualization, Insight, Architecture, Democratization of Information and Visualization”. Moreover, to ease the selection process, a new framework is offered. A novel hybrid CRITIC-ELECTRE model according to the knowledge of authors is applied for the first time in the literature. This framework brings systematic, objective, and repeatable guidance where the bias of experts aimed to be reduced if not totally removed. For the six-must-have technical IIOT criteria, different organizations can apply different weightings. Instead of getting the weights from experts, CRITIC weighting method is used. ELECTRE multi criteria decision making method is combined with CRITIC weights to derive alternative ranking mechanisms to satisfy the need of the organization while considering the impact of dissatisfaction effect. The real-life case study conducted in three different companies demonstrates the applicability of the proposed method. The result of the calculations is shared with the corresponding participating companies. All companies agreed that the weighting provided by the CRITIC method is aligned with their idea, furthermore the suggested ranking of alternatives using ELECTRE is similar to their idea of selection.

This paper contributes to literature in three main ways.

- Detailed analysis of software vendor selection was analysed and Industrial IOT application related technical requirements were analysed.
- Structural ELECTRE MCDM method is combined for the first time with CRITIC weighting system to reduce bias coming from experts.
- Comprehensive evaluation framework is identified to help companies choose their required solution
- The participants of each company agreed on being satisfied with the suggested ranking of the provided method.

Future studies can be targeted to below items.

- Selected CRITIC and ELECTRE can be extended with their fuzzy versions.
- The decision criteria can be extended further by non-technical aspects.
- Sector specific requirements can be added into decision making process.
- Future enabling technologies can be considered in decision criteria.

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Implementation of Lean Principles to Warehouse Design in The Textile Industry: A Real Case Study

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Abstract— A warehouse is a crucial part of firms' logistic system and plays an important role in delivering products from manufacturers to end consumers. Companies give more and more importance today to warehouse design and layout under increasing competitive conditions. Warehouse design and layout is one of the important elements of warehouse management, and an effective warehouse layout significantly reduces operational costs. The aim of the study is 4-year demand planning of a manufacturer's new textile warehouse and selecting the best alternative warehouse location according to the demand and finally applying the lean principles to the current system of the company. This paper has a considerable place in terms of being a real-life application because there is an important gap between scientific studies and real-life applications in the field of warehouse management. In this study, pairwise comparisons were made with fuzzy AHP method and the best alternative was selected with Fuzzy TOPSIS method. In addition, a warehouse design proposal that adopts lean principles will be introduced together with current value stream map and future value stream map. We implemented SAP system and RFID scanning technology to minimize the lead time between a customer order and the shipment of the goods by reducing the waste. Furthermore, this paper provides greater knowledge about Kaizen and its practices in the Lean Warehouse applications in the textile sector.

Keywords – Lean warehouses, lean techniques, value stream map, warehouse location selection, fuzzy AHP

I. INTRODUCTION

A warehouse is a crucial part of firms' logistic system and plays an important role in delivering products from manufacturers to end consumers. So that, warehouse design and layout is one of the important elements of warehouse management, and an effective warehouse layout significantly reduces operational costs. Companies give more and more importance today to warehouse design and layout under increasing competitive conditions. Lean principles originated from manufacturing practice can be adapted to warehouse environment to enhance its productivity. Correct planning is very important because maintaining the strong position of the brand, being in an advantageous position against its competitors, for strong retail network control [1].

The remainder of this paper is as follows. In Section 2, previous research on location selection decision-making and implementation of lean principles to the warehouses are reviewed. Case Study background, forecasting of future sales, multi-criteria decision-making method for site selection and the value stream maps are examined in Section 3. Computational results obtained from the methods are discussed in Section 4 and conclusion remarks are made in the last section.

II. LITERATURE REVIEW

Every firm tries to make its supply chain efficient while competing in the local or global market. Factors such as warehouse location, layout and warehouse design play an important role in achieving supply chain objectives such as market expansion, market penetration and customer support. Therefore, supply chain management is highly influenced by site selection and product quality [2]. In the literature, although there are many studies on warehouse location selection, MCDM methods such as AHP [3],[4],[5],[6], Fuzzy AHP [7], TOPSIS [8] and optimization methods [9], [10] are used. The most significant factors in the

evaluation were found to be cost, infrastructure (electricity and water supply, and telecommunication setup), closeness to customers, market size, availability of workforce, society and environment, governmental policies and regulations and strategic location etc. [11].

Besides location selection, the design of the warehouse greatly affects the supply chain. Warehouse construction and design is one of those strategic decisions that probably won't be able to change for years, as it is very costly and needs to be carefully planned. For this reason, we have seen the use of the lean concept in warehouses quite a lot in the literature in recent years. Lean concept can be applied various warehouse operations and it requires optimizing material flow, order picking, replenishment, and dock operations. Wastes can be decreased and lead time, order picking time, and material handling can be reduced by 50% using lean concepts [12], [13], [14]. Total working time can be saved by integrating RFID technology into lean warehouse design. According to Kilic et al. [15] material handling is one of the most important issues that should be taken into account for eliminating waste and reducing the cost. With lean concept integration, finds that number of workers, the cycle time of warehouse management and the total workload of workers can be decreased [16].

III. METHODOLOGY

A. Case Study Background

ABC company where the application was made is a men's outerwear manufacturer and started its activities in September 2002 in Turkey. The company, which is a family company, has its headquarters in Osmanbey and 2 production factories, one in Okmeydanı and the other in Şirinevler. It produces men's coats, outerwear, overcoats and topcoats in accordance with ISO 9001:2008 standards. The factories are insufficient for storage anymore because of growing business volume. Relevant site selection and planning will be made for a textile warehouse close to the current factories, in which products will be stored and handled to be opened by the company. This current project is about the relevant site selection and 4-year planning of a men's outerwear manufacturer's new textile warehouse applying the lean principles to the current system of the company.

B. Forecasting of Future Sales

For periods of 3 years or more, long-term estimation methods are used in capital expenditures, facility location selection or facility expansion decisions. In this context, the estimation sheet generation tool of Microsoft Excel, which is one of the data analysis tools, was used for this current long-term warehouse need problem. Figure 1 presents the monthly sales of the company for 3 years; 2018, 2019 and 2020. The chart clearly shows that the demand on the company's products and sales decreases drastically during the global COVID-19 pandemic lockdown period. That's why, the 2020 sales data were excluded for forecasting the sales of the next four years. Also, it is clear from the data that the demand on the products sometimes decreases seasonally. That's why, the seasonal changes for the forecasting analysis was considered too.

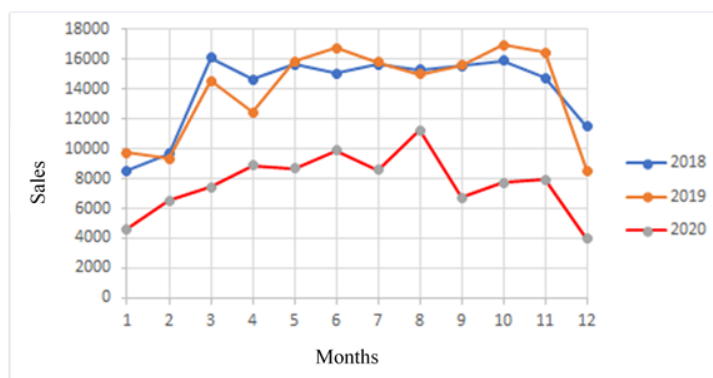


FIGURE I. MONTHLY CURRENT SALES

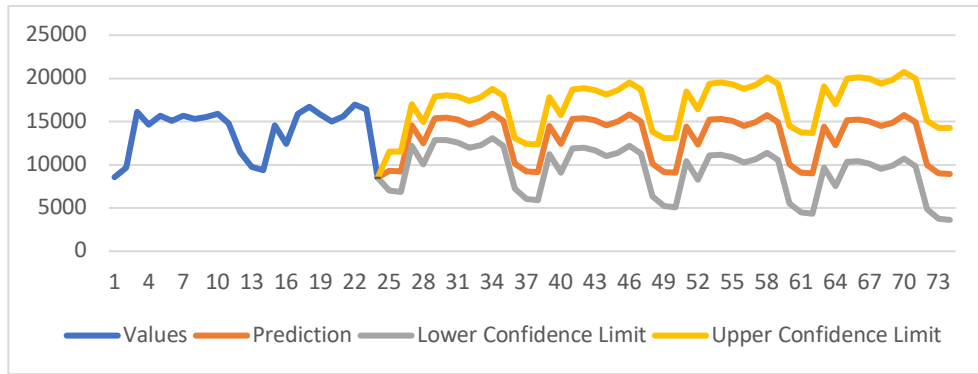


FIGURE II. FORECASTING OF NEXT 4 YEARS' SALES

As mentioned before, the manufacturer's monthly sales figures of the past 24 months were used for forecasting the future sales of the next four years. In the analysis of the data, 12-month periods were chosen as seasonal periods, and an accuracy rate of 95% was preferred in the data. As it is seen from the results of the analysis on Figure 2, it is predicted that 20751 products can be sold as the maximum value in the upper confidence limit. This constitutes that the upper limit will be circulated within the warehouse, is going to be 20751 products at most. Therefore, it has been decided that the volume of the planned warehouse will be created in accordance with the sales of approximately 25000 units by adding a 20% security capacity for the anticipated maximum value of 20751 units of sales.

C. Cost Comparison

Before the selection of the region for the warehouse, it has been questioned and calculated that whether a self-operated warehouse or outsourcing the service from another warehouse company is more meaningful for this manufacturer. Figure 3 and Table 1, demonstrates the costs for different amounts of products. Since, it is foreseen with the Excel's forecasting tool that there will be monthly product input and output in the range of 10,000-25,000 units, a self-operated warehouse is preferred due to lower costs and more flexibility.

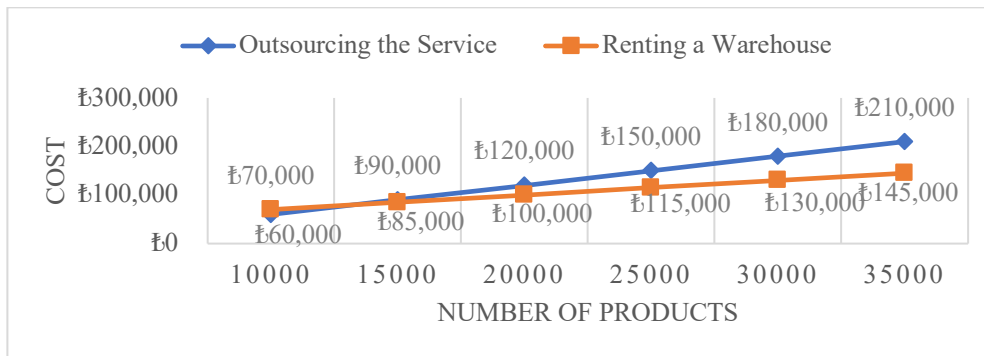


FIGURE III. COST COMPARISON OF OUTSOURCING THE WAREHOUSE SERVICE AND RUNNING A WAREHOUSE

TABLE 1. COST COMPARISON OF OUTSOURCING THE WAREHOUSE SERVICE AND RUNNING A WAREHOUSE

Cost comparison of Outsourcing vs. Renting a Warehouse (per pieces)						
	10000	15000	20000	25000	30000	35000
Outsourcing the Service	₺ 60.000,00	₺ 90.000,00	₺ 120.000,00	₺ 150.000,00	₺ 180.000,00	₺ 210.000,00
Renting a Warehouse	₺ 70.000,00	₺ 85.000,00	₺ 100.000,00	₺ 115.000,00	₺ 130.000,00	₺ 145.000,00

D. Fuzzy Analytical Hierarchy Process

Since basic AHP methods do not include uncertainty and vagueness of the experts judgments, fuzzy set theory has been introduced first by Zadeh and benefited from fuzzy numbers as part of fuzzy set theory, which takes the form of a set of real numbers with a convex and continuous membership function illustrated at Figure 4 [17].

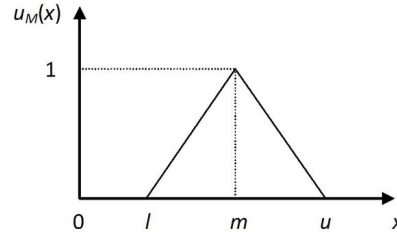


FIGURE IV. TRIANGULAR FUZZY NUMBERS (L,M,U) [16]

Although there are some more techniques embedded in F-AHP, Buckley’s methods is implemented to determine the relative importance of criteria’s weights. The steps of the procedure are as follows:

Step 1: After the hierarchy is established, pairwise comparison is made by using linguistic terms which is given in Table 2 for criteria and alternatives [18].

TABLE 2. LINGUISTIC SCALE FOR FUZZY AHP

Linguistic Term	Abs.	Triangular Fuzzy Number
Absolutely strong	AS	(2,2.5,3)
Very strong	VS	(1.5,2,2.5)
Fairly strong	FS	(1,1.5,2)
Slightly strong	SS	(1,1,1.5)
Equal	E	(1,1,1)
Slightly weak	SW	(0.67,1,1)
Fairly weak	FW	(0.5,0.67,1)
Very weak	VW	(0.4,0.5,0.67)
Absolutely weak	AW	(0.33,0.4,0.5)

Step 2: The pairwise contribution matrix is established which indicates the kth decision maker’s preference of ith criterion over jth criterion, via fuzzy triangular numbers.

$$\tilde{A}^k = \begin{pmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1(n-1)} & \tilde{a}_{1n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{n(n-1)} & 1 \end{pmatrix} \quad (1)$$

Step 3: The geometric mean of fuzzy comparison values of each criterion is calculated with Equation 2.

$$\tilde{r}_i = \left(\prod_{j=1}^n \tilde{a}_{ij} \right)^{1/n} \quad (2)$$

Step 4: After taking the sum of all r_i (l, m, u) vectors, using equation 3 find the inverse of the vector and multiply all r_i vectors with the inverse vector for finding weights fuzzy numbers.

$$W_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \cdots \oplus \tilde{r}_n)^{-1} \quad (3)$$

Step 5: For defuzzification of TFNs, “the graded mean integration approach” is applied as equation (4) and it needs to be normalized with equation (5) [19]

$$\tilde{M}_i = \frac{lw_i + mw_i + uw_i}{3} \quad (4)$$

$$\tilde{N}_i = \frac{M_i}{\sum_{i=1}^n M_i} \quad (5)$$

IV. RESULTS

A. Site Selection Decision Making Computational Results

The factors taken into consideration during the selection of the most suitable location for the warehouse were determined from the literature, and 6 criteria were included in the hierarchy in our case study. These are shown in Figure 5. Pairwise comparisons were made with a single decision maker using the fuzzy AHP method as shown in Table 3. Fuzzy Linguistic Terms used when comparing the criterias. According to the results, the priorities yielded the following list:

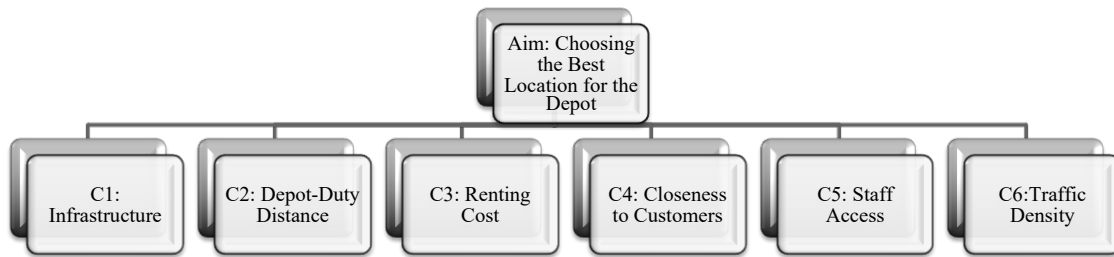


FIGURE V. HIERARCHY MODEL FOR SELECTING A BEST DEPOT FOR THE COMPANY

TABLE 3. PAIRWISE COMPARISON FOR CRITERIA'S WEIGHT

	C1	C2	C3	C4	C5	C6
C1	E	FW	AW	VW	SW	VW
C2	FS	E	FW	E	SS	SW
C3	AS	FS	E	SS	FS	SS
C4	VS	E	SW	E	SW	SW
C5	SS	SW	FW	SS	E	FW
C6	VS	SS	SW	SS	FS	E

C3 (renting cost) > C6 (traffic access) > C4 (proximity to customers) > C2 (depot-duty distance) > C5 (staff access) > C1 (infrastructure). Because infrastructure has low importance, we exclude this criterion when we evaluating the alternatives.

After calculating the weights of the criteria for site selection, it is planned to use the TOPSIS method for the evaluation of alternatives. There were four depot alternatives where Ümraniye, Arnavutköy, İkitelli and Aksaray locations and these alternatives were compared according to the criteria. As a result, Ümraniye was determined as the most suitable location.

TABLE 4. PAIRWISE COMPARISON FOR ALTERNATIVES

	İkitelli	Arnavutköy	Aksaray	Ümraniye
C1	G	MG	F	MG
C2	MP	MG	P	F
C3	G	F	VG	MG
C4	MG	F	G	VG
C5	P	MG	MP	F

B. Lean Warehouse Management

Many lean practitioners consider the term warehouse and lean to be mutually exclusive. However, regardless of how fast inventory is turned, warehouses will always exist to allow a company to deal with variations in customer demand. The key is, to reduce the non-value-added steps in the warehouse as much as possible and to improve velocity and flow in the work environment. Implementation of a lean warehouse starts with value stream mapping step [6]. The current Value Stream Map setting that the company uses in their factory shipping operations is presented on the below Figure 6.

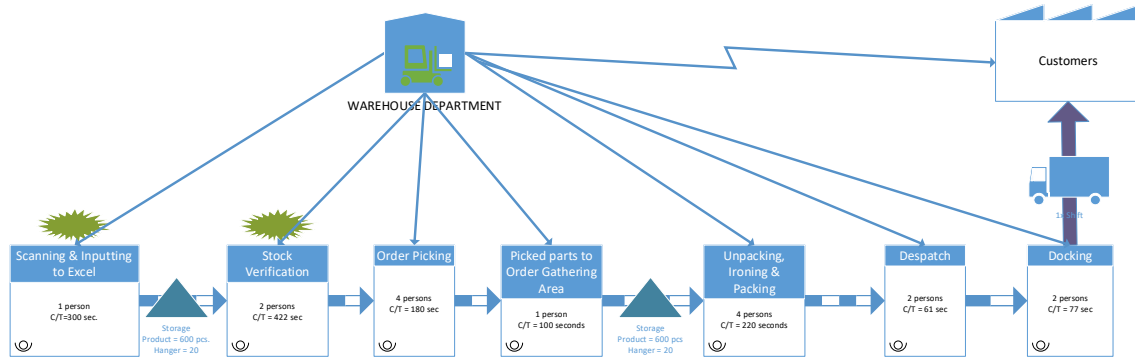


FIGURE VI. CURRENT VALUE STREAM MAP OF THE COMPANY

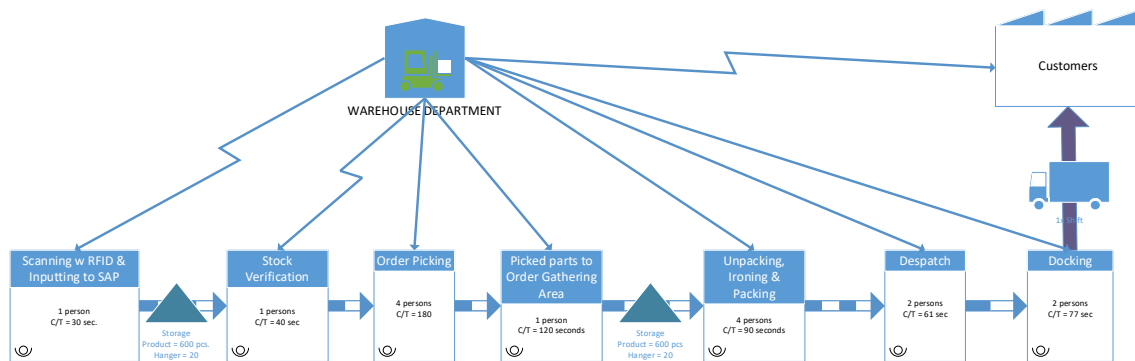


FIGURE VII. FUTURE VALUE STREAM MAP OF THE COMPANY

On the second phase of value stream mapping, some non-value-added steps were identified and removed from the current stream. Figure 7 details the future value stream map after the lean principles applied to the current work flow of the warehouse. The company was using manual data entry with Excel, this was replaced with the SAP system and an RFID scanning technology was implemented to speed up the data entry process which resulted in 270 seconds of improvement in data inputting. Adaptation of the SAP system decreased the stock verification time drastically. Also, the number of personnel required is decreased to one from two at this step. The new improved warehouse layout of the shelves shown in Figure 8 decreased the transfer time of the picked parts to order gathering area by 20 seconds, comparing to the old layout that the company used. Finally, it was detected that unpacking and packing of the products takes a total of 40 seconds, but ironing each product takes approximately 180 seconds and to shorten this consumed time in the new lean system offering, the traditional ironing system was replaced with a hand-held vertical steam iron. This improved the ironing time down to 50 seconds.

V. DISCUSSION

Warehouses are very important links in a supply chain network at local or globalized markets. Warehouse location in the supply chain network determines the efficiency and speed of supply chains. Besides location selection, the implementation of lean principles in the warehouse is also a step of improving the warehouse process and performance, but also of the whole company. The philosophy of lean has been accepted widely for the past 20 years and many different service industries have been using the lean techniques successfully. That's why, the application of lean techniques to warehouse industry should

increase the efficiency in a positive way. Contrary to the belief that lean techniques are generally valid and successful only in manufacturing, the application of Lean in the warehouse activities can lead to significant improvement, such as elimination of waste, improvement of the lead-times and better value creation [20]. In this real-world case study, by using fuzzy AHP decision making technique, the location of the new warehouse was selected as Ümraniye district of the city of Istanbul. The sales of the past two years were used to calculate the forecasting of the next four years with the Excel's forecasting tool, while 12-month periods were chosen as seasonal periods, and an accuracy rate of 95% was considered. The results of the estimation were requiring an area for approximately around 25000 pieces per month and in the light of this data the cost of outsourcing the service and renting a warehouse for operating was compared. Since operating a warehouse was less costly, a new warehouse design is drawn as shown in Figure 8. As a final step, the current and future value stream maps of the manufacturer's warehouse were drawn and some non-value-added steps were identified and removed from the current stream by using the lean techniques. While the total time required before the lean application was 1360 seconds, this time decreased to 578 seconds after the application.

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APPENDIX

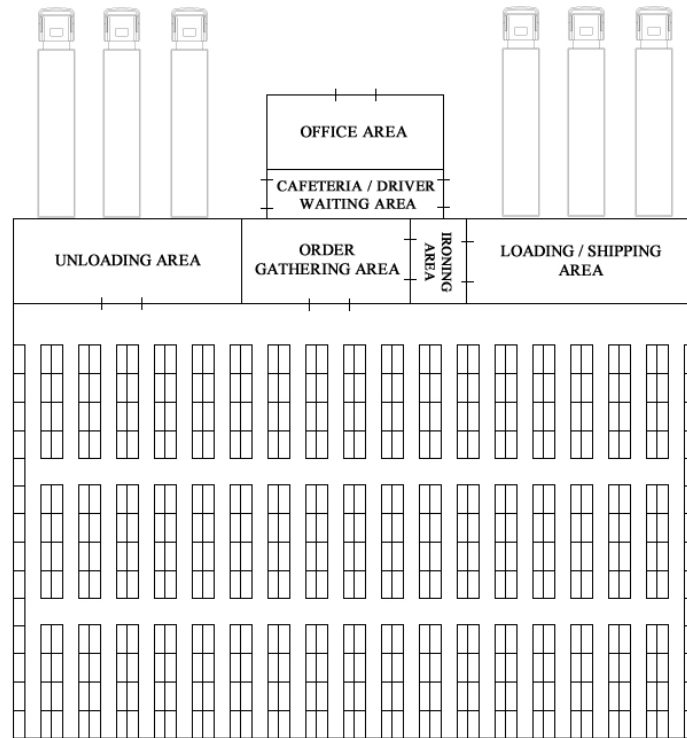


FIGURE VIII. IMPROVED LAYOUT DESIGN OF THE SHELVES

İnşaat Sektöründe Dijital Dönüşüm Sürecine Etki Eden Faktörlerin Dematel Yöntemi ile Değerlendirilmesi

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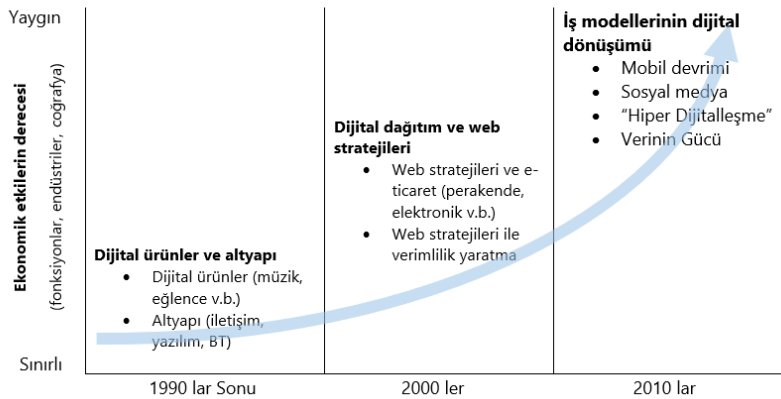
Özet—Dijital dönüşüm artık birçok işletme için kritik önceliğe sahip olmaya başlamıştır. Firmaların uçtan uca süreçlerinin daha iyi yönetilmesi ve rekabet avantajı için artık olmazsa olmaz bir kavram haline gelmiştir. Dijital dönüşüm çalışmaları bir süredir hayata geçirilmekte ve uygulamaları hem üretim hem de tüketim aşamalarında artık sıkça görülmektedir. Ancak her sektör aynı hızla bu dönüşüme ayak uyduramamaktadır. Her sektörün farklı dinamiği olduğu gibi, farklı dijital olgunluk seviyelerine rastlamak mümkündür. İş süreçlerinin dijital dönüşümü söz konusu olduğunda inşaat sektörünün diğer endüstrilerin gerisinde kaldığı görülmektedir. Bu çalışmada özellikle inşaat sektörü özelinde bir değerlendirme yapmak hedeflenmiştir. Dijital dönüşüme etki eden faktörler ortaya konarak, bu alanları başarılı bir dönüşüm için önemini Dematel yöntemi ile analiz edilmesine çalışılmıştır. Çalışmanın özellikle inşaat sektöründe, dijital dönüşümde göz önünde bulundurulması gereken faktörlerin önem derecelendirmesinde yol gösterici olması amaçlanmıştır.

Anahtar Kelimeler — Dijital Dönüşüm, Dematel, İnşaat Sektörü, Dijital Olgunluk, Strateji

I. GİRİŞ

Endüstri 4.0 ile birlikte firmaların dijital dönüşümü konusundan çokça bahsedilir olmuştur. Dijital dönüşüm organizasyonların rekabet edebilirliğini etkileyen, başarılı sonuçlar üretmek için olmazsa olmaz bir olgu haline gelmektedir. Geline aşamada bu kavramın değerlendirilmesinde öz ve sınırlar anlamında tek bir yaklaşımın olduğu söylenemez. Teknolojinin kendisi gibi dijital dönüşüm kavramı da zaman geçtikçe gelişmekte ve farklı yaklaşımlar ortaya çıkmaktadır [1].

Kuruluşlar başarılı sonuçlar elde etmek ve uygun dijital dönüşüm stratejisini oluşturmak için bu deneyime sahip uzmanların görüşlerine başvurmaktadır. Bu konuda adım atmış firmaların yaklaşımlarını şu şekilde özetlemek mümkün olur: Dijital dönüşüm, dijital teknolojilerin etkisine uyum sağlamak, bu uyumu sağlarken de kuruluşun hem iç hem de dış süreçlerine tam olarak entegre etmek [2].



Şekil-1 Dijital Dönüşüm Yapılanmasının Evrimi

Dijital dönüşümün gelişimine bir göz atılırsa başlangıçta kuruluşlar yeni teknolojilerin yeni ürün geliştirme ve bazı süreçlerin basitleştirilmesi için bir yardımcı olarak görmüşlerdir. Bununla birlikte günlük yaşama da girmeye başlayan gelişen teknoloji, aslında kuruluşların bunu birçok alanda kullanmasını, hatta stratejilerini gelişen teknolojiye bağlı olarak oluşturmalarını zorunlu kılmıştır. Bu gelişimin özeti Şekil-1 de üç aşamalı olarak gösterilmektedir [2].

II. DİJİTAL DÖNÜŞÜM VE İNŞAAT SEKTÖRÜ

Teknolojik değişimdeki hız tüm sektörlerde geleneksel süreçleri, çalışma biçimlerini değiştirmektedir. İnşaat sektöründe de dijital dönüşüm daha iyi finansal sonuçlar, daha fazla üretkenlik açısından çok önemli hale gelmiştir. Burada temel anahtar alanlara değinmek yerinde olacaktır [3].

Öncelikle verinin kolay elde edilmesi ve analiz edilmesi için elektronik olarak toplanması önemlidir. Dijital veri yapıları, diğer tüm uygulamaların üzerine kurulacağı sağlam bir altyapı olarak oluşturulmalıdır. Otomasyon kendi kendini organize eden sistemler oluşturmak ve yeni teknolojilerin kullanılması için önemli bir rol oynamaktadır. Farklı sistemler ve farklı aktivitler arasındaki bağlantının kusursuz olması da verimli çalışan otomasyon sistemlerinin en önemli yapı taşıdır. Sistemlere hem iç hem de dış ağlardan erişim, bu erişimin güvenlik endişelerinin giderilmiş bir şekilde yapılandırılması ve mobil sistemlerin etkin kullanımı da öncelikli ele alınması gereken konulardandır [4].

İnşaat sektörünün farklı disiplinle ile olan etkileşimi yüksektir. Bu sebepten sektör ile ilgili tüm alanlarda dijital dönüşüm sağlanarak işletmelerin rekabet gücü geliştirilebilir. Burada 5 temel zorluktan söz etmek mümkündür [5].

- **Ekosistem çapında entegrasyon:** İşletmeler yıllar içinde farklı ihtiyaçlardan dolayı birçok sistem devreye alırlar. Bu sistemler yıllar içinde değişiklik ve yamalarla yaşatılmak istenir. Bu sistemlerde biriken verilerin bütünlük içinde olmaması da ayrı bir sorun teşkil eder. Sonunda kullanıcılar kendilerini birbirinden bağımsız karmaşık sistemler ve verilerle boğuşur halde bulurlar.
- **Rasyonelleşme ve Standardizasyon:** Karmaşık, standart olmayan, firmaya göre özelleşmiş süreç ve sistemlerin bir noktada rasyonelleştirilmesi gerekir. Birbirinden ayrılmış ve farklılaşmış süreçler verimlilik sorunu oluşturacaktır.
- **Dijital Yetenek Oluşturma:** Dijital yetenek dendiğinde çoğunlukla bilgi teknolojisi çalışanlarının akla geldiği zamanlar geride kalmıştır. Sektörde dijital olarak bilgili ve değişime öncülük edebilecek üst düzey liderlere ihtiyaç bulunmaktadır.
- **Dijital Benimsenmenin Sağlanması:** İşletmeler de kültürel ve teknik zorluklardan kaynaklı olarak değişime direnç ve yeni sistemlere adaptasyon sorunu bulunması muhtemeldir. Bu dijital sistemlerden elde edilecek değerlerin kazanılmasını yavaşlatabilir.
- **Yatırım Getirisi ve Değer Oluşturma:** İşletmeler büyük dijital yatırımlardan elde edilen faydayı ölçmekte zorlanabilmektedir. Hızlı geri dönüş beklemek yerine bunun stratejik olarak yapılandırılmış bir beklenti planı ile yönetmek gerekir.

Müşteri beklentileri, talepler, rekabet ve finansal ortam inşaat sektöründe dijital dönüşümü teşvik eden itici güçlerdir. Yeni dijital ekosisteme uyum sağlamakta geciken işletmeler rekabet avantajını elde edemeyeceklerdir [1].

III. İNŞAAT SEKTÖRÜNDE DİJİTAL DÖNÜŞÜMDE BAŞARI FAKTÖRLERİ

Dijital dönüşümün sadece sistemlerin dijitalleşmesi değildir. Dijital dönüşümün başarısı işletme içi ve işletme dışı birçok faktörün doğru yönetilmesine bağlıdır [6]. Bu faktörlerin sonuca etkisinin yanı sıra birbirleri üzerinde de etkisi bulunmaktadır. Aşağıdaki başarı faktörlerinin tespiti yapılırken hem Endüstri 4.0 hem de İnşaat Sektörü özelindeki çalışmalar dikkate alınmıştır.

Vizyon ve Strateji

Sanayi 4.0, teknolojik olarak gelişmeden ziyade işletme süreçlerinin ve iş modellerinde bir değişim gerektirmektedir. Dijital dönüşüm sürecini sadece bir teknoloji yatırımı değil iş modellerinin değiştiği,

gerektiğinde yeni iş modellerine adapte olunan bir süreç olarak ele almak gerekir. Bu açıdan işletmenin stratejilerine uygun bir dönüşüm vizyonu belirlenmeli ve uygulanmalıdır. Dönüşüm sürecinde analiz ve planlama alt yapısının oluşturulması, projelerin bütünsel bir yapıda izlenmesi ve yönetilmesi önemlidir [7].

Organizasyon Yapısı

İşletmenin organizasyonel yapısı dijital dönüşümün önemini işletme içinde kavrayacak ve yaygınlaştıracak şekilde düzenlenmelidir. Çalışanlar için yenilikçiliğin teşvik edilmesi, yeni teknolojilerin kullanıldığı bir yapının oluşturulması gerekmektedir [8].

İş Ortakları ile Entegrasyon

Tedarikçiden müşteriye kadar olan her aşamada yatay entegrasyonun sağlanması önemli bir alan olarak karşımıza çıkmaktadır. Tedarikçiler ile olan iletişim, hizmet alımlarının çevrimiçi sistemler tarafından yönetilmesi, sipariş sevkiyat süreçlerinin elektronik olarak işletilmesi, lojistik süreçlerin otomatize edilmesiyle suretiyle dijital bir yapı sağlanmalıdır. Diğer yandan müşteri istek ve ihtiyaçlarının, müşteri ile ilgili sevkiyat vb. süreçlerin de aynı şekilde dijital bir altyapı ile desteklenmesi önemli bir aşamadır. Tüm bu süreçlerin mutlaka işletmenin iç süreçleriyle bütünlük bir yapıda olması doğru bir dijital dönüşüm için önemlidir [9].

İş Süreçlerinin Entegrasyonu

İşletme içindeki tüm alt süreçlerin birbiriyle etkileşimli bir şekilde yönetilmesi gerekmektedir. Bu süreçlerin entegrasyonu işletme içinde dikey entegrasyon olarak da adlandırılır. Doğru yapılandırılmış bir Kurumsal Kaynak Yönetimi sistemi ile tedarik süreçleri, ürün ve veri akışının kontrol edilmesi, planlama, satış, finans gibi birçok alandaki sistemlerin akıllı ürünler ile birbirine bağlanması ve her aşamanın izlenebilir olması şeklinde ifade edilebilir [9].

Akıllı Saha Yönetimi

Sahadaki işlerin etkin olarak planlanması ve yönetiminin teknoloji ile desteklenmesi ve sahada optimizasyonun sağlanması önemli bir noktadır. İnşaat organizasyonu çalışanları, çalışma sürelerinin sadece %30'unu birincil faaliyetleri için harcamaktadır. Kalan %70'lik kısım ise çeşitli taahhütler, malzeme taşımacılığı, şantiye ve ekipman hazırlığı kapsamındadır [1]. Dijital sistemlerin kullanılması, daha büyük veri kapsamlarının toplanması ve analizi yoluyla çalışma süresi kullanımının verimliliğini artırmaya olanak tanıyacaktır.

Bilgi Sistemi ve Teknoloji Alt yapısı

Dijital dönüşümde gelişmiş teknolojilerin kullanılması artık kaçınılmazdır. Öncelikle ERP alt yapısının organizasyon süreçlerini kusursuz karşılayacak şekilde oluşturulması önemlidir. Bununla birlikte Robot ve Drone teknolojileri, RFID, mobil sistemler, BIM teknolojileri, büyük veri ve raporlama teknolojilerinin süreçlere uygun olacak şekilde seçimi ve konumlandırılması gerekir.

Nitelikli İş Gücü

Dijital dönüşüm sürekli bir eğitim ve gelişim sürecini de beraberinde getirir. Hem yeni iş modellerine adaptasyon hem de gelişmiş teknolojinin kullanımı başarı için en önemli faktörlerdir. Dijital dönüşüm ile birlikte fiziksel güçten beyinsel güce doğru bir geçiş söz konusudur. Daha önce fiziksel olarak yapılan işlerin artık makina ve otomatik sistemler tarafından yapıldığı düşünülürse asıl ihtiyaç bu sistemlerin doğru ve etkin kullanılması olarak karşımıza çıkmaktadır. Çalışanların bu değişime ve yeni teknolojilere ayak uydurması ve gerektiğinde doğru iş gücü kaynağının istihdamı son derece önem kazanmıştır [6].

Güvenlik

Oluşturulan dijital ortamda güvenlik ve gizlilik önemli bir konu olarak karşımıza çıkmaktadır. Hem iç hem dış sistemlerin bütünlük bir yapıda olduğu düşünüldüğünde tüm kademeleri içerecek bir güvenlik stratejisi ve alt yapısının oluşturulması gerekmektedir.

IV. ÇALIŞMA YÖNTEMİ

Üçüncü bölümde ayrıntılı olarak açıklanan başarı faktörlerinin değerlendirilmesi için DEMATEL (The Decision Making Trial and Evaluation Laboratory Method) yöntemi kullanılmıştır. DEMATEL, Cenevre Araştırma Merkezi'nin Battelle Memorial Enstitüsü tarafından karmaşık ve birbiriyle ilişkili sorunları çözmek için geliştirilmiştir [10], [11]. DEMATEL yöntemi, başlangıçta çelişkili ve karmaşık problemlerin anlaşılır hale gelmesi için kullanılmış olsa da ilerleyen dönemlerde yaygın olarak, karmaşık nedensel yapıları görselleştirmek, faktörler arasındaki etkileşim ve faktörlerin değerlendirilmesi için kullanılmıştır.

DEMATEL yönteminin en önemli üstünlüklerinden biri, faktörleri etkileyen (sebep) ve etkilenen (sonuç) faktörleri olarak gruplandırmasıdır.

Literatüre bakıldığında Endüstri 4.0 ve Dijital Dönüşüm konularında Dematel kullanılarak yapılan çalışmalara rastlanmaktadır. Koçak ve Diyardin [7], Endüstri 4.0 geçiş süreçlerindeki kritik başarı faktörlerinin incelenmesinde bu yöntemi kullanmıştır. Ömürgönülşen ve diğerleri [12], Bulanık Dematel kullanarak Lojistik firmalarının Endüstri 4.0 uyum sürecinde dikkate alınacak faktörleri incelemiştir. Saçak ve diğerleri [14] Dematel ile birlikte AHP'yi de kullanarak, bir işletmede nesnelerin internetinin (IoT) başarılı bir şekilde uygulanabilmesi için etkili olabilecek faktörleri incelemiştir. Apilioğulları [13], Dematel yönetimini üretim işletmelerinin dijital dönüşümde başarılı olabilmesi için, ilgili kavramların birbirleri ile olan ilişkisini incelemiştir.

DEMATEL yönteminin aşamaları ve çalışmanın metodolojisi aşağıda gösterilmektedir.

Aşama 1: Direkt İlişki Matrisinin Oluşturulması (Uzman görüşleri)

İlk aşamada uzmanların ikili değerlendirmesi için ölçek belirlenip ilişki değerlendirme matrisi oluşturulur. Burada belirlenmiş olan 8 faktör için araştırılacak potansiyel etkilerin sayısı $8 \times 7 = 56$ olacaktır. Bu değerlendirilmede 5 aşamalı Tablo I de gösterilen değerlendirme ölçeği baz alınmıştır.

TABLO I
DEMATEL DEĞERLENDİRME ÖLÇEĞİ

Sayısal Değer	Tanım
0	Etkisiz
1	Düşük Etki
2	Orta Etki
3	Yüksek Etki
4	Çok Yüksek Etki

Direkt ilişki matrisi A ile gösterilmiştir.

$$A = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

Aşama-2: Normalize İlişki Matrisi

Bu aşamada direkt ilişki matrisi kullanılarak normalize edilmiş direkt ilişki matrisi oluşturulur. Normalize X matrisi (3) numaralı formül kullanılarak elde edilen normalize indisi ile çarpılarak elde edilir.

$$X = sA \quad (2)$$

$$s = \text{Min} \left[\frac{1}{\max_i \sum_{j=1}^n |a_{ij}|}, \frac{1}{\max_j \sum_{i=1}^n |a_{ij}|} \right] \quad (3)$$

Aşama-3: Toplam İlişki Matrisi

Üçüncü aşamada, normalize edilmiş (X) ilişki matrisi elde edildikten sonra aşağıdaki formül kullanılarak toplam ilişki matrisi (T) oluşturulur.

$$T = X.(I - X)^{-1} \quad (4)$$

Bu aşamada toplam etkileme ve toplam etkilenme değerlerini bulmak için aşağıdaki formüller kullanılır.

$$(5) \quad D = \left[\sum_{j=1}^n t_{ij} \right]$$

$$(6) \quad R = \left[\sum_{i=1}^n t_{ij} \right]$$

Satır toplamı D, i faktörünün diğer faktörler üzerindeki toplam etkilerini temsil eder ve faktörün genel gücünü göstermektedir.

Sütun toplamı R, j faktörünün diğer faktörlerden etkilendiğini ve faktörün genel zayıflığını göstermektedir.

Aşama-4: D+R, D-R ve Faktör Ağırlıklarının Belirlenmesi

Bu aşamada ilişki düzeyi olarak adlandırılan D+R, etkileme derecesi olarak adlandırılan D-R değerleri ile birlikte faktör ağırlıkları hesaplanır. Burada,

- D-R değerinin 0'dan büyük olması genel olarak diğer faktörleri etkilediğini gösterir ve faktör “sebebe” grubunda ele alınır.
- D-R değerinin 0'dan küçük olması genel olarak diğer faktörlerden etkilendiğini gösterir ve faktör “sonuç” grubunda ele alınır.

Sebebe ve sonuç gruplarının belirlenmesi problem için önemlidir. Genellikle “sebebe” grubunda yer alan bir faktördeki iyileştirme “sonuç” grubundaki faktörler için de iyileştirme anlamına gelecektir. Kaynakların kısıtlı olduğu ortamlarda bu, önceliklendirme için önemli olacaktır [15].

Faktörlerin önem derecelerini belirlemek için de ayrıca faktör ağırlıkları aşağıdaki formüllerle hesaplanır.

$$(7) \quad W_i = \left\{ (D_i + R_i)^2 + (D_i - R_i)^2 \right\}^{1/2}$$

$$(8) \quad W_i = \frac{w_i}{\sum_{i=1}^n w_i}$$

Aşama-5: Etki-İlişki Haritalarının Oluşturulması

DEMATEL'in değerli çıktılarından biri de faktörlerin birbirleri arasındaki ilişkinin yönünü ve gücünü ortaya koyan Etki-İlişki haritasıdır. Etki-İlişki haritası faktörlerin birbirleri ile olan etki düzeyi ve yönünü anlamakta görsel bir araç sağlamaktadır. Burada iki gösterim şekli vardır. Birinci gösterim şeklinde analitik düzlemde sebebe-sonuç grupları gösterilir. Etki değeri x ekseninde, ilişki değerleri de y ekseninde temsil edilir. Sebebe grubu grafiğin üst kısmında yer alırken sonuç grubu ise alt kısmında yer alır. İkinci gösterim ise faktörler arasındaki etkilerin gösterilmesidir. Çok faktör varsa karmaşıklığı engellemek için toplam ilişki matrisinin tüm değerlerinin ortalaması kullanılarak bir eşik değeri hesaplanabilir [15].

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

Yöntem Nitelikler arasındaki mevcut etkilerin belirlenmesi için DEMATEL (Karar Verme Deneme ve Değerlendirme Laboratuvarı) kullanılacaktır. "Puanlama" kısmındaki matrise bu değerlendirmelerin girilmesi beklenmektedir.				
Değerlendirme Aşağıda verilen tabloda, inşaat sektörü dijital dönüşümü için faktörler arasındaki etkileri değerlendirmeniz beklenmektedir. Bu değerlendirmede, özellikler ikili olarak karşılaştırılacaktır. Faktörlerin kendi üzerinde bir etkisi olmayacağı için faktörlerin kendisiyle kesimi 0 olarak belirtilmiştir. Etkiler ve dereceleri, aşağıda verilen ölçek kullanılarak ankette ifade edilecektir. Ayrıca faktörler hakkında bilgi gerektiği takdirde "Faktörler" sayfasında açıklamalar verilmiştir.				
Etki Derecesi	Tanım			
0	Karşılaştırılan kriterler arasında hiçbir etki yoktur.			
1	Satır ölçütü, sütun ölçütü üzerinde düşük bir etkiye sahiptir.			
2	Satır ölçütü, sütun ölçütü üzerinde orta düzeyde bir etkiye sahiptir.			
3	Satır ölçütü, sütun ölçütü üzerinde yüksek bir etkiye sahiptir.			
4	Satır ölçütü, sütun ölçütü üzerinde çok yüksek bir etkiye			
Örnekler				
Puanlama örnekleri aşağıdaki gibidir:				
"Stratejik Vizyon" faktörünün "Organizasyon Yapısı" faktörü üzerinde YÜKSEK bir etkisi vardır.				
"Organizasyon Yapısı" faktörünün "Stratejik Vizyon" faktörü üzerinde ORTA DÜZEYDE bir etkisi vardır.				
"Organizasyon Yapısı" faktörünün "İş Ortakları ile Entegrasyon" faktörü üzerinde ORTA DÜZEYDE bir etkisi vardır.				
"İş Ortakları ile Entegrasyon" faktörünün "Stratejik Vizyon" faktörü üzerinde DÜŞÜK bir etkisi vardır				
Faktörler	Stratejik Vizyon	Organizasyon Yapısı	İş Ortakları ile Entegrasyon	İş Süreçlerinin Entegrasyonu
Stratejik Vizyon	0	3	3	3
Organizasyon Yapısı	2	0	2	2
İş Ortakları ile Entegrasyon	1	1	0	2
İş Süreçlerinin Entegrasyonu	1	1	2	0

Şekil-2 DEMATEL Anket Örneği

V. UYGULAMA

Bu çalışmada inşaat sektöründeki işletmelerin dijital dönüşümüne etki eden faktörlerin değerlendirilmesi amaçlanmıştır. Üçüncü bölümde detaylı açıklanan faktörler Tablo II'de kodlamaları ile listelenmiştir. Bu çalışmada 4 uzman ile görüşülmüştür. Bu uzmanlardan ikisi inşaat firmalarında özellikle bilgi teknolojileri alanında çalışan yöneticilerdir. Uzmanlardan diğer ikisi daha çok inşaat firmalarına danışmanlık ve proje yönetim hizmetinde bulunan kişilerdir. Uzmanlar değerlendirmelerini ayrı ayrı yapmışlardır. Uzmanların değerlendirilmesi için anket hazırlanmış olup bu ankette faktörler, değerlendirme skalası ile ilgili bilgi verilip Şekil-2'de de görülebileceği üzere hazırlanan matrisin oluşturulması için örneklere yer verilmiştir.

TABLO II
DEĞERLENDİRİLEN BAŞARI FAKTÖRLERİ

F1	Stratejik Vizyon
F2	Organizasyon Yapısı
F3	İş Ortakları ile Entegrasyon
F4	İş Süreçlerinin Entegrasyonu
F5	Akıllı Saha Yönetimi
F6	Bilgi Sistemi ve Teknoloji Alt yapısı
F7	Nitelikli İş Gücü
F8	Güvenlik

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İstanbul Technical University & Bahçeşehir University

Aşama-1: Direkt İlişki Matrisi

Bu aşamada uzman görüşleri bir araya getirilerek direkt ilişki matrisi oluşturulmuştur. Aynı ayrı alınan uzman görüşleri değerlerin aritmetik ortalaması alınarak Tablo III'de görülen tek bir matrise çevrilmiştir.

TABLO III
DİREKT İLİŞKİ MATRİSİ

	F1	F2	F3	F4	F5	F6	F7	F8
F1	0	2,5	2,75	3,75	4	3,25	3	2
F2	1	0	2,25	3	2,5	1,75	3	2,25
F3	1	1	0	3	2,5	1,75	1,5	1,75
F4	1,25	1,75	3,25	0	3,25	2,5	2,25	2,5
F5	1,25	1,5	2,5	2,5	0	2,75	2,5	2,5
F6	1,5	1,5	3,25	4	3,75	0	2,5	3,25
F7	1,25	2,25	2,5	2,75	2,25	1	0	1,75
F8	0,25	1	1	1	1,5	2,25	1,5	0

Aşama-2: Normalize Direkt İlişki Matrisi

Bu aşamada ilk adımda elde edilmiş direkt ilişki matrisi, 2 ve 3 nolu formüller kullanılarak Tablo IV'de görülen normalize ilişki matrisi oluşturulmuştur.

TABLO IV
NORMALİZE EDİLMİŞ DİREKT İLİŞKİ MATRİSİ

	F1	F2	F3	F4	F5	F6	F7	F8
F1	0,0000	0,1176	0,1294	0,1765	0,1882	0,1529	0,1412	0,0941
F2	0,0471	0,0000	0,1059	0,1412	0,1176	0,0824	0,1412	0,1059
F3	0,0471	0,0471	0,0000	0,1412	0,1176	0,0824	0,0706	0,0824
F4	0,0588	0,0824	0,1529	0,0000	0,1529	0,1176	0,1059	0,1176
F5	0,0588	0,0706	0,1176	0,1176	0,0000	0,1294	0,1176	0,1176
F6	0,0706	0,0706	0,1529	0,1882	0,1765	0,0000	0,1176	0,1529
F7	0,0588	0,1059	0,1176	0,1294	0,1059	0,0471	0,0000	0,0824
F8	0,0118	0,0471	0,0471	0,0471	0,0706	0,1059	0,0706	0,0000

Aşama-3: Toplam İlişki Matrisi

Normalize edilmiş ilişki matrisi alınıp 4 numaralı formül uygulanarak Tablo V'deki toplam ilişki matrisine ulaşılmıştır. Bu aşamada ayrıca bir sonraki adımda kullanılacak toplam etkileme D ve toplam etkilenme R değerleri 5 ve 6 numaralı formüllerle hesaplanır.

TABLO V
TOPLAM İLİŞKİ MATRİSİ

	F1	F2	F3	F4	F5	F6	F7	F8
F1	0,1675	0,3444	0,4796	0,5513	0,5583	0,4496	0,4541	0,4226
F2	0,1664	0,1742	0,3604	0,4125	0,3913	0,3042	0,3642	0,3407
F3	0,1454	0,1884	0,2195	0,3623	0,3432	0,2672	0,2631	0,2796
F4	0,1837	0,2584	0,4142	0,3069	0,4379	0,3491	0,3485	0,3661
F5	0,1758	0,2382	0,3686	0,3933	0,2861	0,3428	0,3425	0,3503
F6	0,2139	0,2782	0,4592	0,5151	0,5054	0,2844	0,3978	0,4367
F7	0,1627	0,2504	0,3404	0,3713	0,3503	0,2507	0,2130	0,2930
F8	0,0836	0,1443	0,1982	0,2130	0,2308	0,2265	0,2032	0,1430

Aşama-4: D+R, D-R ve Faktör Ağırlıklarının Belirlenmesi

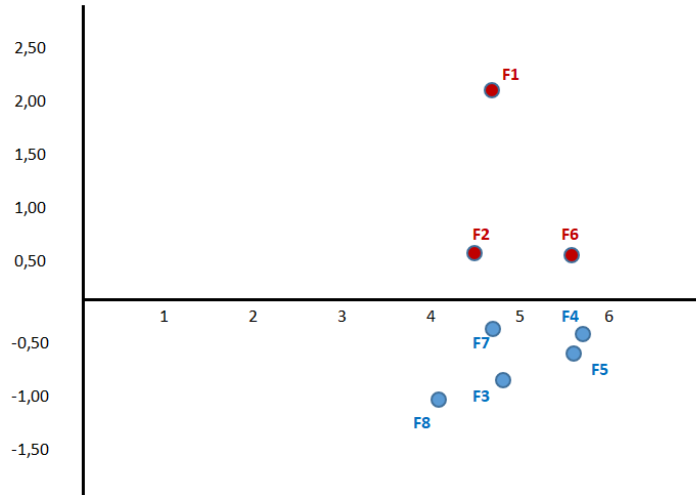
Bir önceki adımda toplam ilişki matrisinden çıkan D ve R değerleri ile Faktörlerin ilişki seviyesi ve etkileme derecesi değerleri D+R ve D-R olarak hesaplanır. Bu değerler aynı zamanda Tablo VI'da da görüldüğü faktörlerin sebep ve sonuç gruplarına da ayrılmasını sağlar.

TABLO VI
D+R, D-R VE AĞIRLIK DEĞERLERİ

	D	R	İlişki Seviyesi		w	W	Tip
			D+R	D-R			
F1	3,4274	1,2991	4,7265	2,1284	5,1836	0,1273	SebeP
F2	2,5139	1,8765	4,3904	0,6374	4,4365	0,1090	SebeP
F3	2,0688	2,8401	4,9088	-0,7713	4,9691	0,1221	Sonuç
F4	2,6649	3,1258	5,7907	-0,4609	5,8090	0,1427	Sonuç
F5	2,4976	3,1032	5,6009	-0,6056	5,6335	0,1384	Sonuç
F6	3,0908	2,4745	5,5653	0,6163	5,5993	0,1376	SebeP
F7	2,2318	2,5865	4,8183	-0,3547	4,8313	0,1187	Sonuç
F8	1,4425	2,6321	4,0745	-1,1896	4,2446	0,1043	Sonuç

Aşama-5: Etki-İlişki Haritalarının Oluşturulması

Elde edilen verilere göre etki grafiği Şekil-3'teki gibi oluşmaktadır.



Şekil-3 Etki Grafiği

Etki grafiği faktörleri sebep ve sonuç olarak gruplarsa da faktörlerin birbirlerine olan etkisini göstermemektedir. Etki-ilişki haritası faktörlerin birbirleri ile olan ilişkisini daha net göstermektedir. Burada çok sayıda ilişki çizilebileceğinden eşik değeri olarak toplam ilişki matrisinin ortalama değeri olarak $\alpha=0,3115$ belirlenmiştir. Bu değerin altındaki ilişkiler dikkate alınmamıştır. Dikkate alınan ilişkiler için ise daha net bir izleme yapabilmek için Tablo VII'de görülen 3 seviyeli bir gruplama yapılmıştır. Bu gruplamaya ve renklere göre etki ilişki haritası Şekil-4'de gösterilmiştir.

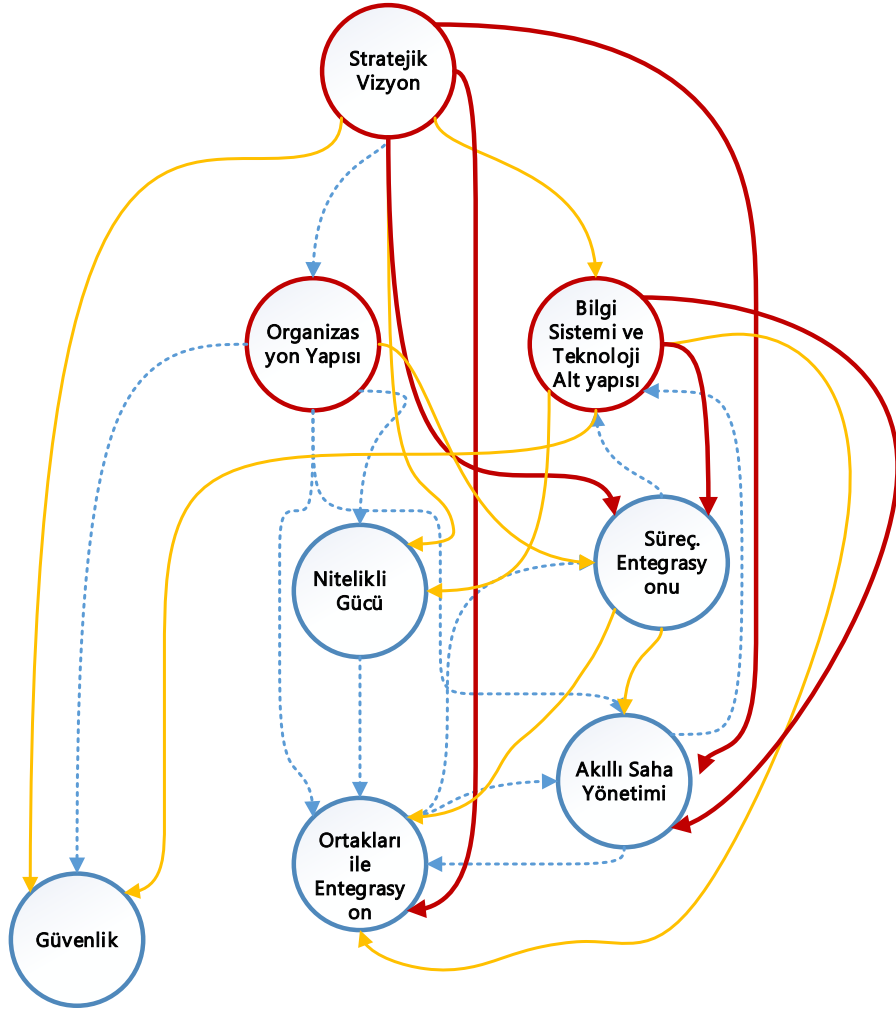
TABLO VII
EŞİK DEĞERİ ÜSTÜ İLİŞKİ SEVİYELERİ

Seviye	Alt Sınır	Üst Sınır
Orta	0,3115	0,3938
Yüksek	0,3938	0,4760
Çok Yüksek	0,4760	0,5583

VI. TARTIŞMA VE SONUÇ

Temel olarak bu çalışmadaki amaç inşaat sektöründe dijital dönüşümde öne çıkan faktörleri analiz etmek ve tüm diğer faktörlerle olan ilişkisini ortaya koymaktır. Hesaplama sonuçlarına göre Stratejik Vizyon (F1), Organizasyon Yapısı (F2) ve Bilgi Sistemi ve Teknoloji Alt Yapısı'nın (F6) diğer faktörlere göre öne çıktığı ve sebep grubunda ele alınabileceği, diğer faktörlerin ise sonuç grubunda ele alınabileceği söylenebilir.

Stratejik Vizyon sebep grubundaki diğer faktörlere göre biraz daha öne çıkmaktadır. Etki ilişki haritasına baktığımızda Stratejik Vizyon faktörünün çok yüksek etkilerinin daha fazla olduğu görülmektedir. Stratejik Vizyon faktörünün İş Ortakları ile Entegrasyon, İş Süreçlerinin Entegrasyonu, Akıllı Saha Yönetimi gibi operasyonel konulara çok yüksek etkisi vardır. Diğer yandan Bilgi Sistemleri ve Teknolojik Alt Yapı faktörünün özellikle Akıllı Saha Yönetimi ve İş Süreçlerinin Entegrasyonu faktörlerine etkisi çok yüksektir. Burada özellikle bu iki faktör teknoloji yoğun konuları kapsar ve çok yüksek etki derecesinin olması beklenen bir çıktı olarak değerlendirilebilir. Organizasyon Yapısı faktörü sebep grubunda yer alan diğer bir faktördür. Çok yüksek ve yüksek etkilediği faktör sayısı az olmasına karşılık etkilenme değeri düşük olan bir faktördür.



Şekil-4 Etki-İlişki Haritası

İş Süreçlerinin Entegrasyonu (F4), Akıllı Saha Yönetimi (F5), Nitelikli İş Gücü (F7) faktörleri sonuç grubunda olmalarına rağmen sebep grubuna yakın oldukları ve ağırlıklarının da değerlendirilmesi gerektiği söylenebilir. Bu faktörler diğer faktörler tarafından yüksek etki altında kalsalar da ilişki değeri olarak dikkate alınmalıdır.

Elde edilen sonuçlar daha genel bir yaklaşımla değerlendirilirse, en başta inşaat sektöründeki firmaların stratejik ve yapısal olarak dijital dönüşüme hazır hale gelmeleri gerektiğini söyleyebiliriz. Firmaların vizyon ve stratejilerini dönüşüme ayak uyduracak şekilde güncellemeleri, yönetim olarak dönüşüme uyumlu bir yapı oluşturmaları gerekmektedir. Bununla birlikte dönüşümün gerektirdiği uygun teknolojilerin kullanılabilmesi için de sistem ve bilgi alt yapılarının güçlendirilmesi gerekmektedir. Bu çalışmadaki sonuçları değerli kılan nokta ise sebep grubundaki bu faktörlerde yapılacak bir iyileştirme veya yapılandırma çalışmasının diğer faktörlerde de çok olumlu etkisinin olacağıdır. Sonrasında sağlıklı bir dönüşüm için dijitale yatkın kadroların oluşturulması ile hem ofis hem de saha çalışmalarının etkin ve verimli yürütülebilmesi için süreçlerin otomatize edilmesini sağlayacak sistemlerin kurulması daha kolay olacaktır.

Çalışmanın kısıtı olarak inşaat sektörü özelinde teknolojik uygulama alanlarının detaylarının karşılaştırılması ve bunlar için bir sıralama oluşturan bir inceleme yapılmaması söylenebilir. Ayrıca belirlenen faktörler inşaat sektörü bakış açısıyla incelenmiştir. Farklı sektörler için bezer çalışmalar ayrıca yapılabilir.

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Investigation of New Approaches for Collaborative R&D and Innovation

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Abstract— The world has faced challenges over the past years such as continuously increasing global competition and a COVID pandemic which directly influenced and changed the conventional ways of working. Increasing competitiveness in the business world and the need for overcoming the challenges bring the necessity of extensive research, multiple perspectives, having sufficient knowledge about multiple factors (such as technology, and science), openness to new approaches and collaboration. To overcome these challenges and stay competitive, new approaches for collaborative R&D and Innovation have started to be maintained through different and advanced tools such as digital meeting platforms, virtual reality, other virtual spaces and places. This provides integrated information sharing and collaboration from the initial concepts through to the realization and the marketing of a product. In this study, new environments and tools for collaborative R&D and Innovation were searched. A systematic review of literature and practice was performed by browsing the web using “Google Scholar” and “Google” search engines using the keywords “Digital Tools”, “Collaboration Tool”, “Innovation Management”, “Innovation Digitalization” and “Collaboration Environments” to determine studies in which new tools and environment for collaborative R&D and/or innovation are mainly discussed and find available relevant practices.

Keywords— Collaborative Innovation, R&D Collaboration, Collaboration Environments, Digital Collaboration Tools

I. INTRODUCTION

Due to rapid technological improvements, the way of doing business has been transforming [1]. Firms not only consider customer needs but also take the full advantage of the new technology to be one step ahead in competition. Therefore, improving the innovation process becomes a fundamental ability to survive in an ever-changing world. The old technologies are not only fading away but also business models and working habits are changing [2]-[3] with the progress of technology and also as a result of some unpredictable global problems that we have had to face in the recent years[4]. The firms have to be more effective in their innovative activities, not only by changing their processes and products but also by taking into account the high costs and limited resources. Due to the COVID pandemic, physical gatherings have completely disappeared for a certain period of time and people had to find new ways to communicate and continue their work. Moreover, the Russia-Ukraine war that broke out all of a sudden, caused communication problems for many scientists with whom global firms were cooperating and this interrupted many important studies. In particular, these types of learnings have revealed the importance of keeping effective collaboration environments that provide accessibility at any time, and even showed the necessity for both firms and managers to adapt them in their daily work areas as much as possible.

For example, the importance of collaborating with customers or users to develop more innovative products and services is a well-known factor for success [5]-[6]. As a result, this type of collaboration has become an important component of growth efforts for many firms or organizations, and there has been a steady increase in work on this topic. Firms need new effective environments in which they could work with both their customers and other organizations or experts. As in the past, the era of creating new products by only kneading knowledge with technology has been completed. Firms now strive to communicate and collaborate directly with their customers to find out what they want. Users can directly report the products they want to use or the features they want to have in the current product [6]. At that point, firms start to look for new abilities which can be gained with the digitalization of their innovation processes. Digitalization can be defined as the way to create value by using digital technologies and digitized information and digital collaboration is the facilitation of the knowledge shared over the information technology based (IT-based) network platforms [3]. IT-based network platforms enable firms to innovate externally. If the internet-based platform is used for communication and information exchanges related to

interesting products or technologies, it is called a “User Community” [7]-[8]. User communities are defined as “innovation communities” when they aim to gather external knowledge or feedback from users or to find resources to feed into innovation processes.

To communicate and collaborate easily and cost-effectively across the firms, digital tools or environments (digital platforms, social media, cloud technology) are required [9]-[14]. Therefore, the new collaborative working environments can be called as a facilitator for firms or organizations in terms of quickly identifying the problem and revealing the solution in sudden situations or adapting to the new business order. Because of that, with the emergence of the change in collaborative innovation, the search for new digital environments and tools where experts can effectively exchange information began to emerge. The aim of this study is to search and analyse new digital collaboration environments and tools which are used in collaborative R&D for innovation management. In the following, sections first, an overview on digital collaboration systems is given, then the methodology of this study is briefly explained and categorization of digital tools/environments is given in the findings section. In the conclusion section, identified digital tools/environments are tabulated as a summary and the results are discussed.

II. DIGITAL COLLABORATION SYSTEMS

In the past, design engineers used to draw products manually on hand. As a result, the slightest changes were requiring the process to completely start over. Too many iterations of the design phase were causing the projects to fall behind the schedule. Especially in the new product innovation process, manufacturing people could only see and evaluate the product when it came to the production stage. As communication and collaboration tools & environments have changed, they have had implications for individuals, teams, and the organization. After 2000s, the widespread usage of digital design tools enabled engineers to do quick design iteration and with the new tools, communication and interaction during product development increased. In the following years, other tools and working environments that facilitate cooperation began to be included in our lives and it became an increasingly popular topic to how to design a workspace to have greater collaboration between the people. Earlier literature focuses on coworking innovation spaces especially incubators, and science parks [15]-[16]. According to [17], innovation spaces have material sides and also social sides. On one hand, the material side represents the digital or physical interaction space. On the other hand, the social side is more related to sharing a common culture. Digital tools, which are developed over time, such as skype, teams and messaging applications, provide a basis for rapid data exchange and suitable environments for discussion[18]-[19]. With these new type of tools and environments, it is possible to share updates with other team members easily and take their feedback. The most important feature of digital tools and environments is that non-value-added works can be eliminated and value-added activities can be performed without time and space limits [20]. Other cloud-based collaboration applications such as HipChat by Atlassian; Webex & Spark by Cisco; Mattermost; Stitch; Teams by Microsoft enable sharing documents and files anytime, therefore teams can create, share, and exchange ideas whenever they want to and together they can keep things move forward. Teams that are trying to solve a problem can communicate effectively as if they were side by side and work for a solution with synchronized steps instantly.

III. METHODOLOGY

In this study, new environments and tools for collaborative R&D and Innovation were searched. For this purpose, a systematic review of literature and practice was performed by browsing the web by using “Google Scholar” and “Google” search engines. The keywords “Digital Tools”, “Collaboration Tool”, “Innovation Management”, “Innovation Digitalization” and “Collaboration Environments” were used both to determine studies in which new tools and environments for collaborative R&D and/or innovation are mainly discussed and to find available relevant practices. The tools and environments, which are included in this research, were selected considering their possible effects and benefits on collaborative R&D and innovation management. The identified new types of collaborative working environments and tools were categorized based on [20] under two groups, namely “Collaborative Platforms/Environments” and “Collaborative Software/Tools” considering the differences between new digital collaborative approaches. The difference in approach is thought to occur in the form of either creating a project-oriented community or enabling directly adaptable solutions within the firm.

IV. FINDINGS

In this section, first the developments in electronic communication technology are briefly described on the basis of [20] in chronological order. Then the identified new types of collaborative working environments and tools are explained under two categories as explained in the previous section.

B. Electronic Messaging Tools

Electronic messaging tools refer to communication tools between individuals based on messaging infrastructure such as email or messaging applications. Emails enable discussions among members of small groups. In the blog or chat services, larger groups may communicate with each other. Despite the benefits, these are still not fully secured.

Electronic Meeting Tools

The electronic meeting systems refer to computer-supported cooperative work environments. In these systems, users have their own computer and join the set meeting simultaneously. It allows individuals to communicate and share ideas simultaneously. Most of these systems have some basic features like voting, agenda creating and discussion. The main ideas behind the creation of the electronic meeting systems are to increase the efficiency of the group and overcome the disadvantages such as not being co-located.

Conferencing Tools

This kind of communication systems does not require face to face interaction. It is mostly used when the group members are in different locations and need to work on the same task or problem. The main difference of the electronic meeting tools from conferencing tools is the possibility of asynchronous working. These systems enable its users flexibility and control over time and access. The blogs, wiki pages, social networking sites, shared calendars and online forums may be given as examples of these kind of tools. The biggest disadvantage of this kind of system is the absence of physical or social existence, which may cause a loss of interest.

Document Management Tools

These tools enable the users to achieve, store and edit the documents online (e.g. Ideagen). Users can easily track previous versions and reach out in case of need. Multiple reviewers can work on the same version of a document in real time and can review comments, changes and discussions from other reviewers. These tools also enable automated progress tracking and sending reminders. It is possible to control access and visibility of the documents and sections. With this integration, document revision times reduce and automatic notifications inform the users of the latest status of the documents. Especially during innovative product or service development processes, it is important to comply and be ready for regulatory inspections.

New Type of Collaborative Working Environments and Tools(CWET)

Today, the use of collaborative environments and tools are increasing in parallel with advances in technology. With the widespread use of the Internet, more and more digital tools have been used instead of the old communication and collaboration environment or tools. Social media has turned into a very natural and comfortable communication and working area for people [22]. Based on these facts, firms are trying to adapt their processes and strategies with these new kinds of collaboration environments or tools. For that purpose, different kinds of platforms or tools are in use that serve multiple purposes i.e. idea generation, problem-solving, co-creation, finding a marketplace, crowdsourcing, using collective intelligence, and completing micro tasks [23]-[25]. All these tools or platforms are based on software. The term Social Software is used for generic products such as email or wikis etc. If these are used for facilitating any kind of business related task or process, then they are called as Collaborative Software [26]. Collaborative Software enables work on common tasks in order to achieve the common targets. By using such tools in a workplace, a collaborative working environment is constituted and people are enabled to work by providing all kinds of information and connections they may need regardless of their location. As of today, collaborative software can also enable project management and design studies. These tools actually aim to create a collaborative environment to bring together internal experts with external sources, customers, problem solvers.

Collaborative Platforms/Environments: The term of crowd-sourcing refers to using collective knowledge from external resources [27]-[29]. The below mentioned platforms or environments aim to gather individuals, experts, students or organizations to create or support innovation by using crowd-sourcing. Either it can be an organizational structure or an internet-based platform that people apply and join the community. Such structures mostly gather people in order to solve the challenges or to produce innovative solutions in predetermined project titles. Two examples of this type are given below.

Demola: Demola [30] is an open innovation platform, born in 2008, that mainly focuses on university-business collaboration model for creating new products and services. Multidisciplinary university students and their supervisors work together with third party organizations or firms to find solutions to real-life

challenges. Duration of solving these challenges usually lasts 8 weeks and is divided into 4 events to increase interaction between the students, experts and other participants including kick-off sessions and final meetings. In order to support teams, also some work phases are set: discovery phase, the ideation and prototyping phase, and refining and packaging phase. Intellectual Property rights of all works are protected.. Additionally, students who participate in these innovation studies, also obtain academic credit recognition for their work. The purpose of the platform is to explore even weak signals for innovation and identify change drivers. The platform seeks people who would like to stay updated, focus on possibilities and keep their minds open and be curious all the time. According to Demola platform, the old visions of the future are no longer enough to explore different stories and challenge narratives. Demola enables to combine firms' expertise with highly educated university students and discover what the ones wouldn't discover on their own.

Viima: Viima support innovation process mainly through facilitating collection and management of the innovative ideas. The platform lets the firms gather ideas from experts, customers and all the other stakeholders and help to prioritize the ideas to pick the right ones as an open innovation platform. The ideas are automatically categorized and can be easily noticeable by the users. Stakeholders can rate and criticize the ideas. It enables the user to easily refine and develop ideas with their team and let them analyze the progress of the innovation. With the pre-defined metrics, the right people rate your idea and evaluations can be used for prioritization with visualization tools.

Topcoder: Topcoder is a web-based platform which aims to ensure access to resources from people around the world in a short span of time. Individuals either join as solution producers or get work done on this kind of crowdsourcing platform.

Collaborative Software/Tools: The difference between such tools from platforms and environments is to facilitate collaborative innovation by creating a standard interface within the firm and to create a ground that will accelerate collaborative innovation by eliminating the nonvalue-added works in the processes. Besides, these tools offer access to crowdsourcing platforms or environments to reach external resources. Using these tools allow you to connect either with other organizations or with your own customers/stakeholders. These tools include multiple features, from project management to idea generation to supporting collaborative innovation to finding solutions for problems and can generally be integrated into artificial intelligence applications and repetitive tasks can be transferred to AI. Tools have dedicated channels to support the most relevant people working together to complete a task. They provide synchronous or asynchronous communication. They make it possible to vote on ideas, make decisions on the right innovative idea, access real-time reports, monitor KPIs, and learn about the market or future insights[31]-[32].

Slack: Slack is a cloud-based team collaboration app that aims to connect people who matter most to complete the task. Slack enable people to have real-time communication, create teams, track the tasks, easily follow the updates and regardless of location and time have real-time data from anywhere. The platform enables creating channels to connect with the most related colleague to discuss, share and store recent data.. These channels also aid to search for old files or conversations. For example, whilst a part of the team might be discussing design issues, others can concurrently discuss the logistic side in the dedicated channel. Slack also supports integrations to some external services like Asana, GitHub, Jira or artificial intelligence. These platforms enable users to work synchronously and asynchronously. Team building opportunities provided by applications have begun to replace mail exchanges. Receiving a quick reply instead of waiting for a response to a sent e-mail and direct communication are among the other advantages of these applications.

UpBoard: UpBoard tool developed by Praxie is a cloud based-tool for proposing solutions for innovation and design thinking, change management, manufacturing operations, project management, process digitization and consulting processes. The tool has its own library to scan data resources from internal and external databases. It also enables market scanning and creating users' own growth platform to prioritize and discuss the trends, emerging market spaces or future disruptions. The tool offers the best practice templates to create ideas and supports transforming these ideas into products or services by setting development phases and evaluation gates.

Jira: Jira is a web-based tool for team collaboration that enable users to create boards for transparent follow up, and project management, and includes scrum or agile. It is used for team collaboration, lean innovation and project management.

Yambla: Yambla is a tool to support collaborative idea creation and innovation management. It supports overcoming the firm's challenges by focusing on ideation. Users and stakeholders can share their promising innovative ideas and solutions and these ideas can be scored and prioritized to be turned into full-fledged

products or services. In the platform, users can start campaigns to collect new ideas, build dedicated teams to complete deliverables and also discuss with the community. In innovation management, users can set gates to decide to move forward or not and set KPIs to measure the important metrics. Yambla enables including not only R&D colleagues but also all the other stakeholders in the innovation process.

Braineet: This tool enables users to map out their innovation process and portfolio, and centralize all knowledge, deliverables and data in one place. By using this tool, users can create a workflow to guide project members on their objectives and measure what works and what doesn't. It also includes frameworks such as design thinking, scrum, and agile. Braineet also offers integration with other tools such as Microsoft Teams and Zapier to create project members' own channels to work together. Braineet is also a New Product Development software where the users can maximize their new product's success rates. Braineet enables to grant access to relevant stakeholders at project and portfolio levels and build real-time reports on development phases. The tool eliminates manual work, copy/pasting and reworks. A clear view of the data ensures the user to make the right investment in the right idea and kill or iterate or pivot new product development when necessary.

Qmarkets: Qmarkets is an idea and innovation management software. This software supports firms to drive an internal innovation culture by breaking down organizational silos, using the collective intelligence of the employees and overcoming bureaucratic structure in the innovation process. The software enables employees not only to offer their ideas but also to collaborate on the ideas submitted by other stakeholders. By using this software, users can invite their stakeholders or clients to generate ideas for new products and services or digital co-creation engagements. It involves Q-ideate process, which is basically defined by 5 steps; (1) define campaigns which tackle your strategic business goals, (2) invite the most relevant users to submit ideas and collaborate, (3) invite experts to review and rate the ideas, (4) implement the chosen idea, (5) measure and reward.

InVision: InVision is a web-based visual collaboration tool specifically created for the designers to turn designs into prototypes complete with gestures and animations. All the users or stakeholders can provide feedback from the beginning of the design and it is possible to keep users up to date about the progress. InVision brings teams and tools together in one real-time collaborative workspace. It can be integrated with Microsoft Teams and Zoom. Users work collaboratively, take and give feedback, send reviews, and make changes easily. Thus, teams can work smarter, faster and more in sync.

Mural: Mural is a kind of digital whiteboard that creates a collaboration space to empower users to innovate. It is possible with this tool to collaborate with customers or stakeholders to discover new insights, visualize the ideas and possible solutions or collect design requirements for prototyping. Teams can work together in real-time or asynchronously, and can talk about new ideas and insights. The tool aims to support brainstorming and ideation for innovation. The tool can be integrated with Microsoft Teams, Zoom, and Webex.

Stackfield: Stackfield is a web-based collaboration tool that combines all the features that teams may need to collaborate and increase productivity. With team chat, users can exchange information with other users or use dedicated channels to solve the problem or create specific ideas. In these communication channels, the documents shared are available all the time. For generating ideas, it is possible to create subject-based discussions and ensure important decisions remain clear, reasonable and easy to find. The tool also has features such as audio and video conferencing and screen sharing to discuss design proposals or presentations or help others. Stackfield has wiki pages to share policies, templates or plans.

V. CONCLUSION

When the studies and practices were examined, twelve digital tools/platforms were identified and it is found that the use of different tools and platforms can be considered by focusing on five different purposes in collaborative R&D and innovation; namely, (1) gathering and assessing customer insights, (2) generating and elaborating ideas, (3) task assignment and solution creation, (4) synthesizing and analyzing the collected data and (5) design and/or development (See Table 1). Firstly, users collaborate to gather insights from external resources and see what the latest trend is. Main activities include collecting the data generated from the market and deciding how to shape strategy or defining where to invest. Secondly, team performs collaborative work on producing ideas, deciding which of the ideas will be put into practice, and detailing the ideas. Thirdly, task assignments for the realization of the innovation idea and the creation of solution proposals are performed in collaboration. Fourth purpose involves analyzing, interpreting and reporting data. Fifth purpose involves design and development; team works to turn innovative ideas into a product or service.

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

TABLE XIII
 Tools and Environments Categorized By Collaboration Phases

		Collaborative Platforms/Environment			Collaborative Software/Tools								
		Demola	Viima	TopCoder	Slack	Upboard	Jira	Yambla	Braincet	Omarkets	InVision	Mural	Stackfield
Focuses on collaboration	gathering & assessing customer insights					x	x	x	x	x			
	generating and elaborating ideas	x	x		x	x	x	x	x	x	x	x	x
	task assignment and solution creation	x		x		x	x	x	x	x	x	x	x
	synthetizing and analyzing the collected data					x	x	x			x		x
	design or development						x				x		

The results of the study show that majority of the collaborative tools and environments investigated in this study especially supports collaboration in terms of increasing productivity, accessing different ideas and perspectives, and producing internally and externally generated solutions. In the future studies, usability of these platforms and tools for various purposes can be compared, the effect of these platforms and tools on individual creativity can be explored, the required personality characteristics for the effective use of these tools and environments can be investigated.

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Kent İçi Raylı Ulaşım Sistemlerinde Metro İstasyonlarının Yapısal ve Mimari Tasarım Kriterleri Üzerinde İnceleme

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Özet — Dünya genelinde kent içi raylı ulaşım sistemleri güvenilirlik, rahatlık, taşıma kapasitesinin yüksek olması, konforlu ve hızlı ulaşım sağlaması gibi ölçütler sebebiyle yolcular için kent içi toplu ulaşım sistemleri arasında öncelikli konumda yer almaktadır. Kent içi raylı ulaşım sistemleri içerisinde yolculuk güzergâhında, başlangıç noktasından bitiş noktasına devamlılığı ve hızlı olması sebebiyle en büyük yolcu trafik potansiyelini karşılayan sistem ise metrolardır. Ayrıca, raylı ulaşım sistemlerinin en önemli noktası ise insanların sistemi ilk deneyimlediği yerler olan istasyonlardır. Metro sistemi içerisinde yolcu sirkülasyonunu sağlayan istasyonlar, yolcuların ihtiyaçlarına ve bulunduğu bölgenin kültürel değerlerine göre tasarlanmalıdır. Metro istasyonlarında yolculuk sırasında kullanıcıların kentle ilişkisi kesilmektedir. Bu nedenle yapısal ve mimari tasarımda yapılacak her iyileştirme yolcu çekme kapasitesini de artıracaktır. Bu çalışmada, metro istasyonlarının mevcut standartlara bağlı tasarım ölçütleri değerlendirilerek, günümüz şartlarında getirilebilecek öneri ve iyileştirmeler ele alınmış ve istasyonların kapasite hesabının aşamaları verilmiştir.

Anahtar Kelimeler — Metro İstasyon Tasarımı, Mekân Organizasyonu, Çevre Planlaması, Yolcu Kapasitesi, Sürdürülebilirlik

I. GİRİŞ

En genel anlamda toplu ulaşım, özel araç (araba, bisiklet vb.) dışında yapılan yolculuklar için kullanılan bütün ulaşım modlarını içerisinde barındıran bir tanımdır. Bu tanım şehir içi ve şehirlerarası yapılan yolculukların tamamını kapsar. Kent içi toplu ulaşım için ise bu tanım, iş, okul, eğlence veya gezme gibi eylemleri yerine getirmek amacıyla kullanılmaktadır. Otobüs, metrobüs, metro, bölgesel demiryolu, minibüs, tramvay, hafif raylı sistem vapur ve feribot gibi sistemler kent içi toplu ulaşımında kullanılan araçlardır. Bu araçların ne yoğunlukla kullanılacağı ise şehrin nüfusu, trafik yoğunluğu, denize kıyısı olup olmaması gibi faktörler de göz önünde bulundurularak ekonomik koşullar çerçevesinde belirlenmektedir.

Kent içi raylı ulaşım sistemleri, hafif raylı sistemler, tramvaylar, metrolar, bölgesel demiryolu trenleri, manyetik yataklı sistemler ve monoraydan oluşmaktadır. Raylı ulaşımında sistem seçimini belirleyen en önemli unsurlardan birisi öngörülen yolcu kapasitesidir. Dolayısıyla metrolar, özellikle büyük şehirlerde yaygın olarak kullanılan ve en yüksek yolcu kapasitesine sahip (60 bin kişi/saat) sistemlerdir [1]. Yer altında veya bazen yer üstünde hareket eden ve yol kesişmesi olmayan bu sistem, kendi içinde kapalı bir yapıdır. Diğer türlerin ulaşamadığı yüksek hızlara ulaşabilen tam korumalı metro sistemleri genellikle 2-10 vagon dan oluşurlar. Yüksek düzeyde otomasyon gerektiren bu sistem yüksek yatırım maliyetine karşılık en düşük işletme giderleriyle çalışmaktadır [1]. Bu açıdan bakıldığında metro istasyonlarının tasarımında dikkat edilmesi gereken unsurlar diğerlerine göre fazladır.

Bu çalışmada; metro istasyonlarının çevre planlamasına, istasyonların mekân organizasyonuna, istasyon tasarımında kullanıcıyı etkileyecek öğelere, istasyon konumlandırılmasına yönelik yer seçimini etkileyen parametrelere, engelli yolcular için gerekli tasarımlara ve istasyonların kapasitelerine ilişkin başlıklar ile metro istasyonlarının yapısal ve mimari tasarım ölçütleri incelenmiştir. Ayrıca metro istasyonlarının kapasitelerinin hesaplanmasına yönelik kullanılan ölçütler sıralanmış ve kapasite hesabının temel akış süreci aktarılmıştır. Metro istasyonu içerisinde kullanıcıyı rahatlatarak ve yolcu trafiğine katkıda bulunacak mevcut standartlar kapsamında tasarım ölçütleri incelenerek metro istasyonları üzerinde yapılabilecek iyileştirme ve öneriler sunulmuştur.

II. TASARIM KRİTERLERİ

Bugüne kadar yapılmış metro yapılarından elde edilen geleneksel tecrübelerle dayanarak metro istasyonlarında yardımcı bazı bölümler bulunmaktadır. Bu bölümlerde, yolcuların treni beklediği alan olan peron platformu, bilet alış ve turnike geçiş alanının yer aldığı bilet holü katı, istasyon elektromekanik ve personel mahallerini kapsayan teknik alanlar, düşey sirkülasyonu sağlamaya yardımcı merdiven grupları ve asansörler bulunmaktadır [2].

A. İstasyonların Çevre Planlaması

İstasyon yapısının çevresi, yolcu sirkülasyonunun yoğun yaşandığı yerler olması nedeniyle, araç parkları ve yolcu yaklaşımlarının önemli olduğu yerlerdir. Buna göre istasyona ulaşım; tarifli, kolay ulaşılabilir, yaya sirkülasyonu ve girişleri çevre ile uyumlu planlanmalıdır. Tasarlanan istasyonların, kalıcı, fonksiyonel, çevre ile uyumlu ve kendine özgü kimliği olmalıdır. İstasyona gelen yolcuların ulaşımını kolaylaştırma amaçlı, kısa ve uzun süreli otoparklar sağlanmalı ve ihtiyaca bağlı olarak otobüsle ulaşım için yaklaşım cepleri konulmalıdır. Yapılacak otoparkların, istasyon-otopark ilişkisi sağlanmalıdır [3].

B. İstasyonların Mekân Organizasyonu

Metro istasyonları, sadece ulaşım amaçlı kullanılmasının yanında, içinde çok farklı amaçları barındırabilecek potansiyel alanlara da sahip olabilirler. Yolcular tarafından sıklıkla tercih edilen metroların daha sıcak, canlı ve yaşanabilir iç mekân atmosferine sahip olması, yer altı mekânlarının boğucu ve tekdüze olma fikrini ortadan kaldırmak açısından önemli olmaktadır. İşletme ve bakım için ekipman ve ofis hacimleri sağlanmalıdır [3][4].

Mekânların dolaşım alanı ve aktiviteler arasındaki ilişki, öncelik sıralamasına göre aşağıdaki gibi düşünülebilir:

- Giriş
- Bekleme Salonu
- Postane ve/veya banka/ATM
- Bilet alış/bileti geçerli kılma
- Yatay hareket
- Perona iniş/çıkış
- Tren bekleme
- Binme/inme
- İstasyondan çıkış
- İstasyon ve işletme için gerekli hizmetler

1) *Bilet Holü:* Yolcuların girişten sonra ulaştığı mekânlar bütün olarak bilet holü katı olarak tanımlanır. Bilet holü katında; bilet gişeleri, satış mekânları, danışmalar, banka/ATM, merdiven/yürüyen merdiven/asansör önü birikme alanı gibi unsurlar bulunabilir. Ayrıca, bu katta donanım ve personel için mekânlar yer almalıdır. Bilet holünde, gişe önünde oluşabilecek kuyruklar için yeterli alan bırakılmalıdır.

2) *Peron:* İstasyonlarda, uygulama alanına göre değişirse de dünyada genel anlamda kullanılan 2 tip peron vardır.

- Yan peron: Peronlar karşılıklı yerleştirilir, hatlar ortadır ve her ana hatta bir peron vardır. (Şekil I-A)
- Orta peron: Tek peron vardır, hatlar peronun her iki yanından geçer. Orta peron, sirkülasyon ve tefriş yerleşimi (oturma grupları, yönlendirme levhaları, merdivenler vb.) açısından yan perona göre daha avantajlıdır. (Şekil I-B)



ŞEKİL 1

YAN(A) VE ORTA(B) PERON GÖSTERİMLERİ

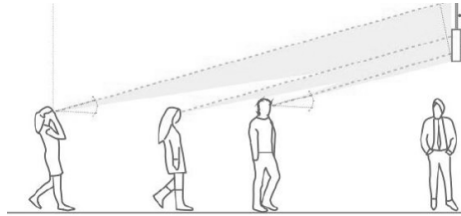
- 3) *Yatay ve Düşey Dolaşım Alanları:* İstasyon girişleri, yolcuların, yaya ve diğer ulaşım sistemlerini kullanarak rahatlıkla ulaşabilecekleri şekilde olmalıdır. Giriş-çıkış için gerekli merdivenler ve kapılar yeterli sayıda olmalıdır. İstasyon içerisinde, mümkün olduğunca gereksiz kot (yükseklik farklılıkları) değişikliklerine gidilmemeli, net sirkülasyon alanları oluşturulmalıdır. Mekân tasarımında, kuytu köşeler oluşturulmamalı ve yeterli aydınlatma seviyesi sağlanmalıdır.
- 4) *Yardımcı Mekânlar:* İstasyonlarda, elektro-mekanik tesisat odaları, kontrol, depolama ve personelin ihtiyaç duyduğu odalarla birlikte, yolcuların durumuna göre değişiklik gösteren yardımcı mekânların, yerleşimi, büyüklüğü ve dağılımı istasyonların özelliklerine göre seçilmelidir.
- 5) *Merdivenler:* Merdivenler (Şekil 2), temel olarak istasyonlarda giriş-çıkış ve sirkülasyonu sağlama amaçlı, tren yolcu ve acil durum yolcu yükünü karşılayacak şekilde hesaplanmalıdır. Merdiven önlerinde, olağandışı artışlarda yığılmayı azaltacak uzunlukta yeterli alanlar bırakılmalıdır.



ŞEKİL 2

MERDİVEN ÖRNEĞİ

- 6) *Yolcu Bilgilendirme Sistemleri:* Her istasyonda, inen-binen yolcuların giriş-çıkışları, peronu, acil kaçışları ve düşey sirkülasyon elemanlarını kolaylıkla bulabilecekleri yardımcı işaretler olmalıdır. Bu işaretler, yolculara sistemi kullanmak için gerekli tüm bilgi ve talimatı sağlamalıdır. Yolcu bilgilendirme ekranları (Şekil 3) bu amaç için kullanılan sistemlerdir. Aktarma istasyonlarında ya da büyük istasyonlarda, danışma bürosu, yolcuları aydınlatıcı anons sistemi yapılmalıdır.



ŞEKİL 3

YOLCU BİLGİLENDİRME EKRANI

C. Kullanıcıyı Etkileyecek Öğeler

1) *Biçim:* Biçim, mimari bütünü oluşturan temel değişkenlerden biridir. Bazı mekânlar boşluğuyla ön plana çıkarken, bazı mekânlar ise kütleleriyle ortaya çıkmaktadır. Yer altı metro istasyonları, kapalı hacimler olduklarından yapı dışı kütleleriyle değil iç mekândaki boşlukları ile algılanmaktadır. İstasyonların biçimlenişinde, istasyonun yapım yöntemi etkilidir. İstasyon yapısı tünel yöntemiyle inşa edildiyse iç mekânda eğrisel biçimler; aç-kapa yöntemiyle inşa edildiyse köşeli biçimler görmek olasıdır. Ancak, iç mekân biçimi yapısal biçime bağlı kalmayarak farklılaşabilmektedir [5][6].

2) *Akustik:* İstasyonlarda akustik açıdan yolculara rahat bir ortam sağlanmalıdır. İstasyonlardaki gürültü seviyeleri, potansiyel kullanıcıların rahatlıkla sohbet edebilecekleri düzeyde olmalıdır. Gürültü seviyelerinin minimumda tutulmasını sağlamak için yalıtım ekipmanları geliştirilmeli ve bakımları yapılmalıdır. Ses yalıtım ekipmanı olarak üretilen sünger vb. malzemeler istasyonlar içerisindeki akustiğin iyileştirilmesi için kullanılabilir [6][7].

3) *Doku*: Yer duygusu, bazı coğrafi yerlerin sahip olup diğerlerinin sahip olmadığı, ancak bireyin ilişki kurabileceği bir özelliği ile ait olma veya bağlanma yoluyla insanlar tarafından tutulan bir duygu veya algıyı ifade eder. İyi tasarımın, bu algıları, herkes için olumlu bir yer duygusu aşlamak için alanı korumak ve nihayetinde geliştirmek için kullanması önemlidir [8].

4) *Renk*: Tüm iç kaplamalar, ışığı iyi yansıtan, ışık kaynağı ihtiyacını en aza indiren, parlak ve temiz bir istasyon iç mekânı üreten ve aydınlatma sağlamak için yüksek enerji gereksinimlerinden kaçınan bir malzeme, renk ve ton paletinden seçilmelidir [8].

5) *Aydınlatma*: Metro istasyonları, genelde doğal ışık almayan kapalı alanlar olduğundan aydınlatmanın ortam üzerinde önemli bir etkisi bulunmaktadır. Yer altı metro istasyonlarında; güvenli dolaşıma olanak veren, kullanıcı konforunu sağlayan, engelli güvenliğini dikkate alan, aydınlık alanlara göre loş ve karanlık alanlara yumuşak geçiş sağlayan aydınlatmalar yapılmalıdır. Aydınlatmalar, metro sürücülerinin dikkatini dağıtmamalı veya engellememelidir. Yüz tanımayı ve iyileştirilmiş görünürlüğü geliştirmek için gerekli olan yerlerde beyaz ışık kullanılmalıdır [8].

6) *Havalandırma*: Yer altı metro istasyonu tasarımında tahliye için kullanılacak havalandırma çıkışlarını yerleştirirken, mülklere yakınlığı ve tesisin işletilmesinden kaynaklanan gürültünün hassasiyeti dikkate alınmaktadır. Havalandırmalar, istasyon içerisindeki yolcuların konfor seviyesinin artmasına ve rahatlamalarına da yardımcı olmaktadır [8].

7) *Sanatsal Çalışmalar*: Yer altı metro istasyonları kent kurgusu içinde farklı mekânlar oluşturduklarından, istasyonlara kimlik kazandırmak veya kentle ilişkisini kurmak için, istasyon içindeki yolculu alanlarda sanatsal çalışmalara da yer verilmektedir. Dünyadaki örneklere bakıldığında, istasyonlarda temalı çalışmalar yapıldığı görülmektedir. Tema olarak; tanınmış kişi, istasyon ismi, yazıyla anlatım gibi başlıklar seçilebilmektedir [8].

Ç. Yer Seçimini Etkileyen Parametreler

1) *Yolcu Çekme Kapasitesi*: Peron ve platformlar, istasyon tasarımlarında kullanılmak üzere kararlaştırılan yolcu talep seviyelerinin üzerinde bir kapasite için hassasiyet testinden geçirilmelidir. Bu duyarlılık testinin amacı, istasyon altyapısının hangi unsurlarının ilk önce başarısız olacağını belirlemek ve projenin ömrünün ötesinde büyümeyi karşılamak için beklenmedik durum ve istasyon yönetim planlarının hazırlanmasını sağlamaktır. [8]

2) *Emniyet*: Metro istasyonlarına gelen yolcuların park et devam et (özel araç, toplu taşıma park alanları vb.) gibi yenilikleri kullanması için sistemin emniyetli olması gerekmektedir. Bütünleşmiş park tesisleri istasyon girişine yakın olmalı, istasyona gelen yollar engelden arındırılmalı, istasyon girişine düz hatlı güzergahlar sağlamalı ve personel pozisyonlarından denetim sağlamalıdır [8].

3) *Entegrasyon*: İstasyon konumlandırılmasında entegrasyonun sağlanabilmesi, diğer toplu ulaşım sistemleriyle olan bağlantısı ve altyapı sistemlerine yakın olmasıyla elde edilmektedir. İstasyon bileşenleri ve kaplamaları, mekanik, elektrik, iletişim, hat çapında sistemler, drenaj ve yangın güvenliği sistemlerine uyum sağlamak ve bunlarla tamamen entegre olacak şekilde tasarlanmaktadır [8].

4) *Hizmet Alanı*: Genel olarak tüm toplu ulaşım sistemlerinden beklendiği gibi metro ağının tasarımında da hizmet alanını en üst seviyeye çıkartmak potansiyel kullanıcıların istasyona erişimini artırdığı için önemli bir amaçtır. Hizmet alanı, istasyonların sıklığının doğrudan bir sonucudur. Potansiyel yolcuların yüksek olduğu bölgelere yakınlık ve diğer toplu ulaşım modları ile kurulmuş yüksek entegrasyon gibi unsurlar metro istasyonlarının hizmet alanı kriterini artırmaktadır [9].

5) *Yapım Metodu ve Maliyeti*: Raylı sistem projelerinin ve özellikle metroların öngörülen yolculuk hacmi, sistemin tüm yapısını etkileyen en önemli girdilerden birisi olarak karşımıza çıkmaktadır. Dolayısı ile yolcu talebinin büyüklüğü, maliyet tahminini etkilemektedir. Bu bakımdan fizibilite etütlerinde ortaya çıkan öngörü hatalarını en düşük seviyeye indirmek gereklidir. Buna ek olarak ulaştırma yatırımları uzun dönemli etkileri olan yüksek maliyetli yatırımlardır. Bu nedenle, bu tür büyük altyapı projelerine ilişkin önceliklerin doğru belirlenmesi ve kısıtlı ekonomik kaynakların en fazla yarar getirecek biçimde kullanılması çok önemlidir. Dolayısıyla, verilecek kararlarla oluşturulan herhangi bir ulaştırma projesinin daha sonra yapılacak ulaştırma yatırımlarının yerini ve biçimini bağlayıcı etkileri vardır. Ayrıca metro istasyonlarının ve hatlarının inşaat yapım yöntemleri şehrin yer altı zemin durumuna, topografik şartlara, şehir bölge planına ve mimari eğilimler ile inşaat yönteminin ulaşılabilirliğine son derece bağlıdır. Dolayısıyla seçilecek yapım yönteminin maliyeti de bu durumlara bağlı olarak değişkenlik gösterebilmektedir [9].

D. Engellilere Yönelik Tasarımlar

Engelliler grubuna hareket olanağı kısıtlı olanlar, tekerlekli sandalye kullananlar, duyma ve görme engeli olan kimseler, valiz veya bebek arabaları ile yaşlılar dahildir. Bu tipteki potansiyel kullanıcıların istasyonlara erişimleri için asansörler ve yürüyen bantlar kullanılmaktadır. Asansörler, bozulma/bakım durumları düşünülerek, en az iki adet olarak tasarlanmalıdır [10]. İstasyonlarda TS 9111'e göre, korkuluklarda/küpeşterlerde, kapılarda, asansörlerde, kabartmalı haritalarda veya kat planlarında hissedilebilir semboller ve harfler uygulanmalıdır [10].

Kabartmalı tabelalar, Braille (körler) alfabesiyle yazılarak, görme engelli yolcuların ihtiyaç duyacağı alanların kullanımı için bilgilendirme amacıyla ve yardım çağrısı için oluşturulan ekipmanlarda kullanılmaktadır. Eğer bir kontrol paneli yanında tabela yer alacaksa, kolay erişilebilir olmalı hem ayakta duran biri hem de tekerlekli sandalyede oturan birinin ihtiyaçlarını karşılayacak şekilde, yerden 120-160 cm yükseklikte bulunmaktadır [10]. Her istasyonda 1 adet engelli WC planlanmaktadır. Hareketi kısıtlanmış olan kullanıcılar, istasyon içerisindeki engelli tuvaletini diğer yolcular kadar kolay kullanabilmesi sağlanmaktadır [10].

Görme engelli veya görüşü kısıtlı yolcuların kolaylıkla algılayabilmesi için tüm kapı açma aksesuarları, kapı kanat rengiyle kontrast renkte olmalı ve kapı kilidi gerektiğinde acil durumlarda müdahaleye izin verecek mekanizma ile donatılmalıdır.

İstasyonlarda bekleme amacıyla kullanılan oturma elemanları, hareketi kısıtlanmış yolculara yardımcı olmak üzere, engelli asansörlerinin yakınında planlanmalı, görme engelli veya görme kusuru olan yolculara engel teşkil etmemeli ve ayrıca baston kullanan görme engellilerin bulabileceği noktalara konumlandırılmalıdır.

E. İstasyon Kapasite Hesabı

İstasyon peron kapasitesi, peronun 4 dakikada boşaltılması ve peronun en uzak noktasındaki yolcunun güvenli alana en fazla 6 dakika içinde kaçışını sağlayacak şekilde iki hesaba bağlı olarak yapılmaktadır. Peron kapasite hesabında ilk olarak, peron net alanının, normal ve acil durum yolcu yükü için yeterli olup olmadığına bakılmaktadır. Yolcu başına ayrılacak alanlar Tablo I'de verilmiştir [11][12].

TABLO XIV

PERON KAPASİTELERİ

Kullanılan Değerler	Birim	Kapasite
Peron Kapasitesi (normal işletme)	m ² /kişi	0,5
Peron Kapasitesi (izdiham)	m ² /kişi	0,28

Peronların acil ve normal durum için yeterli büyüklükte tasarlandığı hesaplama ile teyit edildikten sonra, peron çıkışlarının kapasitesi değerlendirilmektedir. Acil durum yolcu yükü için yapılan çıkış kapasite hesabı normal işletme için de yeterli olmaktadır. Sonrasında, peron çıkışlarına yerleştirilen sabit merdiven, yürüyen merdiven, kapalı/korunaklı acil kaçış merdivenlerinin yeterli olup olmadığına hesabı yapılmaktadır. Düşey sirkülasyon elemanlarının yeterliliği için yapılacak hesapta kullanılacak değerler Tablo II'de verilmiştir [11][12][13][14].

TABLO XV

DÜŞEY ELEMANLARIN KAPASİTELERİ

Kullanılan Değerler	Birim	Kapasite
Merdiven Kapasitesi (normal işletme yukarı)	kişi/0,60m-dk	35
Merdiven Kapasitesi (normal işletme aşağı)	kişi/0,60m-dk	40
Merdiven Kapasitesi (acil durum)	kişi/dk/m	56
Yürüyen Merdiven Kapasitesi (normal işletme-0,65 m/sn)	kişi/dk-1m genişlik	120
Yürüyen Merdiven Kapasitesi (acil durum)	kişi/m-dk	75
Rampa (normal işletme)	kişi/m-dk	65
Rampa (acil durum)	kişi/m-dk	82

4 dakika hesabında, acil durum peron yolcu yükü, peron çıkış kapasitesine (düşey sirkülasyon elemanlarından bir dakikada geçen toplam kişi sayısı) bölünür ve elde edilen sonuç 4 dakikadan az olmalıdır. Sonucun 4 dakikadan fazla çıkması durumunda hareket analizi yapılarak mekanik tasarım ile yolcular için tehlikeli bir durumun oluşmadığı kanıtlanmaktadır. Mekanik önlemlerin yetersiz olması

durumunda ise, yangın kapısı veya duman perdesi gibi mimari önlemler ile, peronda güvenli alan tesis edilmelidir.

6 dakika hesabında ise, peronun en uzak noktasındaki yolcunun, kendine en yakın çıkışa yürüme süresi hesaplanmaktadır. İstasyonun belli bölgeleri için yürüme hızları Tablo III’de verilmiştir. Peron çıkışlarında bekleme olup olmadığı da hesaplanarak, bekleme süreleri 6 dakika hesabına eklenmektedir [14].

TABLO III
YÜRÜME HIZI KAPASİTELERİ

Kullanılan Değerler	Birim	Kapasite
Yürüme Hızı (peron-yatay) (acil durum)	m/dk	37,7
Yürüme Hızı (konkors-yatay) (acil durum)	m/dk	61
Yürüme Hızı (yukarı merdiven) (acil durum)	m/dk	14,6
Peron, Koridor ve Rampa Kapasitesi (acil durum)	kişi/dk/m	82
Kapı Geçiş Kapasitesi – Tek Kanat (acil durum)	kişi/dk	60
Kapı Geçiş Kapasitesi – Çift Kanat (acil durum)	kişi/dk	82

III. SONUÇLAR VE ÖNERİLER

Şehirlerde meydana gelen dinamik büyüme ve değişimler, toplu ulaşım sistemlerinin de değiştirilip iyileştirilmesine yol açmaktadır. Metro hatları ve metro istasyonları da buldukları kent ve insanların karakterini yansıtmaktadır. Metro istasyonları, geçmişten günümüze yapılan literatür çalışmaları ile çeşitli standartlar gözetilerek inşa edilen ve yüksek teknoloji ürünü yüksek maliyetli yatırımlar olarak karşımıza çıkmaktadır.

Bu çalışmada; metro istasyonlarının çevre planlaması ve mekân organizasyonu, kapasite hesap akışı ve bunlara ek olarak potansiyel kullanıcıları etkileyen unsurlar ele alınmıştır. Bu ölçütler detaylı şekilde incelenerek tasarıma yönelik uygulamalar aktarılmıştır.

Metro istasyonlarının girişleri, potansiyel kullanıcıların raylı sistemi deneyimledikleri ilk noktalar olarak karşımıza çıkmaktadır. Dolayısıyla istasyon giriş noktalarının şehrin ihtiyaçlarına, potansiyel kullanıcı sayısına, yer altı zemin durumuna, şehir bölge plan ve mimari anlayışa bağlı olarak şekillendirilmesi önemlidir. Gerekli koşulları şehrin dinamik büyümesine göre sağlayamayan girişlerin, sayılan unsurlara bağlı kalınarak yeniden düzenlenmesi düşünülebilir.

Metro ağı, şehrin diğer toplu taşıma sistemleri ile bütünleşmiş hale getirilmelidir. Dolayısıyla metro istasyonları arazi durumu, inşaat ve mimari anlayışa bağlı kalınarak diğer toplu taşıma sistemleri ile uyumlu olarak tasarlanmalıdır. Yüksek uyuma sahip istasyonlar yüksek karmaşıklığı da beraberinde getireceklerinden maliyetler artacaktır. Buna karşın düşük entegrasyon ise potansiyel yolcuların azalması ile sonuçlanacak ve işletme maliyetleri yükselecektir. Entegrasyonun, şehrin ihtiyaçlarına, istasyonların inşası için gerekli finansmanın bulunabilirliğine, istasyon çevresinde arazinin ilgili değişikliklere uyumuna, yolculuk kapasitelerine ve sürelerine bağlı kalınarak değerlendirilmesi metro istasyonlarının tasarımındaki en zor aşamaları oluşturmaktadır. İstasyon çevresi diğer ulaşım modları ile gelen potansiyel kullanıcıları da yakından ilgilendirmektedir. Gelen özel ve toplu ulaşım araçlarının park edebildikleri noktaların oluşturulması, yaya ve bisikletli kullanıcıların istasyona ulaşımının diğer yollardan ayrılması, istasyondan ayrılan araçların çevre ve şehir yolları ile bağlantısı, entegrasyon ile raylı sistemlerde kullanılan diğer modların (tramvay, hafif raylı sistem vb.) istasyonlarının metro istasyonunun çevresinde konumlandırılması da çevresel karmaşıklığı ve arazi kullanımını etkileyen unsurlardır. Bu tip uygulamalar ile desteklenmeyen raylı ulaşım modlarında potansiyel yolcu sayısı düşecek ve dolayısıyla işletme maliyetleri yükselecektir.

Metro istasyonlarının büyük ve karmaşık olması sebebiyle yolcular için yönlendirmelere, el haritalarının dağıtılmasına ve bilgi ekranlarının sayısının artırılmasına gerek duyulmaktadır. İstasyona yaklaşan metro araçlarının kapasiteleri yolcu bilgilendirme ekranlarında gösterilerek bekleyen yolcuların araç yoğunluğu hakkında bilgi sahibi olmaları sağlanabilir. Bu sayede yolcuların karar verme süreçleri hızlandırılarak sirkülasyon düzenlenebilir.

İstasyon kapasitesi perona gelen ve perondan ayrılan yolcuların sayısı ile doğru orantılıdır. İstasyon girişi ve peron kapasitesi, yürüme hızları, yatay ve dikey sirkülasyon elemanlarının kapasiteleri ile istasyon yolcu kapasiteleri hesaplanabilir. İstasyon kapasite hesabı tasarım üzerinde dolaşım alanlarının yapımına etki eder. Bu durum yolcu kapasitesine bağlı olarak artar ya da azalır. Kapasite hesabına göre istasyon tasarımı şekillenir ve kullanıcı konforu artar. Buna bağlı olarak istasyon kapasite hesabında yapılacak hatalar metro

sisteminin kullanılabilirliğini düşürecek ve gün geçtikçe daha hantal bir ulaşım sistemi ortaya çıkacaktır. Kapasitesi, şehirlere bağlı olarak sürekli değişkenlik gösteren büyük metro sistemlerinin tasarımında bu hesaplamaların dikkatlice yapılması önem taşımaktadır.

Sonuç olarak, şehirlerin gelişmesi, refah seviyesindeki artış ve sanayileşme gibi unsurlar toplu ulaşım sistemlerine doğrudan bağlıdır. Toplu ulaşım sistemleri ve özellikle raylı ulaşım düşük işletme maliyetleri sağlayarak kentin iş gücüne şiddetli olarak katkı yapmaktadır. Bu bağlamda, kent içi toplu taşıma sistemlerinde metronun yeri çok büyük öneme sahiptir. Metro hatları ve istasyonları bu çalışmada verilen belirli ölçütler çerçevesinde dikkatlice tasarlanmalı ve mümkün olduğunca şehrin ihtiyaçlarına uygun modeller seçilmelidir.

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Kentsel Dönüşümde Önceliklendirmeye Yönelik Sayısal bir Yaklaşım: İstanbul’da bir Uygulama

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Özet— Kuzey Anadolu Fayı’na yakın yerleşim yerlerinde yaşayan nüfusun büyüklüğü ve olası depremin yıkıcı etkisi göz önüne alındığında mevcut yapılaşmanın ağır can ve mal kayıplarına yol açarak ekonomik anlamda olumsuz bir etki yaratacağı görülmektedir. Dönüşüme ayrılacak olan bütçe ve zaman kısıtları altında mevcut risk faktörlerinin incelenmesi ve sayısal yaklaşımdan yararlanılarak öncelik verilmesi gereken bölgelerin seçilmesi amaçlanmaktadır. Aynı zamanda web sitesi uygulaması sayesinde belediye, yüklenici firma ve ev sahipleri bir araya getirilerek kentsel dönüşümün hızlı ve kontrol altında ilerlemesi amaçlanmaktadır.

Anahtar Kelimeler—Kanvas iş modeli, web sitesi tasarımı, risk analizi ve yönetimi, kentsel ulaşım, önceliklendirme yaklaşımı

I. GİRİŞ

Doğal afet, insanlar ve yerleşim yapıları üzerinde fiziki, sosyal, ekonomik ve çevresel kayıplara yol açarak normal yaşamın ve insan faaliyetlerinin aksamasına veya durmasına neden olan doğa olaylarının sonuçları olarak tanımlanmaktadır [1].

Kayıtlı veriler incelendiğinde ülkemizde değişik türde birçok doğal afet olayının yaşandığı görülmektedir. Bu afetler atmosfer ve yer olayları ile biyolojik kökenli olaylar olmak üzere üç temel gruba ayrılmaktadır [2]. Türkiye’nin fiziki coğrafi koşulları bu afetlerin sıklıkla yaşanmasına neden olmaktadır [3].

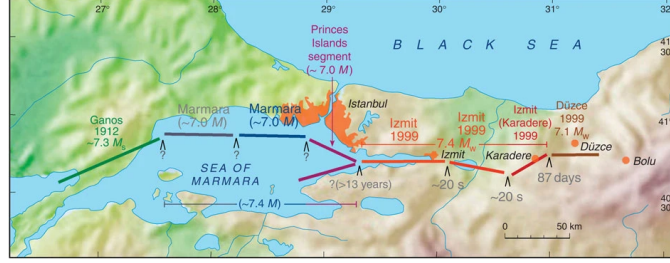
Ülkemiz Alp-Himalaya Deprem Kuşağı üzerinde yer almakta olduğu için nüfusunun yaklaşık 50%’si 1. Derece deprem bölgesinde yaşamaktadır [4]. Aynı zamanda can ve mal kaybı özelinde en etkili doğal afetin deprem olduğu bilinmektedir [5]. Bu bilgiler ışığında 1900 yılından itibaren günümüze kadar geçen sürede Türkiye’de meydana gelen büyük depremler Tablo I’de gösterilmektedir.

TABLO I
CUMHURİYET TARİHİNDE MEYDANA GELEN ÖNEMLİ DEPREMLER

Tarih	Büyükölük (M)	Yer	Ölü Sayısı	Yaralı	Ağır Hasarlı Konut
6.05.1930	7,2	Hakkâri Sınırı	2514	-	3000
26.12.1939	7,9	Erzincan	32962	-	116720
20.12.1942	7,0	Niksar-Erbaa	3000	6300	32000
26.11.1943	7,2	Tosya-Lâdik	2824	-	25000
1.02.1944	7,2	Bolu-Gerede	3959	-	20865
28.03.1970	7,2	Gediz	1086	1260	9452
30.10.1983	6,8	Erzurum-Kars	1155	1142	3241
17.08.1999	7,4	Marmara	18374	36948	93618
1.05.2003	6,4	Bingöl	184	515	8142
23.10.2011	7,2	Van	644	1966	38515
24.01.2020	6,8	Elâzığ	41	1631	3200
30.10.2020	6,9	İzmir	114	1035	506

Kaynak: AFAD Verilerinden derlenmiştir.

Bu senaryo dışında fayın iki ayrı parçasının farklı zamanlarda kırılması sonucunda en büyüğü 7,3 M olan iki farklı depremin yaşanması beklenmektedir [13]. 1999 depremi sonrasında yapılan bir diğer çalışmada ise tek seferde 7,4 veya üç farklı seferde 7,0 büyüklüğünde depremin meydana gelmesi beklenmektedir [14]. Şekil 3'te üç farklı deprem ile kırılması düşünülen fay görülmektedir.



ŞEKİL 3 MARMARA FAYI'NDA OLMASI MUHTEMEL DEPREM SENARYOLARI

Yukarıda üzerinde durulan bütün senaryolar incelendiğinde büyüklüğü 7,5 olan deprem senaryosunun farklı deprem merkezlerine göre alternatif çözümlerinin incelenip en kötü etkileme durumunun temel senaryo kabul edilmesi kararlaştırılmıştır.

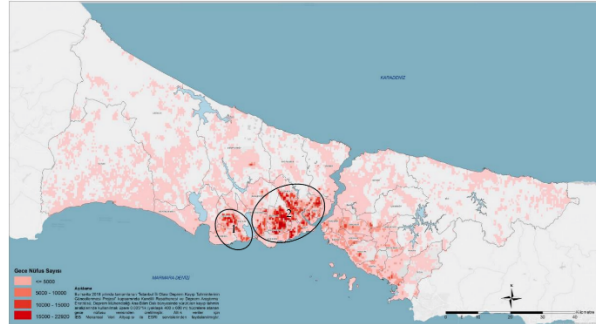
Riskli yapılar, 6306 sayılı kanununun 2. maddesinin d bendinde “Riskli alan içinde veya dışında olup ekonomik ömrünü tamamlamış olan ya da yıkılma veya ağır hasar görme riski taşıdığı ilmî ve teknik verilere dayanılarak tespit edilen yapı” olarak tanımlanmıştır (Resmî Gazete, 2012). Bu kapsamda CSM, MADRS ve CM analiz yöntemleri ile tahmin edilmiş verilerden yola çıkılarak oluşturulan hasar durumu tablosu Tablo II’de gösterilmektedir [6].

TABLO II
SENARYO DEPREM İÇİN BİNA HASAR TAHMİNLERİ

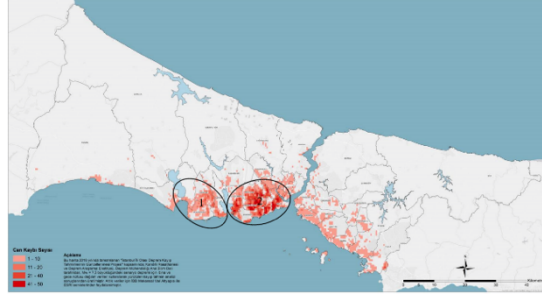
Hasar Durumu	Analiz Yöntemi			Ortalama	Toplam Bina Sayısının %'si
	CSM	MADRS	CM		
Çok Ağır Hasar	18.580	9.309	12.595	13.495	1,2%
Ağır Hasar	39.512	27.131	36.391	34.345	2,9%
Orta Hasar	143.136	129.554	166.966	146.552	12,6%
Hafif Hasar	282.953	289.787	332.139	301.626	25,9%
Hasarsız	682.149	710.549	618.239	670.312	57,5%

III. İLÇE UYGULAMALARI

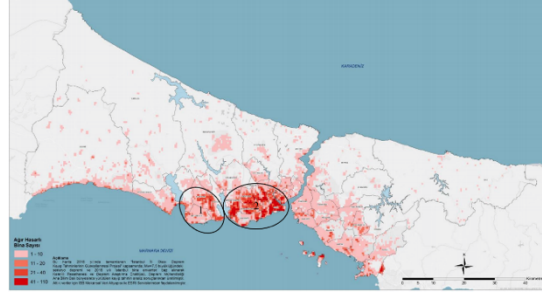
Çalışmanın uygulama aşamasına geçilen kısımda kentsel dönüşüme uğraması beklenen adaları içeren iki ilçenin çeşitli varsayımlar altında seçilip bu ilçelerde yer alan bölgelerin belirlenen kısıtlar altında sayısal yöntemler ile önceliklendirme uygulamasının yapılması amaçlanmaktadır. İlçelerin seçilmesinde literatür araştırmalarında kullanılan İstanbul ilinin gece nüfusu dağılımı (Şekil 4), senaryo depremin gerçekleşmesi durumunda tahmini can kaybı sayısının dağılımı (Şekil 5) ve senaryo depremin gerçekleşmesi durumunda ağır hasarlı bina dağılımı (Şekil 6) bilgilerinden yararlanılacaktır.



ŞEKİL 4 GECE NÜFUSU DAĞILIMI (BÖLGE SEÇİMİ YAPILMIŞ)



ŞEKİL 5 TAHMİNİ CAN KAYBI SAYISI DAĞILIMI (BÖLGE SEÇİMİ YAPILMIŞ)



ŞEKİL 6 AĞIR HASARLI BİNALARIN SAYISAL DAĞILIMI (BÖLGE SEÇİMİ YAPILMIŞ)

Şekil 4’de gece nüfusunun en yoğun olduğu iki bölge gösterilmektedir. Aynı zamanda Şekil 5’de senaryo deprem sonrasında tahmini can kaybı sayısının en yüksek olduğu iki bölge gösterilmektedir. Şekil 6’da ise ağır hasarlı binaların en yoğun olduğu iki bölge belirlenmiştir. Bu bilgiler ışığında detaylı araştırma yapılması amacıyla belirlenen bölgeler içerisinde kalan 15 ilçe seçilmiştir. Avcılar, Bağcılar, Bahçelievler, Bakırköy, Bayrampaşa, Beyoğlu, Esenler, Esenyurt, Eyüp, Fatih, Gaziosmanpaşa, Güngören, Küçükçekmece, Şişli ve Zeytinburnu seçilen ilçelerdir.

Tablo III’de seçilen ilçelerin nüfusları, ilçelerde 1980 yılından önce inşa edilen yapıların sayısı, senaryo deprem durumunda hasar alması beklenen bina ve altyapı sayısı, depremin yaratacağı can kaybı ve ağır yaralı sayıları ile deprem sonrası geçici barınma ihtiyacı sayısı gösterilmektedir. Elde bulunan veriler ilçelerin nüfuslarına göre normalize edilmiştir. İlçelerin belirlenebilmesi amacıyla 7 farklı kriterin ağırlıklandırılması gerekmektedir. Bu kapsamda ekip üyelerinin 2 farklı karar verici olduğu varsayılmış ve ikili karşılaştırma matrisleri hazırlanmıştır.

TABLO III
İLÇELERİN NÜFUS, YAPILAŞMA VE HASAR / CAN KAYBI BİLGİLERİ

İlçeler	İlçe Nüfusu	1980 Öncesi Bina Sayısı ve Yüzdesi		Çok Ağır Hasarlı Bina Sayısı	Ağır Hasarlı Bina Sayısı	Can Kaybı Sayısı	Ağır Yaralı Sayısı	Altyapı Hasarları (Noktasal)	Geçici Barınma İhtiyacı
Avcılar	448.822	2.596	53%	233	1.261	465	239	95	34.935
Bağcılar	745.125	6.072	15%	796	1.825	1.179	652	88	59.513
Bahçelievler	611.059	3.892	17%	796	2.090	1.633	879	90	61.199
Bakırköy	229.239	4.869	41%	782	1.306	1.046	581	80	28.910
Bayrampaşa	274.735	8.295	40%	614	1.182	520	340	32	23.064
Beyoğlu	233.323	17.052	62%	410	840	217	150	20	10.295
Esenler	450.344	6.582	28%	391	813	638	352	33	31.271
Esenyurt	954.579	499	1%	563	1.768	1.003	553	116	67.410
Eyüp	400.513	11.966	35%	300	841	168	110	35	16.066
Fatih	443.090	31.899	73%	2.083	3.496	1.484	985	72	46.784
Gaziosmanpaşa	491.962	12.786	44%	132	403	140	83	17	13.963
Güngören	289.441	2.513	23%	342	611	754	415	40	27.478
Küçükçekmece	792.821	7.535	19%	1.240	2.616	1.515	925	107	72.774
Şişli	279.817	10.601	51%	69	208	58	28	9	4.845
Zeytinburnu	293.574	2.594	16%	510	1.025	668	372	49	31.030

Kaynak: İBB ve Kandilli, 2020

Karar vericilerin ikili karşılaştırma matrisleri sonucunda ortalama puanlama matrisi bulunmuştur. Aynı zamanda her iki karar vericinin puanlamalarının tutarlılığı kontrol edilmiştir. Ortalama puanlama

International Engineering and Technology Management Summit 2022– ETMS2022
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matrisinde geometrik ortalamaları alınıp toplam geometrik ortalamalara bölünerek her bir kriterin ağırlığı belirlenmiştir. Matrise göre en yüksek ağırlığa sahip birinci kriter “Can kaybı sayısı” (39,56%), ikinci kriter “Çok ağır hasarlı bina sayısı” (22,09%) ve üçüncü kriter ise “Ağır yaralı sayısı” (18,35%) olmuştur. Bu üç kriterin toplam ağırlığı 80,00% olarak bulunmuştur. İlçelerin nüfuslarına göre normalize edilmiş matrisinden yola çıkılarak kriter ağırlıklarına göre TOPSIS karar verme yöntemi kullanılarak ilçelerin sıralamaları elde edilmiştir.

TABLO IV
İLÇELERİN TOPSIS YÖNTEMİNE GÖRE SIRALAMA SONUÇLARI

	S*	S-	C*	Sıralama
Avcılar	0,0531	0,0023	0,0407	12
Bağcılar	0,0391	0,0062	0,1365	8
Bahçelievler	0,0223	0,0185	0,4528	3
Bakırköy	0,0021	0,0642	0,9680	1
Bayrampaşa	0,0258	0,0130	0,3343	6
Beyoğlu	0,0454	0,0049	0,0978	9
Esenler	0,0435	0,0046	0,0960	10
Esenyurt	0,0526	0,0022	0,0408	11
Eyüp	0,0643	0,0006	0,0093	13
Fatih	0,0037	0,0511	0,9326	2
Gaziosmanpaşa	0,0721	0,0001	0,0017	15
Güngören	0,0242	0,0172	0,4161	4
Küçükçekmece	0,0299	0,0105	0,2599	7
Şişli	0,0743	0,0002	0,0029	14
Zeytinburnu	0,0242	0,0146	0,3764	5

TOPSIS yöntemine göre sıralanan ilçeler incelendiğinde ilk sırada Bakırköy’ün olduğu görülmektedir. Fatih ve Bahçelievler ilçeleri de ikinci ve üçüncü sırayı almaktadırlar. Bu sonuçlara göre kişi başına kriter puanlarına göre sıralama yapıldığında ilk sırada yer alan Bakırköy ilçesi ile referans değerleri ile göreceli olarak risksiz kabul edilen Şişli ilçesi çalışmanın devamında incelenmek üzere seçilmiştir.

Tablo 5’de Şişli ilçesinin mahallelerinin nüfusları, yaş bağımlılık oranları, senaryo deprem durumunda hasar alması beklenen bina ve altyapı sayısı, depremin yaratacağı can kaybı ve ağır yaralı sayıları ile deprem sonrası geçici barınma ihtiyacı sayısı gösterilmektedir. Elde bulunan veriler mahallelerin nüfuslarına göre normalize edilmiştir. Mahallelerin belirlenebilmesi amacıyla 7 farklı kriterin ağırlıklandırılması gerekmektedir. Bu kapsamda TOPSIS karar verme yöntemi için gerekli olan kriter ağırlıkları bir önceki aşamadan alınmıştır.

TABLO V
ŞİŞLİ’NİN MAHALLELERİNİN NÜFUS, YAPILAŞMA VE HASAR / CAN KAYBI BİLGİLERİ

Mahalleler	Mahalle Nüfusu	Yaş Bağımlılık Oranı	Çok Ağır Hasarlı Bina Sayısı	Ağır Hasarlı Bina Sayısı	Can Kaybı Sayısı	Ağır Yaralı Sayısı	Altyapı Hasarları (Noktasal)	Geçici Barınma İhtiyacı
19.Mayıs Mahallesi	11.276	24%	2	5	2	1	0	145
Bozkurt Mahallesi	10.844	35%	3	7	2	1	0	174
Cumhuriyet Mahallesi	7.042	33%	2	4	2	1	0	96
Duatepe Mahallesi	8.205	37%	2	4	2	1	0	115
Ergenekon Mahallesi	2.630	35%	2	5	1	1	0	48
Esentepe Mahallesi	7.204	29%	2	7	0	0	2	116
Eskişehir Mahallesi	12.208	35%	4	14	3	2	0	286
Feriköy Mahallesi	14.713	39%	3	7	3	2	0	229

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

Fulya Mahallesi	17.353	31%	2	5	3	1	2	192
Gülbahar Mahallesi	23.014	26%	2	7	3	1	0	313
Halaskargazi Mahallesi	1.669	47%	1	3	1	0	0	31
H. Edip Adivar Mahallesi	16.971	32%	2	6	2	1	0	266
H. Rıfat Paşa Mahallesi	3.954	52%	1	5	1	0	0	101
Harbiye Mahallesi	2.565	49%	1	3	0	0	0	39
İnönü Mahallesi	3.780	27%	3	11	1	0	0	104
İzzetpaşa Mahallesi	8.071	30%	2	6	2	1	0	158
Kaptan Paşa Mahallesi	3.323	34%	0	1	0	0	0	54
Kuştepe Mahallesi	15.990	34%	5	22	4	3	0	397
M. Şevket Paşa Mahallesi	19.230	35%	4	13	5	3	1	440
Mecidiyeköy Mahallesi	20.130	28%	3	8	4	1	0	286
Merkez Mahallesi	13.456	37%	4	10	3	1	3	194
Meşrutiyet Mahallesi	7.864	34%	7	13	4	2	0	188
Paşa Mahallesi	18.185	33%	5	22	4	2	1	410
Teşvikiye Mahallesi	11.845	45%	3	6	3	1	0	155
Yayla Mahallesi	11.281	35%	4	14	3	2	0	308

Kaynak: İBB ve Kandilli, 2020

Mahallelerin nüfuslarına göre normalize edilmiş matrisinden yola çıkılarak kriter ağırlıklarına göre TOPSIS karar verme yöntemi kullanılarak mahallelerin sıralamaları elde edilmiştir.

TABLO VI
MAHALLELERİN TOPSIS YÖNTEMİNE GÖRE SIRALAMA SONUÇLARI

	S*	S-	C*	Sıralama
19.Mayıs Mahallesi	0,0311	0,0039	0,1105	19
Bozkurt Mahallesi	0,0284	0,0048	0,1442	17
Cumhuriyet Mahallesi	0,0198	0,0099	0,3336	7
Duatepe Mahallesi	0,0238	0,0073	0,2353	11
Ergenekon Mahallesi	0,0052	0,0323	0,8622	2
Esentepe Mahallesi	0,0493	0,0015	0,0288	24
Eskişehir Mahallesi	0,0201	0,0091	0,3120	8
Feriköy Mahallesi	0,0266	0,0057	0,1771	16
Fulya Mahallesi	0,0341	0,0032	0,0857	20
Gülbahar Mahallesi	0,0390	0,0018	0,0437	22
Halaskargazi Mahallesi	0,0126	0,0379	0,7500	3
H. Edip Adivar Mahallesi	0,0386	0,0017	0,0425	23
H. Rıfat Paşa Mahallesi	0,0281	0,0070	0,1987	14
Harbiye Mahallesi	0,0478	0,0023	0,0451	21

İnönü Mahallesi	0,0215	0,0164	0,4324	4
İzzetpaşa Mahallesi	0,0231	0,0076	0,2476	10
Kaptan Paşa Mahallesi	0,0559	0,0000	0,0002	25
Kuştepe Mahallesi	0,0192	0,0099	0,3414	6
M. Şevket Paşa Mahallesi	0,0218	0,0086	0,2831	9
Mecidiyeköy Mahallesi	0,0319	0,0041	0,1129	18
Merkez Mahallesi	0,0257	0,0064	0,1985	15
Meşrutiyet Mahallesi	0,0026	0,0393	0,9368	1
Paşa Mahallesi	0,0245	0,0065	0,2109	13
Teşvikiye Mahallesi	0,0245	0,0072	0,2280	12
Yayla Mahallesi	0,0180	0,0107	0,3735	5

TOPSIS yöntemine göre sıralanan mahalleler incelendiğinde ilk sırada Meşrutiyet mahallesinin olduğu görülmektedir. Ergenekon ve Halaskargazi mahalleleri de ikinci ve üçüncü sırayı almaktadırlar. Bu sonuçlara göre kişi başına kriter puanlarına göre sıralama yapıldığında 2. ve 3. sırada yer alan Ergenekon ve Halaskargazi mahalleleri çalışmanın devamında incelenmek üzere seçilmiştir.

IV. ÜRÜN TASARIMI

Çalışmanın ürün tasarımı aşamasında risklerine göre sıralanacak olan adaları internet üzerinden erişilen bir web sitesi sayesinde İstanbul sakinlerinin hizmetine sunulması planlanmıştır. Bu sayede İstanbul'da yaşayanlar binalarının bulunduğu ilçe, mahalle, ada ve parsel bilgilerini sistemimize girerek binaları için belirlemiş olduğumuz risk kategorisini ve mahalleleri için tahmin edilen olumsuzlukları öğrenebileceklerdir. Aynı zamanda belediye, yüklenici firma ve ev sahibi arasındaki bağlantıyı uygulama üzerinden gerçekleştirerek riskli yapıların olduğu bölgelerdeki dönüşümün gönüllü bir şekilde hızlandırılması amaçlanmıştır.

A. GZFT Analizi

1) *Güçlü Yanlar:* Ekip oluşabilecek sorunları ve geliştirme durumlarını hızlı bir şekilde değerlendirme, çözüm bulma ve bulunan çözümü anında uygulama kabiliyetine sahiptir. Ekip hızlı öğrenme kabiliyetine sahiptir. Web sitesinde veriler doğru bir şekilde yerleştirilmiştir. Sitenin ara yüzü güzel, kullanımı kolaydır. Bölgelerin risk durumunun araştırılması için Kandilli Deprem Araştırma Enstitüsü'nün ve İstanbul Büyükşehir Belediyesi'nin web sitelerinin farklı araştırmalardan alınmış verileri araştırmalar doğrultusunda alınmış ve birçok bilimsel yöntemler kullanılarak yapılan hesaplar doğrultusunda belirli sonuçlar elde edilmiştir. Bu sonuçlar oluşturulan web sitesinde düzenlenmiştir ve kolayca ulaşılabilir. Yapılan iş, potansiyel olarak birçok hayati kurtarabilecek bir iş olduğu için ekip var gücüyle, motive bir şekilde çalışmalarını sürdürmüştür.

2) *Zayıf Yönler:* Ekibin dar olmasından, aynı zamanda ekibin başka işleri olması dolayısıyla kişi başına düşen iş yükü fazladır. Yapılan iş bir proje olduğu için süre limiti vardır. Yapılan iş ile bitirilmesi gereken sürenin örtüşmesi için konu sınırlamaları yapılmaktadır. Yapılan iş için gereken kaynaklar bütçeyi zorlamaktadır.

3) *Fırsatlar:* Hesaplamalar sonucunda çıkan veriler, ev sahiplerinin, müteahhitlerin ve belediyelerin ilgisini çekecektir. Araştırmalara dayanarak yapılan kentsel dönüşüm çabaları birçok ev sahibini riskten kurtaracaktır. Yapılacak kentsel dönüşüm çalışmaları, istihdam imkânı sağlayacaktır. Bu durumun web sitesine olan ilgiyi artıracığı tahmin edilmektedir. Belediyelerin desteği, müteahhitlerin ilgisini siteye çekebilecektir. Yapılan proje, Şişli ve Bakırköy ilçelerini kapsamaktadır. İşin bütün Türkiye'yi kapsayacak şekilde büyüme potansiyeli vardır.

4) *Tehditler:* Yapılan projenin belediyelerin ilgisini çekmemesi durumunda, Şişli ve Bakırköy ilçelerindeki ev sahiplerine adalarındaki risk durumunu söyleyen bir sosyal sorumluluk projesi olarak devam edecektir. Ülkemizin içinde bulunduğu ekonomik şartlar, vergi durumları, inşaat sektöründeki durgunluk, her ev sahibinin kentsel dönüşüm sırasında kalacak yer için bütçesinin olmaması gibi sorunlar kentsel dönüşümün hızını azaltmasının yanında siteye olan ilgiyi de düşürecektir. Gerekli pazarlama faaliyetlerinin bütçe kısıtları nedeniyle yeterli ve etkili şekilde yapılamaması durumunda iş yeterli bir şekilde tanıtılamayabilir ve proje başarılı olamayabilir. Projenin başarılı olma durumunda, rakipler devreye girecektir ve pazar payımızı azaltmaya çalışacaklardır.

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

B. İş Modeli Kanvası

Şekil 7’de ürün için oluşturulan iş modeli kanvası gösterilmektedir. Üç farklı kullanıcıyı bir araya getirerek değer yaratması amaçlanan ürün kanvası üzerinde yer alan bölümleri ekip üyelerinin detaylı istişareleri sonucu oluşturularak şekle eklenmiştir.

İş Modeli Kanvası				
Tasarlayan: Atakan Altunel, Kubilay Karaçam			Tarih: 25.12.2020	
Anahtar Ortaklıklar İstanbul Büyükşehir Belediyesi Yüklenici inşaat firmaları İstanbul sakinleri Araştırmacılar Yatırımcılar	Anahtar Etkinlikler Riskli bölgelerin analiz süreçleri. Web sitesi geliştirme süreçleri. Belediye ve yüklenici firmalar ile ortak çalışma süreçleri. Son kullanıcı ile test süreçleri. Ürünün kullanma sürülmesi ve değerlendirme. Anahtar Kaynaklar Web sitesi Veri derleme ve analiz çalışması	Değer Teklifi Ev Sahipleri için Değer Tekliflerimiz: Binaların risk durumu hakkında bilgi sunulması. Binaların kentsel dönüşüm sürecinde yüklenici firma alternatifleri hakkında bilgi sunulması. Belediye ile iletişim kanallarına web sitesimiz üzerinden ulaşılabilmesi. Yüklenici Firmalar için Değer Tekliflerimiz: Riskli binaların dönüştürmek ve yeniden yapıtırmak isteyen ev sahipleri ile web sitesimiz üzerinden iletişime geçebilmeleri. İçer Belediye için Değer Tekliflerimiz: Deprem sonrasında ilçelerinde oluşacak olumsuz durumların önüne geçilebilmesi için kentsel dönüşümün uygulanmasını sayesinde hızlandırılması.	Kullanıcı İlişkileri Üç farklı kullanıcının (belediye, ev sahibi, yüklenici firma) bir araya getirilmesi Şikayet ve destek hattı sayesinde kullanıcılar arasındaki iletişimin kontrolü ve puanlanması Web sitesimizin sürekli geliştirilmesi sayesinde kullanıcılara minimum zamanda maksimum bilginin verilmesi ve alternatif seçeneklerin sunulması amaçlanmaktadır. Kanallar Web sitesi Instagram Facebook Youtube	Kullanıcı Bölgeleri Konutları kentsel dönüşümüne uğrayacak ev sahipleri Kentsel dönüşüm tecrübesi olan yüklenici inşaat firmaları Belediyelerin kentsel dönüşüm ile ilgili bölümleri
Maliyet Yapısı Web sitesi maliyetleri. Çalışan maliyetleri.		Gelir Akımları Belediyenin ödeme desteği Yüklenici firmaların aylık ödemeleri		

ŞEKİL 7 İŞ MODELİ KANVASI

C. Ürünün Hukuki Boyutu

6306 sayılı “Afet Riski Altındaki Alanların Dönüştürülmesi Hakkında Kanun” incelendiğinde kentsel dönüşüm sıralamasının ev sahiplerinin başvuru yapması, kararın değerlendirilmesi, bina incelemesi sonucunda riskin tespit edilip rapor hazırlanması, raporun ilgili kurum tarafından onayı, yüklenici firma seçimi, inşaat projesinin hazırlanması ve projenin ilgili kurumun onayı sonucunda uygulanması şeklinde gerçekleştiği görülmektedir (Resmî Gazete, 2012). Bu süreç incelendiğinde uygulamsının Kandilli Rasathanesi’ne ait resmi verileri kullanarak ada bazında risk durumunu göstermesi amaçlanmaktadır.

Aynı zamanda ikamet eden kişilerin uyguladaki sonuçları inceleyerek kentsel dönüşümüne başvurabilmesi için belediye kanalları ile iletişim ve hazır form bilgileri sitemize eklenecektir. Belediyelerin riskli yapı onayı verdiği binalar için ise bölgede yer alan ve sitemize başvuru yapmış yüklenici inşaat firmaları uygulamamızda listelenecek ve ev sahiplerinin kendileri ile iletişime geçerek süreçleri belediyenin kontrolü ile gerçekleştirmeleri sağlanacaktır.

Bir başka ifade ile kanunun maddeleri incelendiğinde belediye, yüklenici firma ve ev sahibinin bir uygulama üzerinden bağlantı sağlayarak iletişim halinde olmalarında hukuki bir engel bulunmamaktadır. Aynı zamanda site üzerinden yapılacak olan anketler ile bina sakinlerinin kentsel dönüşümüne bakış açıları incelenerek üçte ikilik çoğunluğun oluşup oluşmadığı denetlenebilecektir. Bu sayede orta riskli binalar içerisinde de öncelik sıralaması yapılabilecektir.

D. Ürünün Ekonomik Analizi

Ürünün gelir kalemleri belediyelerin destekleri ve yüklenici inşaat firmaları ile yapmış olduğumuz aylık abonelik sözleşmelerinden oluşmaktadır. Kentsel dönüşümü hızlandırmak ve teşvik etmek amacıyla yapılan projede binalarını dönüştürmek isteyen ev sahipleri üzerinden bir gelir kalemi yaratılması beklenmemektedir. Bu sebeple de proje ekonomik olarak asıl amacı destekler ve abonelik gelirleri ile giderlerini karşılayabilecek sürdürülebilir bir sistem haline gelebilmektir. Aşağıda ürünün 2023 yılının sonuna kadar olan finansal göstergeleri ve tabloları ile birlikte yatırımın fizibilite analizleri gösterilmiştir.

Ek olarak 2021 yılında 8, 2022 yılında 20 ve 2023 yılında 45 firma ile abonelik sözleşmesi yapılacağı hesaba katılmıştır. Ayrıca Şişli ilinin tamamına hizmet verilmesi amaçlanan tarih 2021 yılının 6. ayı ve Bakırköy ilinin tamamına hizmet verilmesi hedeflenen tarih ise 2022 yılının 3. ayı olarak planlanmaktadır.

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

Bu sayede artan işgücü eksikliği 2022 ve 2023 yıllarında çalışan alımı ile giderilecektir. 2021 yılında 1, 2022 yılında 2 ve 2023 yılında 3 çalışan ile ürünü geliştirmeye ve talepleri karşılamaya devam edilecektir.

TABLO VII
FİNANSAL GÖSTERGELER

Gider Tablosu	2021	2022	2023
Ürüne Bağlı Giderler	₺42.000	₺93.600	₺164.160
Hosting Maliyetleri	₺6.000	₺7.200	₺8.640
Çalışan Maliyetleri	₺36.000	₺86.400	₺155.520
Yönetim Giderleri (25%)	₺10.500	₺23.400	₺41.040
Beklenmeyen Giderler (5%)	₺2.625	₺5.850	₺10.260

Gelir Tablosu	2021	2022	2023
Toplam Gelirler	₺54.000	₺127.200	₺278.640
<i>Abonelik Gelirleri</i>	₺48.000	₺120.000	₺270.000
<i>Belediye Destek Gelirleri</i>	₺6.000	₺7.200	₺8.640
Toplam Giderler	₺55.125	₺122.850	₺215.460
<i>Ürüne Bağlı Giderler</i>	₺42.000	₺93.600	₺164.160
<i>Yönetim Giderleri</i>	₺10.500	₺23.400	₺41.040
<i>Beklenmeyen Giderler</i>	₺2.625	₺5.850	₺10.260
FAVÖK	-₺1.125	₺4.350	₺63.180

₺ 40.000 kredi çekilmiştir. 12 ay ertelemeli, 36 ay vadeli ve aylık 1.50% faiz oranlı.			
Nakit Akışı	2021	2022	2023
Başlangıç Nakit Dengesi	₺40.000	₺38.875	₺15.877
+Net Gelir	-₺1.125	₺4.350	₺63.180
-Borç Ödemeleri	₺0	₺27.348	₺27.348
Bitiş Nakit Dengesi	₺38.875	₺15.877	₺51.708

Başabaş Noktası Analizi	2021	2022	2023
Toplam Gelirleri	₺54.000	₺127.200	₺278.640
Ürüne Bağlı Giderler	₺42.000	₺93.600	₺164.160
Sabit Maliyetler	₺13.125	₺29.250	₺51.300
FAVÖK	-₺1.125	₺4.350	₺63.180
Başabaş Noktası	₺59.063	₺110.732	₺124.862
<i>(Gelir - Başabaş Noktası)</i>	-₺5.063	₺16.468	₺153.778

Oranlar	2021	2022	2023
Enflasyon Oranı (TCMB)	10,84%	9,20%	9,10%
CDS	3,10%	2,50%	2,10%
<i>Toplam İskonto Oranı</i>	13,94%	11,70%	11,20%

Net Bugünkü Değer Analizi	2020	2021	2022	2023
Toplam İskonto Oranı	0,00%	13,94%	11,70%	11,20%
Toplam Gelirler	₺0	₺54.000	₺127.200	₺278.640

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

Toplam Giderler	₺40.000	₺55.125	₺122.850	₺215.460
Nakit Akışı	-₺40.000	-₺1.125	₺4.350	₺63.180
İndirgenmiş Nakit Akışı	-₺40.000,00	-₺987,36	₺3.417,90	₺44.642,19
NBD	₺7.072,73			
IRR	6%			
Yatırımın Geri Dönüş Oranı	2020	2021	2022	2023
FAVÖK	₺0	-₺1.125	₺4.350	₺63.180
Yatırımın Maliyeti	₺40.000	₺0	₺0	₺0
ROI	166%			
İskonto Edilmiş ROI	2020	2021	2022	2023
FAVÖK (İskonto Edilmiş)	₺0	-₺987	₺3.418	₺44.642
Yatırımın Maliyeti	₺40.000	₺0	₺0	₺0
İskonto Edilmiş ROI	118%			

Geri Dönüş Periyodu	2020	2021	2022	2023
FAVÖK	₺0	-₺1.125	₺4.350	₺63.180
Yatırımın Maliyeti	₺40.000	₺0	₺0	₺0
Geri Dönüş Periyodu (yıl)	2,58			

İskontolu Geri Dönüş Periyodu	2020	2021	2022	2023
FAVÖK (İskonto Edilmiş)	₺0	-₺987	₺3.418	₺44.642
Yatırımın Maliyeti	₺40.000	₺0	₺0	₺0
İskontolu Geri Dönüş Periyodu (yıl)	2,84			

Tablolar incelendiğinde NBD, ROI, PP gibi güçlü yatırım göstergelerinin hepsinde yatırım yapılabilir sınırı üzerinde değerler elde ettiği görülen uygulamanın geri dönüş süresi 2,84 yıl olarak bulunmuştur. Ayrıca iskonto oranı hesaplanırken kullanılan formül CDS ve beklenen enflasyon değerinin toplamı şeklinde ifade edilmiştir. Bu sayede ülkenin risk faktörü dolaylı olarak yatırım kararına etki etmiştir.

V. SONUÇ

Üzerinde çalışılan projenin misyonu; deprem konusundaki bilimsel çalışmalar neticesinde toplanan verilerin amacımız doğrultusunda kullanılarak, belediyelerin ve devletin desteğini de alarak, ev sahipleri ile yüklenici firmaların, kentsel dönüşüme girmesi istenen evler ile ilgili görüşmeler ve fikir alışverişi yapabilecekleri, güvenilir, güçlü ve verimli bir platform oluşturmaktır. Ek olarak uzun vadeli tahminlerde farkındalık faktörü sayesinde 2025-2030 yılları arasında yüksek büyüme ve kullanım oranı hedeflenmektedir. Ayrıca çalışmanın başlangıç amaçlarından birisi olan 10 yıl içerisinde kentsel dönüşüm sorununu ortadan kaldırma hedefine bu farkındalık sayesinde ulaşılması beklenmektedir.

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Laser Scanning in Construction Management: A Review

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Abstract— As is known, digital technologies have become an essential part of our lives because of their enormous benefits. Digital technologies have proven to be super beneficial in accomplishing many engineering tasks. In this paper, the utilization of one of the most-common digital technology which is laser scanning in construction management is reviewed. Literature shows that laser scanning independently or in conjunction with other digital technologies may facilitate the construction management process. Therefore, using laser scanning for different construction management objectives, such as automated progress control, quality of management process, construction schedule control, building's life cycle, modern structure monitoring, assessment of structural components and development of as-built models are discussed. And, the challenges of implementing laser scanning in construction management are also presented briefly. In the end, a conclusion is carried out.

Keywords— Concrete, Construction management, Digital technologies, Laser scanning, BIM.

I. INTRODUCTION

In the last decade, the interest in digital technologies (DTs) rises due to their significant advantages. The use of digital technologies in the construction sector is undertaking a considerable transition from traditional labour-intensive methods to automation [1]. Information and communication technologies (ICTs) that make it easier to create, store, and organize knowledge as well as encourage various forms of communication between humans are referred to the DTs [2]. One of the most-common digital technologies is laser scanning. Laser scanners are surveying tools that enable measuring 3D point coordinates by fusing data of distance and angle. This technique was initially just a tool for measuring distances. Later, the formerly included systems, such as mirrors or photomechanical devices, to deflect the laser beam and calculate one or two deflection angles that allowed for the creation of 2D or 3D point clouds, respectively [3].

The first technology used in terrestrial settings was static scanners. These scanners, also known as terrestrial laser scanners (TLS), are distinguished by mirrors that focus the laser in the vertical plane to measure elevation angles (rotation around a horizontal axis), while rotation around a vertical axis may be accomplished using a different mirror or a device that calculates azimuth angles. Static surveys were not effective enough to produce the necessary 3D models in a timely manner due to the growing necessity to digitally record larger facilities in terrestrial contexts. In fact, during the past few years, there has been an increase in demand for mobile LiDAR technology [3].

Although extensive research has been carried out in the 1980s and 1990s on laser applications to environmental and land surveying, the potential of laser scanning for civil engineering applications was not fully realized until the latter 1990s [3]. Following then, the number of applications of laser scanning for the construction industry sharply increased. The processing of laser scanning data primarily intends to offer inventory information. Various laser scanning applications exist for all construction processes, and by combining precise context data capture with a structured BIM approach to engineering design, huge potential benefits can be obtained [4].

In this paper, a literature review of several applications of laser scanning in construction management is presented to show the impact of this technique on managing the construction process.

II. APPLICATIONS OF LASER SCANNING IN CONSTRUCTION MANAGEMENT

Literature shows that laser scanning independently or along with other digital technologies may be used for different construction objectives such as automated progress control, quantity and quality of management process, construction schedule control, building's life cycle, modern structure monitoring, assessment of structural components and development of as-built models. In the following sections, an

intensive review related to the use of laser scanning for accomplishing the mentioned construction objectives is presented.

A. Automated Progress Control Using Scanning Technology

Controlling the progress of the construction project is essential for project management. Construction managers typically stroll over the site to check on the status of various tasks and gauge the project's present state. The current method of progress control takes a long time because it has to collect and extract data from budget data, timetables, and construction drawings [5]. Automated progress control could improve the construction project management effectiveness by lowering costs, time, and labour requirements. This issue has been considered to be solved in the past using image processing and other methods, but the outcomes were unsatisfactory. Now, a novel effort based on laser scanning is made to set up a system that can evaluate progress with the lowest possible amount of human input [6]-[8]. To do this, three steps were taken:

- First, a 3D model and a work schedule were combined to create a 4D model.
- Second, point cloud data were collected every day of the project utilizing 3D laser scanning technology.
- Third, Java software was created to compute advancement as a percentage of completion by superimposing the point clouds on the 3D model.

More details related to the suggested system are provided in Figure 1.

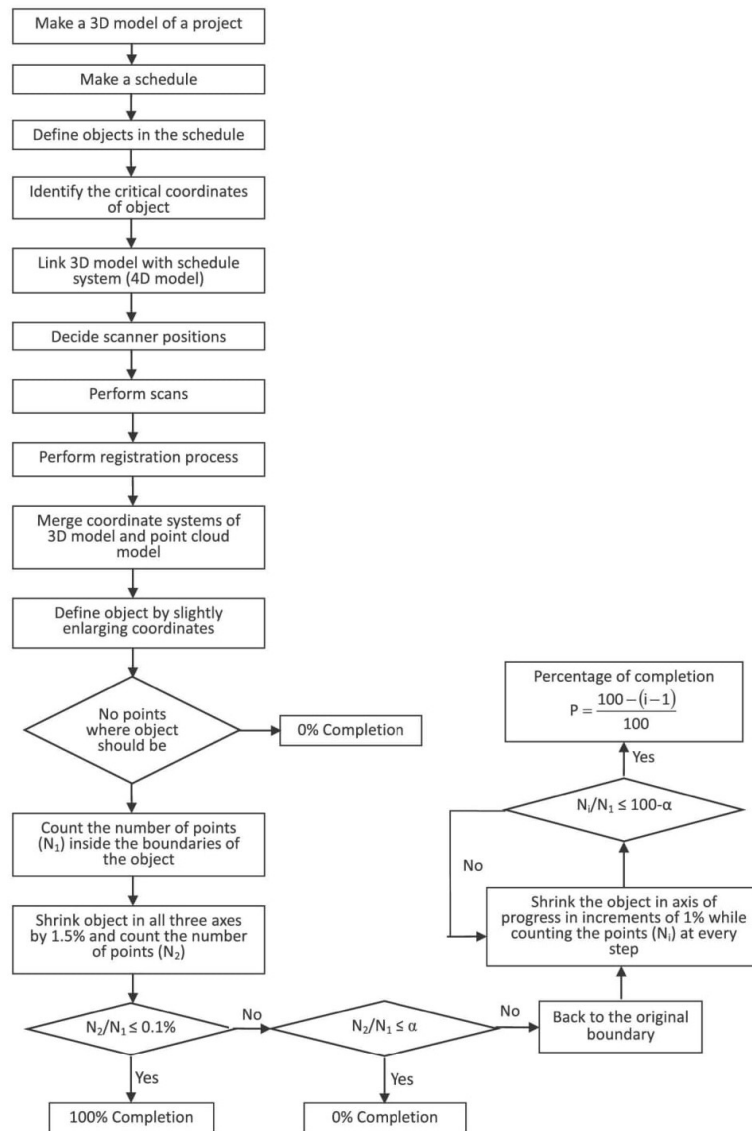


Figure 1. shows the flowchart of the system, [6]

In Figure 1. α is a threshold value, and it depends on the shape of the object, and i is the iteration counter reordered by the java program. The percentage of completeness of a simple structure built out of simple elements can be computed by this proposed system. By rotating the 3D model in several directions, the system can distinguish between the object whose progress is being tracked and all different objects that may be on the way. This approach is much more precise than image processing because point clouds create a 3D environment to depict the construction site rather than jumbled-up photos, completely eliminating the detrimental effects of colour and lighting [5].

B. Quality Management Using Laser Scanning

In the construction quality management (CQM) process, the key difficulty is accurately identifying and quickly analysing construction products for each step. Many studies on non-contact sensing and fault identification methods were carried out to address this problem [9]. Identification of quality defects, design deviation analysis, code and specification compliance analysis, and functional testing are all part of the quality inspection process.

Functional deficiencies or inability of construction products to fulfil codes and specifications are the most common types of construction quality problems. Traditionally, visual inspection and tape measurement are utilized to physically find quality defects during inspection prior to delivery. The majority of current research in the identification of construction quality defects concentrates on product surface flaws such as cracks, spalling, and dimensional and surface quality [10]-[12].

1) **CRACKS**: Automating the crack detection and measurement process has been conducted utilizing a testing approach like lasers [13]. To accurately identify cracks in concrete bridges, Valenca et al. [14] proposed an integrated approach of laser scanning and image processing, considering colour RGB values (MCrack-TLS). The flowchart of the suggested approach is shown in Figure 2.

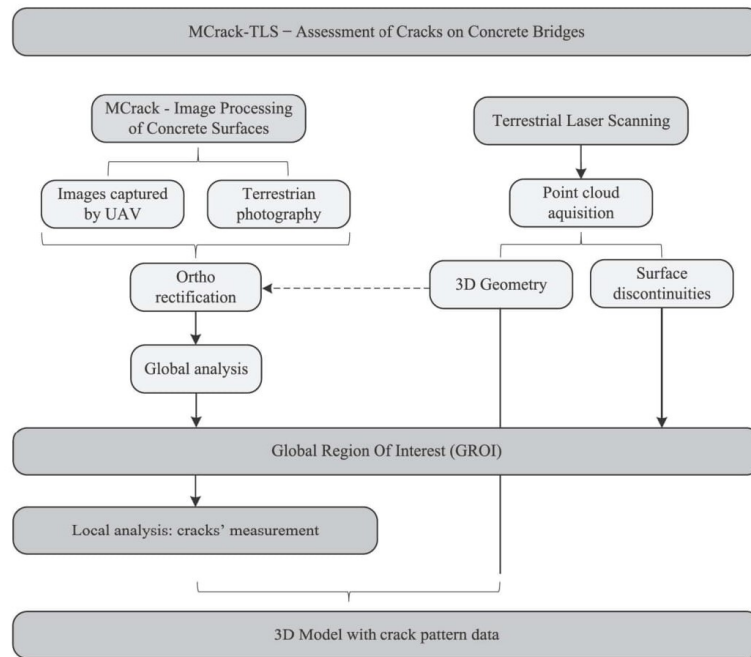


Figure 2. shows the suggested flowchart MCrack-TLS, [14].

This method is a reliable and precise procedure that allows for the acquisition and recording of the overall cracking pattern. The width, length, and direction of the discovered cracks can be measured locally. These characteristics show how the suggested strategy can be a valuable tool for defining and maximizing maintenance interventions for concrete bridges. The primary benefit of MCrack-TLS over conventional approaches is automatic data processing, which increases speed, efficiency, reliability, and both the amount and quality of information [14].

2) **SAPLLING**: Spalling defects on concrete surfaces have been located and measured using a ground laser scanner, but shallow spalling that is less than 3 mm deep has not yet been detected [15]. One of the first investigators to suggest an automatic approach to identifying surface damaged areas using TLS

observations/information was Teza, Galgaro, and Moro [16]. This approach was founded on the computation of specific surface attributes as mean and Gaussian curvatures. A concrete bridge's piers and T-shaped beams in Italy were chosen for this purpose, and the collected data were compared to on-site visual examination. Figure 3 a and b show surface defects from weather-related events on the concrete pier that TLS RGB values were able to detect.

The point cloud was separated into manageable sub-areas, as seen in Figure 8 b, and the offered algorithm was performed to every sub-area independently. The study's results reveal a respectable level of consistency between the red-coloured damage areas and the checked damage areas determined by Gaussian curvature computation.

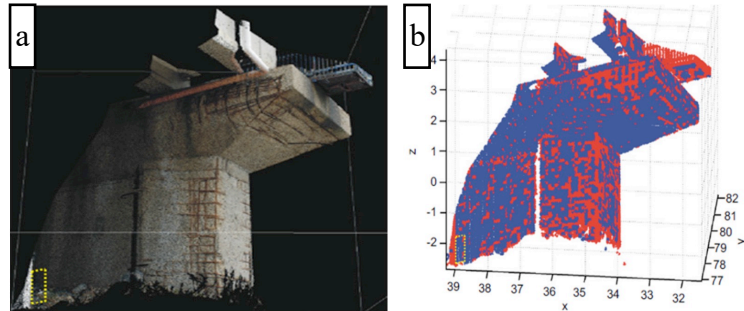


Figure 3. shows Concrete pier face damage detection: (a) point cloud with RGB data; (b) deformation calculations results, [16].

3) *DIMENSIONAL and SURFACE QUALITY ASSESSMENT*: BIM and laser scanning-based system was proposed for quality assessment (QA) of precast concrete. In Figure 4 a, it is assumed that a pre-cast concrete element has been positioned at a present location, and the laser scanner is above the element, scanning the entire surface of the panel in a single scan. The two primary modules of the planned dimensions and surface QA system in connection to BIM are depicted in Figure1(b) [17]. The proposed procedure is explained in detail in Figure 1(c).

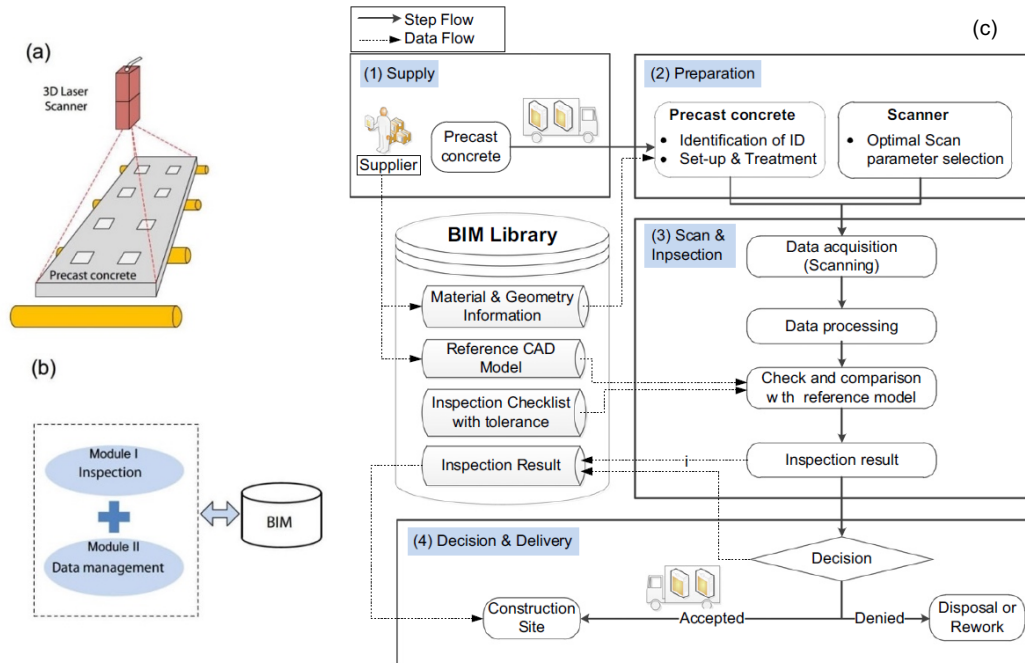


Figure 4. shows a summary of the planned method for evaluating the quality of precast concrete employing BIM and laser scanning [17].

The outcomes of the experiments show that the proposed BIM and laser scanning-based quality evaluation process has the ability to provide an independent and accurate evaluation of the quality of precast concrete components.

C. Construction Schedule Control By 4D Modelling And Laser Scanning

Using laser scanning and 4D modelling as a system for automated building progress control is provided in this section. The suggested system recognizes model objects ("Recognize Objects") in the captured data by employing the project 4D model ("Design and Plan") and field laser scanned data ("Sense"). The system may therefore automatically deduce and predict advancement ("Calculate Progress") based on the results, which upgrade the construction timetable ("Update Schedule") [18]. Management may review the progress and revised schedule to determine what corrective steps are necessary, however, the updated schedule is still crucial to enable accurate analysis of upcoming scans. Figure 1. clarifies the proposed system.

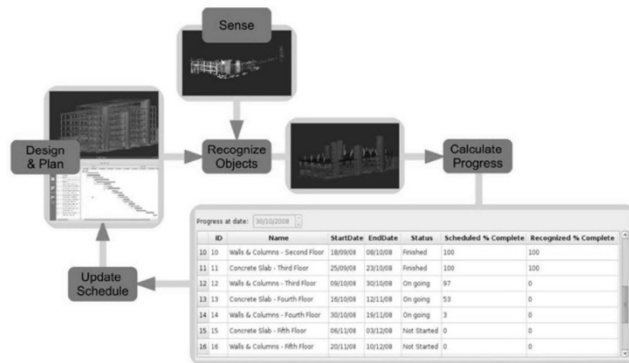


Figure 5. shows how to update the timetable and calculate progress automatically, [18].

D. Development Of As-Built Models Using Laser Scanning

As-built models for existing buildings are becoming more and more in demand as a result of the expanding BIM applications in the building process. Traditional approaches typically employ commercial software, such as CAD, Revit, and 3-Ds Max, to construct BIM models of buildings. The BIM model is manually constructed in accordance with design or measurement data that has its origins in traditional measurement techniques, which take a long time to complete. Additionally, in the absence of CAD data, it is required to generate a CAD base map using 2-D discrete point data that was gathered using a tool like a total station, which takes a lot of time [19]. Furthermore, since the total station only records one point, it is challenging to measure irregular structures and even impossible to precisely map them. Because of its effectiveness and high precision, 3-D laser scanning has become a widely used technology to obtain entire point clouds in many engineering projects. The automatic production of BIM models for existing buildings using 3-D laser scanning data has been the subject of numerous studies. M. Dobelis et. al. [19] conducted a case regarding 3D modelling of existing buildings from laser scanner data.

With the phase shift technology scanner FARO 3D 120, the building was laser scanned from nine different angles Figure 6(a). A point cloud is a name given to the unprocessed data generated by laser scanning, which is a collection of vertices in a 3D coordinate system. These vertices specify or visually represent the x, y, and z coordinates of the points on the structure's outside surface. Due to inadvertent noise recording, not all scan points in the set of data could be utilized. Faro Scene and Leica Cyclone software were employed to clear out the noise points, Figure 6(b). In this investigation, the point cloud data was used to create the BIM models, Figure 6(c) [19].

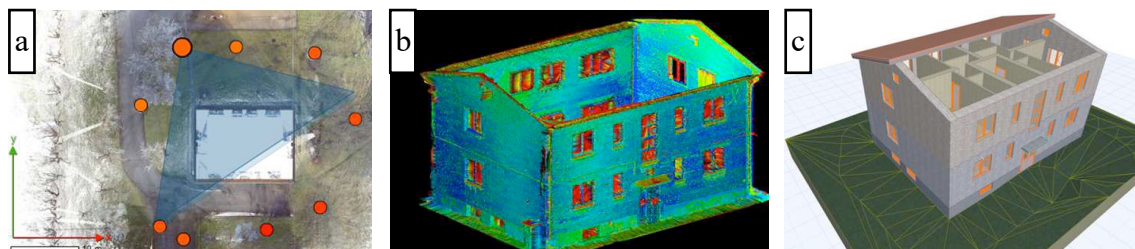


Figure 6. Shows the steps of the creating as-built models, a) on site scanning, b) visualized model of the building in Leica cyclone software, and c) BIM model in ArchiCAD, [19].

E. Application of BIM and 3D Laser Scanning in the Life Cycle of the Building

The primary uses of BIM and 3-D laser scanning during the maintenance phase are structure health monitoring, and energy modelling and management. Structural health monitoring aims to track, evaluate, and identify different loads and structural actions throughout their service life [20]. Compared to the conventional approach, implementing 3-D laser scanning technology increased efficiency by 50% and reduced cost by 40% for the Yongxin Floodgate Pumping Station Project in China [20]. France. Patil et al. [21] presented a method for evaluating the structural performance of a curtain wall that integrates 3-D laser scanning, Building Information Modelling, and Finite Element Analysis. The steps of the proposed method are summarized in Figure 7.

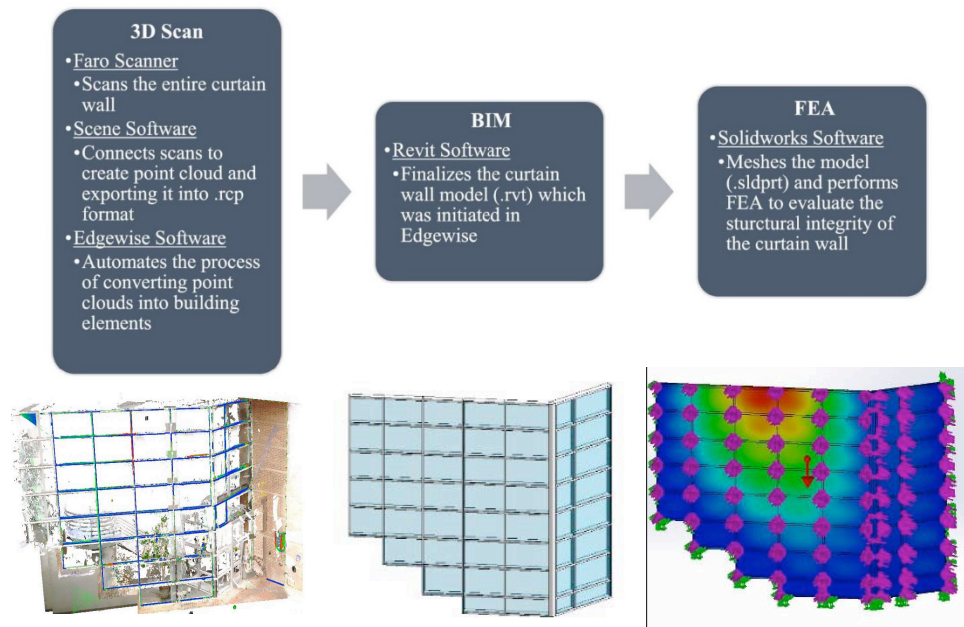


Figure 7. shows the workflow of the proposed method to assess the structural performance, [21].

The suggested SCAN-BIM-FEA process is capable of capturing and documenting current structural integrity issues, identifying the potential failure mechanism through FEA, as well as assisting engineers in specifying better panel designs and assisting contractors in choosing appropriate installation techniques. Facility managers can utilize this procedure to plan and schedule preventative maintenance depending on the actual state [21].

III. CHALLENGES OF IMPLEMENTATION LASER SCANNING IN CONSTRUCTION MANAGEMENT

Laser scanning is proven as a beneficial method in facilitating the construction management process. However, there are many challenges to utilizing this technique. Based on the literature, laser scanner specifications, such as its laser source type, laser wavelength, and operating principles, have a significant impact on how well it performs inspections [18]. Also, environmental conditions may affect the accuracy of the results. Therefore, the scanning work is preferred to be done during a day with good lighting and no rain [21]. Concerning the expense of using BIM, no precise data exists. For instance, 60% of the respondents in a survey didn't know the cost of implementing BIM and laser scanning on a project. A cost estimate was given by a few responders, and it varied between 0.01% to 5% of the cost of the project [22]. In addition, the big file sizes for laser scanning, expensive purchase price and update costs, and appropriate qualifications and associated costs are considered factors affecting the implementation of laser scanning in the construction field [22].

IV. CONCLUSION

This paper provided a brief review of employing laser scanning technology in construction management. The impact of implementing this technique in conjunction with other digital technologies on construction management was examined, considering many aspects. It can be concluded that laser scanning

is a promising way to ease the management of construction projects. However, the challenges of employing laser scanning in the construction industry should be considered.

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Mağaza Tabanlı Talep Tahmini: Topluluk Öğrenmesi Yaklaşımları ile Zaman Serisi Yaklaşımını Karşılaştırılması

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Abstract— Talep tahmini konusu literatürde sıklıkla kullanılan ve hemen hemen her alanda uygulanan bir çalışma alanıdır. Talep tahmini, şirketler için gelecekteki oluşacak olan talebin tahminlenmesi sayesinde stratejik avantajlar yaratmaktadır. Özellikle birden fazla mağazası olan firmalar, ürünleri için mağaza bazında talep tahminleri yapmak zorundadırlar. Bunun nedeni, her ürüne olan talebin mağazaya göre farklılık gösterebilmesidir. Bu amaçla literatürde geleneksel yaklaşımların birçok örneği olmasına rağmen son yıllarda talep tahmini için makine öğrenmesi yöntemleri yaygın olarak kullanılmaktadır. Makine öğrenimi problemlerinde geleneksel algoritmalarla birlikte topluluk öğrenme algoritmalarının kullanılması da talep tahmini başarısını olumlu yönde etkilemiştir. Bu çalışmada; Bir şirketin ürünlerinin mağaza bazlı geçmiş satış verileri ile talep tahmini, makine öğrenmesi yöntemiyle tahmin edilmiş ve topluluk öğrenme algoritmaları ile geleneksel makine öğrenmesi algoritmalarının sonuçları karşılaştırılmıştır. Elde edilen sonuçları iyileştirmek için en başarılı algoritmalar hiperparametre optimizasyonu uygulanmış ve tahmin başarısı artırılmıştır. Aynı zamanda zaman serisi yaklaşımları da verisine uygulanmış ve en başarılı yöntemin tespit edilmesi için karşılaştırmalar gerçekleştirilmiştir.

Keywords— Talep Tahmini, Makine Öğrenmesi, Topluluk Öğrenmesi, Zaman Serisi Yaklaşımı, Öznitelik Mühendisliği

I. GİRİŞ

Talep tahmini literatürde sıklıkla kullanılan ve hemen hemen her alanda uygulanan bir konudur. Şirketler için gelecekteki talebi tahmin edebilmek stratejik avantaj sağlayan önemli bir unsurdur. Talep tahmini üretimin güvenli bir şekilde sürdürülebilmesinde önemli bir rol oynamaktadır. Talep tahmini içerisinde bulunduğu karmaşıklıklar gereği açık bir araştırma konusudur ve literatürde birden fazla yöntemi bulunmaktadır. Özellikle birden fazla mağazaya sahip olan firmalar, ürünlerinin satışı için mağaza bazında talepleri tahmin etmek zorunlulukları ortaya çıkmaktadır. Bunun nedeni, her ürüne olan talep mağazanın bulunduğu konumdaki potansiyel müşterinin demografik yapısı gibi sebeplerden dolayı farklılıklar gösterebilmesidir. Bu amaçla literatürde geleneksel yaklaşımların pek çok örneği bulunsa da son yıllarda talep tahmini için yapay zeka ve makine öğrenmesi tabanlı yöntemler yaygın olarak kullanılmaktadır. Bu çalışmada geleneksel talep tahmini açıklanıp ardından makine öğrenmesi hakkında teorik bilgilendirmeler yapılmıştır. Bu yapılan bilgilendirmeler ışığında açık kaynaktan bulunan bir mağaza zincirinin veri setlerine makine öğrenmesi algoritmaları uygulanarak algoritmalarının sonuçları karşılaştırılması hedeflenmiştir. Geleneksel makine öğrenmesi algoritmaları ve hızlandırma türünde olan algoritmalar veri setine uygulanmış müteakiben çıkan sonuca göre en başarılı üç algoritmaya hiperparametre optimizasyonu uygulanarak en iyi sonuçları veren parametreler bulunmuştur. Bulunan bu değerlerin stabilitesini test etmek adına 10'lu çapraz geçirme uygulanmıştır. Çalışmanın son aşamasında zaman serisi algoritmaları çalışma prensibi açısından teorik bilgiler verilmiş ve veri seti üzerinde uygulama yapıp ortalama hata kareleri açısından incelenmiştir. Sonuç olarak uygulama için kullanılan veri seti için zaman serisi tabanlı algoritmaların kullanılmasının daha başarılı sonuçlar verdiği gözlemlenmiştir. Bu çalışma Tekin ve Sarı'nın daha önce gerçekleştirmiş olduğu mağaza tabanlı talep tahmin çalışmasının devamı niteliğindedir [22].

II. LİTERATÜR TARAMASI

Üretilen ürünün miktarını ve talebini doğru ve net bir şekilde tahmin etmek şirketler için zorlu bir iş. Bu tahmindeki hatalar, şirketin işleyişini ve karlılığını derinden etkileyebilir [1]. Yapılan tahminler şirketlerin birçok departmanı ile ayrı ayrı paylaşılmalı ve her biri kendi iç planlamasını bu tahminlere göre

yapmalıdır. Talebi tahmin etmek için birçok bilimsel yöntem önerilmiştir ve özel sektörde birçok geleneksel talep tahmin yöntemi kullanılmaktadır. Bu yöntemler üç ana başlık altında değerlendirilebilir [2]. Bu konular nitel yöntemler, nicel yöntemler ve yapay zeka tabanlı yöntemler olarak ele alınmaktadır. “Öznel” veya “ölçüt-karar tabanlı” teknikler olarak da adlandırılan nitel tahmin teknikleri, öncelikle tahmin ve genelleme yapmak için insan kapasitesini kullanır [3]. Standart düzeltilmiş bilgilerin gelecekte de devam edeceğini tahmin edebileceğimiz nicel yöntemler için süreklilik tahmini de denilebilir [3]. Yapay zeka temelli yöntemler, saklanan bilgilere dayalı olarak nasıl karar verilebileceğini ve eylem planlarının oluşturulabileceğini ve örnek verilerden öğrenerek veya insan uzmanları sorgulayarak bilgisayarla çalışabilen bilgilerin nasıl elde edileceğini anlamayı içerir [4].

Literatürde birçok alanda talep tahmini uygulamaları yapılmıştır. Özellikle enerji alanında farklı uygulamaları görmek mümkündür. Suganthi ve Samuel, Ghalekhondabi v.d, Hsu v.d, Singh v.d. enerji talebini tahmin etmek için talep tahmin teknikleri kullanmışlardır [5-8]. Bu çalışmalara ek olarak; Fildes ve Kumar [9] telekomünikasyon alanında, Nenni [10] moda endüstrisi alanında, Archer [11] turizm alanında, Bougadis ve ark. [12] su tüketimi alanında farklı talep tahmin çalışmaları yürütmüştür.

Gelişen teknolojinin talep tahmin uygulamalarında yaygınlaşmasıyla birlikte yapay zeka tabanlı talep tahmin uygulamaları artmış, talep tahmini için derin öğrenme ve makine öğrenmesi yöntemleri kullanılmaya başlanmıştır. Bu noktada Abbasimehr v.d. [13]., Tan v.d. [14], Choi v.d. [15], Kong v.d. [16], Uzun Kısa Süreli Bellek (LSTM) yöntemi ile talep tahmin uygulamaları gerçekleştirirken, Bennett v.d. [17], Al-saba v.d. [18], Adamovski ve Karapataki [19], Güven ve Şimşir [20] yapay sinir ağları kullanarak talep tahmin uygulamaları geliştirmiştir.

Derin öğrenme yöntemlerine ek olarak, talep tahmini uygulamaları için makine öğrenmesi yöntemleri de kullanılmış ve bu uygulamalar için hem geleneksel hem de topluluk öğrenme algoritmaları tercih edilmektedir. Tercih edilen makine öğrenimi algoritmalarının doğası bir regresyon problemi olduğundan Rastgele Orman, XGBoost, Catboost, LightGBM gibi topluluk öğrenmesi algoritmaları ile ARIMA, SARIMA, ARIMAX, SARIMAX gibi zaman serisi temelli algoritmalar da kullanılmaktadır. Bu algoritmaların çalışma prensipleri ve kullanım alanları aşağıda verilmiştir.

Rastgele Orman: Rastgele orman algoritması karar ağaçları yapısını kullanan bir denetimli öğrenme algoritmasıdır. Klasik karar ağaçları eğitim verilerine uygun sonuç verme eğilimindedir. Rastgele Orman algoritmaları ise ağaç yapısında bulunan farklı dallardan da istatistiki değerler çıkarımı yaparak eğitim verisine bağlı kalmayı azaltarak daha objektif çıktılar vermeyi hedefleyen bir yapıda çalışmaktadır. Bu yapısı sayesinde tek bir karar ağacına göre doğruluğu daha yüksek tahminlemeler çıkarmaktadır [21]. Rastgele Orman algoritması Denklem 1’de ifade edilmiştir.

$$\hat{m}(x) = \frac{1}{M} \sum_j \hat{m}_j(x) \quad (1)$$

Formülde \hat{m}_j bireysel ağacı temsil ederken, tahmin değeri her bir ağacın tahminin ortalamasını baz almaktadır.

LightGBM: LightGBM algoritması, gradyan tabanlı karar ağaçlarının yeni bir çeşidi olarak 2017 yılında Ke v.d tarafından önerilmiştir [23]. Sınıflandırma ve regresyon dahil olmak üzere çeşitli modelleme zorluklarını çözmek için kullanılır. LightGBM, birçok veri örneğini ve işlevi barındırmak için iki yeni strateji kullanmaktadır. Bu stratejiler gradyan tabanlı tek taraflı örnekleme ve özel işlev gruplandırmasıdır. LightGBM, karar ağacını dikey olarak artırırken, diğerleri, temel gradyan artırma teknikleri veya Aşırı Gradyan Yükseltme ile karşılaştırıldığında yatay olarak genişletir. Bu işlevsellik, LightGBM'nin büyük hacimli verileri işleme yeteneğini geliştirir.

Catboost: Prokhorenkova tarafından 2018 yılında önerilen bu algoritma, gradyan bazlı hızlandırma tipi algoritmaların yeni bir versiyonu olarak kullanılmaktadır [24]. Catboost, bilgi kaybını en aza indirirken kategorik özelliklerle güvenilir bir şekilde çalışır. Extreme Gradient Boosting ve LightGBM gibi diğer gradyan artırma algoritmaları, CatBoost ile aynı değildir. Hedef sızıntıyı çözmek için, gradyan artırma yöntemlerinin yararlı bir varyasyonu olan sıralı artırımı kullanır. Catboost modeli şu şekilde temsil edilebilir:

$$Z = H(x_i) = \sum_j J_j = 1c_j 1\{x \in R_j\} \quad (2)$$

$H(x_i)$ karar ağacının açıklayıcı değişkeni iken x_i , ve R_j ağaç yapraklarına karşılık gelen ayrık bölgeleri temsil etmektedir.

XGBoost: Literatürde oldukça sık kullanımına rastlanan bu gradyan arttırma tabanlı algoritma Chen ve Guestrin tarafından önerilmiştir [25]. XGBoost, birçok karar ağacı kullanan ve sınıflandırma ve regresyonda yaygın olarak kullanılan gelişmiş bir gradyan tabanlı karar ağacı algoritmasıdır. Ağacın sınıflandırma işlevini daha yeniden üretilebilir hale getirmek için XGBoost, ağacın sınıflandırma işlevinin boyutunu optimize etmek için bir düzenleme yöntemi kullanır. Düzenleme ayrıca, büyük veri durumlarında gerekli olan özellik değeri tahminine de yardımcı olur. XGBoost'un çalışma prensibi Denklem 3'te gösterilmektedir.

$$Z = F(x_i) = \sum T_t = 1f_t(x_i) \quad (3)$$

x_i açıklayıcı değişkenleri temsil ederken, $f_t(x_i)$ her ağacın çıktı fonksiyonunu temsil etmektedir.

ARIMA: Tahminleme yaparken tek değişken üzerinden zama serisi analizi yaparak sonuç veren bir yöntemdir. Kullandığı veri setinde geçmiş değerler üzerinden modelleme yapar ve buna göre tahminleme sonuçları çıkarır. [26]

SARIMA: SARIMA modeli de ARIMA modeli gibi veri setindeki bir sonraki adımı tahminleme yaparken geçmiş veriler üzerinden modelleme yaparak geleceği tahminlemeye çalışır ancak ARIMA' dan farkı modellemede hataları minimize etmek için algoritma da mevsimsellik ve mevsimsel değişimlerden oluşacak gözlemlerin de eklenmesi ile modelleme yapar [27].

ARIMAX: ARIMA modeli zaman serisi problemlerinde kolay uygulama ve tatminkar sonuçlar verse de gerçek problemler karşısında yetersiz kalabileceği durumlar mevcuttur. Bu yetersizliğin sebebi ARIMA algoritması ile modelleme yaparken tek değişken üzerinden modelleme yapılmaktadır. ARIMAX algoritması ile modelleme yapılırken tek değişkene bağlı kalmadan birden fazla değişken ile modelleme yapılabilmektedir bu yapıda ARIMAX' ın üstün yanısıdır [28].

SARIMAX: SARIMAX modeli SARIMA modelinin bir uzantısıdır. ARIMAX modelindeki gibi bu modelde de tek değişkene bağlı kalmadan çıktının başarımını arttırmak için dışsal değişkenlerle modelleme yapan bir algoritmadır. [27].

III. ÖNERİLEN METODOLOJİ VE MODELLEME

Bu çalışmada kullanılan veri seti, bir şirketin mağaza bazlı ürünleriyle ilgilidir. Bu çalışma, bu ürünlerin önceki satış eğilimlerini kullanarak mağaza bazlı ürünlere yönelik gelecekteki talebi tahmin etmeyi amaçlamaktadır. Bu öngörü firmalar için çok önemli çünkü kısa, orta ve uzun vadeli faaliyetlerini talebe göre planlayacaklar. Bu çalışmada kullanılan temel özellikler Tablo 1'de gösterilmiştir. Bu veri seti on farklı mağazanın elli farklı kalem satış bilgisinden oluşmaktadır. Temel veri seti dört farklı sütun ve 958000 satırdan oluşmaktadır.

Veri setine ilk olarak veri analizi ve veri ön işleme teknikleri uygulanmıştır. Veri setinden eksik satır ve sütunlar çıkarıldı. Ayrıca, yinelenen satırlar bulunmuş ve veri kümesinden çıkarılmıştır.

Özellik mühendisliği adımında, tarih sütunu ilgili tarihin yılını, ayını, haftanın gününü gösteren üç gruba bölünmüştür. O aydan sonra mağaza ve eşya bilgisi sahte kolon versiyona dönüştürülerek 1 ve 0 seçeneklerine dönüştürülmüştür. Özellik mühendisliğinin son bölümünde önceki satış bilgileri sütunlar halinde kaydırılmıştır.

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

TABLO XVI
TALEP TAHMINİNDE KULLANILAN TEMEL ÖZELLİKLER

Özellik	Açıklama	Veri Tipi	Satır Sayısı	Ortalama	Standart Sapma	Minimum	Maximum
Tarih	Satışların tarih bilgileri	Tarih	958000				
Mağaza	Mağazanın Kimlik Numarası	Kategorik	958000	5.50	2.872	1	10
Ürün	Ürünün SKU Numarası	Kategorik	958000	25.5	14.431	1	50
Satış	Satılan Ürün Sayısı	Sayısal	958000	52.25	28.801	0	231

Veri ön işleme ve özellik mühendisliği adımından sonra veri setine geleneksel makine öğrenmesi algoritmaları ve topluluk öğrenme algoritmaları uygulanmıştır. Her bir algoritmanın ortalama hata kareleri Tablo 2’de gösterilmiştir.

Tablo 2’de ki sonuçlara göre en başarılı üç algoritma olan Catboost, Light Gradient Boosting Machine ve Extreme Gradient Boosting algoritmaları hiperparametre optimizasyonu uygulanmıştır. Bu aşamada, bu algoritmalar için en optimum parametreleri bulmak için ızgara arama yaklaşımı uygulanmıştır. Bu nedenle farklı öğrenme hızları, max_depth, tahmin edici sayısı parametreleri birleştirilmiş ve model bu farklı parametrelerle ayrı ayrı yerleştirilmiştir. Hiperparametre optimizasyon aşamasının sonunda Light Gradient Boosting Machine, öğrenme oranı 0,2, maksimum derinlik 1, tahmin edici sayısı 120 ile, Extreme Gradient Boosting, öğrenme oranı 0.4, maksimum derinlik 5, tahmin edici sayı 200 ile, Catboost, 0.03 öğrenme oranı ile derinlik 4 ile optimum parametrelere sahip olduğu sonucuna varılmıştır.

K-Fold Çapraz doğrulama, modelin geliştirilmesini ve kararlılığını test etmek için önemli bir adımdır. Böylece her bir algoritmaya en iyi parametre kombinasyonları ile 10 Katlı çapraz doğrulama uygulanmıştır. Bu sayede kurulan modellerin stabilitesi ölçümlenmiştir. Sonuçlar Tablo 3’ te gösterilmektedir.

Uygulama yapılan veri seti zaman serileri içerdiğinden zaman serileri algoritmaları karşısındaki performansı da değerlendirilmek üzere zaman serileri algoritmaları da uygulanmıştır.

TABLO II
VARSAYILAN PARAMETRELERİYLE ALGORITMA SONUÇLARI

Model	MSE	Model	MSE
CatBoost Regressor	143,548	Random Forest Regressor	215,47
Light Gradient Boosting Machine	146,539	Passive Aggressive Regressor	215,815
Extreme Gradient Boosting	148,657	Extra Trees Regressor	236,329
Ridge Regression	178,689	Decision Tree Regressor	236,79
Bayesian Ridge	179,699	ARIMA	45,707
Linear Regression	179,704	SARIMA	28,232
Least Angle Regression	179,765	ARIMAX	23,456
Huber Regressor	183,171	SARIMAX	24,137

TABLO III
EN BAŞARILI ÜÇ TOPLULUK ÖĞRENMESİ ALGORİTMASINA 10 KATLI ÇAPRAZ DOĞRULAMA UYGULAMASI SONRASI ORTALAMA
KARASEL HATA SONUÇLARI

K	CatBoost Regressor	Light Gradient Boosting Machine	Extreme Gradient Boosting
0	141,899	141,873	144,037
1	143,679	143,457	145,693
2	144,487	144,499	146,657
3	142,137	141,972	144,04
4	145,151	145,03	147,046
5	143,144	143,223	144,682
6	142,743	142,946	145,157
7	143	143,219	145,12
8	143,48	143,44	145,108
9	143,157	143,315	145,411
Ortalama	143,288	143,297	145,295
SD	0,9364	0,9172	0,9333

10 Kat Çapraz doğrulama sonuçları, CatBoost Regressor algoritmasının minimum Ortalama Karesel Hataya sahip olduğunu göstermektedir. Sonuçların değerlendirilmesi sonucunda Light Gradient Boosting Machine ve Catboost tahminde bu kadar benzer sonuçlar vermesine rağmen üretim modeli olarak topluluk öğrenme algoritmaları arasında Light Gradient Boosting Machine seçilmesin öngörmektedir. Çünkü LightGBM ve Catboost'un çalışma süreleri karşılaştırıldığında LGBM, Catboost'tan yaklaşık 50 kat daha hızlıdır. Ancak ortalama karesel hatalar açısından değerlendirildiğinde hızlı algoritma olması zaman serisi algoritmaları ile karşılaştırıldığında tatmin edici bir sonuç sergileyememiştir.

IV. SONUÇ

Talep tahmini şirketler için stratejik kararlar vermesi açısından her zaman önemli bir kavram olmuştur. Bilgisayarların yaygın olmadığı dönemlerde de bu konu şirketler açısından önem arz etmektedir. Bilgisayarların hayatımıza girmesi ile birlikte geleneksel programlamalardan ziyade makineler de insanlar gibi geçmiş deneyimlerini kullanarak geleceği tahminleyebilir mi sorusu ortaya çıkmıştır. Makine öğrenmesi geçmiş dönemlere ait verilerin bilgisayarlar içerisinde istatistiki sonuçlar üretip gelecek hakkında tahminleme yapmasını sağlamaktadır.

Bu projede talep tahmini problemi için makine öğrenmesi tabanlı algoritmalar bir mağaza zincirinin gelecek talepleri yapabilmesi için uygulanmıştır. Geleneksel ve boosting türündeki algoritma sonuçları karşılaştırılmış, daha optimum sonuçlar elde edebilmek amacıyla en başarılı algoritmalara hiperparametre optimizasyonu uygulanmıştır. Bulunan optimumum parameter dizilimli bu algoritmalar, model stabilitesi test edilme amacıyla 10'lu çapraz geçişleme işlemi uygulanarak standart sapma değerleri ölçümlenmiştir. Bu sonuçlara göre; hızlandırma türünde olan LightGBM algoritmasının verdiği hatanın CatBoost'a çok yakın bir değerde olması ve LightGBM ile kurulan modelin CatBoost'a göre sonuç çıkarma süresininin yaklaşık elli kat daha hızlı olması nedeniyle sonuçlar değerlendirilirken bu performans da göz önünde bulundurulmuştur. Bu noktada, geleneksel makine öğrenmesi yaklaşımı ile modelleme yapılması noktasında LightGBM modelini kullanmanın sonuç üretme hızı da göz önünde bulundurulmalıdır.

Proje de son olarak aynı veri setine zaman serisi tabanlı algoritmalar da uygulanmış ve kullanılan veri seti için zaman serisi algoritmalarının makine öğrenmesi algoritmalarına göre daha az hata ile tahminleme yaptığı gözlemlenmiştir. Uygulanan zaman serisi algoritmalarından ARIMAX ,SARIMAX 'a göre en başarılı sonuçları vermiştir. Bu sonuçta kullanılan veri setinin mevsimsellikten çok fazla etkilenmediği sonucunu çıkarmıştır.

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Perakende Mağazacılığında Fijital Alışveriş Deneyimleri: Hazır Giyim Perakendeciliği Sektöründe Niteliksel Bir Araştırma²

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Özet—Araştırmada perakende mağazacılığında fijital uygulamalar gerçekleştiren bir hazır giyim markası incelenmiştir. Çalışmada perakende mağazacılığında fijital kavramını tanımlamak, fijital mağazaların perakendeci ve tüketici tarafından avantajlarını ve dezavantajlarını incelemek ve fijital uygulamaların alışveriş deneyimini nasıl etkilediğini araştırmak hedeflenmiştir. Fijital alışveriş deneyimlerinin incelenmesinin amaçlandığı bu çalışmada nitel araştırma yöntemi ve araştırma deseni olarak örnek olay tercih edilmiştir. Araştırmada veri toplama teknikleri olarak yarı yapılandırılmış görüşme ve gözlem kullanılmıştır. Toplanan veriler içerik analizi tekniği ile analiz edilmiştir.

Araştırmada perakende mağazacılığında fijital kavramı, dijital araçlarla çevrimiçi ve çevrimdışı alışveriş deneyimlerinin müşteriler tarafından görülen üstün yönlerini fiziksel mağazalarda bir araya getiren ve müşteriye kişiselleştirilmiş bir deneyim sunan bir perakendecilik yöntemi olarak tanımlanmıştır. Fijital mağazaların uzun vadede geleneksel mağazalara karşı daha düşük maliyetli olduğu tespit edilse de kısa vadede yüksek yatırım maliyetlerinin olmasının markaların fijitalleşmesini engelleyen faktör olduğu sonucuna varılmıştır. Fijital uygulamaların müşterilerde markaya karşı bağlılık hissini oluşturduğu ve mağazada satış artışı sağladığı tespit edilmiştir. Ayrıca, artırılmış gerçeklik teknolojisinin hızlı giyim sektöründe kullanılabilirliğinin düşük olduğu ve Türkiye’de oluşturulan fijital mağazalarda regülasyon nedeniyle kâğıt kullanımının sifıra indirilmesinin mümkün olmadığı sonucuna varılmıştır. Son olarak, fijital uygulamaların alışveriş deneyimini çoğunlukla olumlu etkilediği, yaş almış ve dijital okuryazarlığı düşük müşterilerin alışveriş deneyimini ise olumsuz etkilediği sonucuna varılmıştır.

Anahtar Kelimeler— İnovasyon, Fijital, Fijital Pazarlama, Fijital Alışveriş Deneyimi, Perakendecilik, Akıllı Mağaza

I. Giriş

Teknolojinin gelişmesiyle birlikte fiziksel ve dijital dünyaların birleşimi için yeni imkanlar oluşmaktadır. Nesnelerin interneti gibi gelişmeler, dijital teknolojilerin fiziksel yaşantımıza nasıl daha derinden bütünleştiğini gösteriyor. Bu nedenle, internetin artık sadece insanlarla, medyayla ve içerikle ilgili olmayacağı, aynı zamanda, bilgi alışverişinde bulunabilen, birbirleriyle ve insanlarla etkileşime girebilen ağ bağlantılı nesnelere olarak, gerçek dünyadaki fiziksel varlıkları da içereceği iddia edilmektedir [1]. Ortaya çıkan bu teknolojik gelişmelerle birlikte, fiziksel ve dijital dünyaların harmanlanmasını kavramsallaştıran ve İngilizcede fiziksel (physical) ve dijital (digital) kelimelerinin karışımından ortaya çıkan “fijital” terimi önerilmiştir.

Uluslararası literatür incelendiğinde fijital alışveriş deneyimi kavramıyla ilgili kısıtlı sayıda çalışmanın yapıldığı görülmektedir. Bu çalışmalardan çok az bir kısmıysa perakendecilikte uygulanan fijital uygulamaları bütüncül şekilde ele almakta olup söz konusu yayınlar ise çoğunlukla literatüre dayalı çalışmalardır [2], [3]. Gerçekleştirilen araştırmaların çoğunluğu bir veya iki fijital uygulamaya yoğunlaşmış şekilde araştırılmıştır. Türkiye’de yapılan çalışmalara da bakıldığında çoğunlukla fijital alışveriş deneyimi olarak sadece artırılmış gerçeklik ve sanal gerçeklik teknolojilerinin ele alındığı görülmektedir. Fijital alışveriş deneyimini ele alan çalışmalarda çoğunlukla fijital deneyimin pozitif yönlerinin aktarıldığı görülmektedir.

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Bu çalışmada fiziksel bir perakendecilik mağazasında fiziksel alışveriş deneyimi sunan ve bu deneyimi yaşayan kişilerle yarı yapılandırılmış görüşmeler yapılmıştır. Araştırmada bu mağaza içerisinde gerçekleştirilmiş tüm fiziksel uygulamalar ele alınmış ve bu uygulamaların müşteri ve perakendeci tarafında olumlu ve olumsuz yönleri tartışılmıştır. Ayrıca, fiziksel alışveriş deneyimi tanımlanmış ve bu kavramın müşterinin alışveriş deneyimini nasıl etkilediği incelenmiştir.

II. Fiziksel Kavramı

Fiziksel ve dijital dünyaların, birlikte ve arasında bir sınır olmadan, bütüncül bir şekilde var olabileceği bir dünyayı ifade eden fiziksel kavramı, ilk kez Mayıs 2007 tarihinde harita mühendisliği alanında yapılan bir konferansta kullanılmıştır. Kullanıcıların, duvara asılı haritalar ve atlas kitapların, bir sıra teknolojik aletlerle birlikte kullanılarak yeni bir harita sisteminin sunulduğu makalede, bu yeni sistem “Fiziksel Harita” (Phygital Map) olarak adlandırılmıştır [4]. Pazarlama alanında ise fiziksel kavramı ilk kez Haziran 2007 tarihinde Amerikan Reklam Ajansları Birliği başkanı Chris Weil tarafından, fiziksel ve dijital dünyaların bir arada var olabileceği bir dünyayı tanımlamak için kullanılmıştır [5]. Fiziksel pazarlama, tüketicilere benzersiz bir deneyim yaşatmak için her iki kanalın avantajlarını kullanarak, bu iki dünyayı bütüncül bir dünya olarak sunmaktadır [6]. Fiziksel pazarlama kavramı, e-ticaret araçlarını fiziksel mağazalarla birleştiren, genellikle bir markanın veya ürünün dijital varlığını sürükleyici bir gerçek dünya deneyimine bağlayan kavramsal bir fikir olarak kullanılır [1]. Genel olarak, fiziksel pazarlama, dijital teknolojiyi fiziksel alanlara kusursuz bir şekilde entegre ederek, tüketiciye benzersiz ve akılda kalıcı bir müşteri deneyimi sunmayı içermektedir [7].

A. Fiziksel alışveriş deneyimi.

Fiziksel deneyimin müşteri için dijital deneyimden daha ilgi çekici ve akılda kalıcı olduğu bilinmektedir. Buna rağmen, dijital teknolojiyle birlikte müşteri için bu deneyim daha fazla artırılabilir bilinir ve çevrimiçi/çevrimdışı dünyaların bütüncül bir şekilde çalışması, tüketici için daha rahat bir alışveriş deneyimi sağlayabilir [3]. Tüketici, fiziksel dünyada deneyimlediği ürünü hemen dijital araçlarla sipariş vermeyi isteyebileceği gibi, çevrimiçi dünyada karşılaştığı ürünü de fiziksel dünyada hemen deneyimlemeyi isteyebilir [8]. Bu nedenle, fiziksel deneyim, ürünlere veya hizmetlere değer katabilir ve tüketicinin yaşadığı deneyimden dolayı, tüketici ve marka arasındaki sadakati güçlendirebilir [9].

Fiziksel alışveriş deneyimi, fiziksel ve dijital dünyaları aynı satış noktasında birleştiren, müşteriler için benzersiz deneyimler sunan bir perakendecilik yöntemi olarak tanımlanır [10]. Müşteri deneyimleri, markanın rekabette avantaj elde etmesinde çok önemli rol oynamaktadır [11]. Markaların müşterilerine benzersiz bir müşteri deneyimi sunarak, rekabette öne geçme isteği sonucunda, son zamanlar fiziksel uygulamalar perakendecilik, bankacılık, eğitim, harita mühendisliği, havayolları, turizm, eğlence gibi çeşitli alanlarda kullanılmaktadır [12], [4], [8], [13]. Bir araştırmaya göre, müşterilerin %50’sinin fiziksel ve dijital öğeleri birlikte deneyimlemeye istekli oldukları belirtiliyor. Ayrıca, söz konusu araştırma, markaların fiziksel konseptini kullanmasının ürünlerinin satışını da olumlu yönde etkilediğini ortaya koyuyor [3]. Bu araştırmanın yanı sıra, Ulusal Perakende Federasyonu (NRF) tarafından yapılan bir anket çalışması, müşterilerin %66’sının teknolojinin alışveriş deneyimlerini iyileştirdiğini düşündüğünü gösterdi [14]. Bu nedenle, fiziksel alışveriş deneyimi, müşterileri ve onların satın alma davranışlarını etkileyen bir araç olarak kullanılabilir [15].

III. Fiziksel Alışveriş Deneyimleri Üzerine Örnek Olay Çalışması

A. Araştırmanın Amacı ve Önemi

Araştırmanın amacı perakende mağazacılığında fiziksel çalışmalar yapan bir hazır giyim markasını örnek olay incelemesi yöntemi ile inceleyerek fiziksel kavramının alışveriş deneyimine katkılarını araştırmaktır. Dünyada fiziksel mağazaların her geçen gün artmasına rağmen, ülkemizde fiziksel deneyimler sunan markaların sayısı oldukça azdır. Bunun yanı sıra, fiziksel kavramı üzerine yapılmış sınırlı sayıda akademik çalışma mevcuttur. Bu çalışmada alan yazınına yeni gelişmekte olan bir kavram ile ilgili tartışmayı Türkiye’de hazır giyim sektöründe faaliyet gösteren bir firma özelinde örnek olay deseni ile derinleştirmek ve müşterilerine fiziksel alışveriş deneyimi sunmak isteyen perakende markalarına yol gösterici olabilecek belli ipuçları sunarak katkı sağlayabilmek hedeflenmiştir.

B. Araştırmanın Deseni

Fiziksel alışveriş deneyimlerinin incelenmesinin amaçlandığı bu çalışmada nitel araştırma yöntemi ve bu araştırma yönteminin bir deseni olan örnek olay çalışması tercih edilmiştir. Örnek olay çalışmasının desenlerinden ise bütüncül tek durum deseni seçilmiştir.

Tüketiciye fiziksel alışveriş deneyimi sunan bir hazır giyim markasının incelendiği bu çalışmanın üç temel araştırma sorusu vardır:

1. Perakende mağazacılığında fijital kavramı nasıl anlaşılmalı, ele alınmakta ve uygulanmaktadır?
2. Fijital mağazaların perakendeci ve tüketici tarafından avantajları ve dezavantajları nelerdir?
3. Fijital uygulamalar alışveriş deneyimini nasıl etkilemektedir?

C. Veri Toplama Yöntemi ve Aracı

Araştırmada veri toplama yöntemleri olarak yarı yapılandırılmış görüşme ve gözlem kullanılmıştır. Konuyla ilgili literatür taranarak sorular oluşturulmuş ve uzman görüşüne başvurulmuştur. Araştırmada yarı yapılandırılmış görüşme kullanılması amaç, görüşmenin gidişatına göre sorularda değişiklik yapmak veya yeni sorular eklemekle katılımcıların araştırma konusuna ilgili görüşlerini derinlemesine öğrenmek ve vakayla ilgili detaylı bilgi toplamaktır. Yapılan görüşmeler öncesinde hazırlanan yarı yapılandırılmış görüşme formu Dokuz Eylül Üniversitesi Rektörlüğü'ne sunularak etik kurul izni alınmış ve sonrasında katılımcıların onamları alınarak görüşmeler gerçekleştirilmiştir. Görüşmeler, İstanbul ilinde yerleşen perakende mağazasına gidilerek her bir katılımcıyla ayrı ayrılıkta yapılmış ve her bir görüşme 20-60 dakika aralığında sürmüştür. Görüşmeler, ses kayıt cihazına izin veren katılımcılarda ses kayıt cihazıyla, ses kayıt cihazına izin vermeyen 1 katılımcıdaysa not alma yöntemiyle kayıt altına alınmıştır. Katılımcılara etik ilkeler, araştırmanın amacı ve görüşme süreciyle ilgili bilgiler verilmiş, görüşme izni alındıktan sonra demografik bilgilerin sorulmasıyla görüşme başlamıştır. Görüşme soruları yarı yapılandırılmış görüşme doğrultusunda hazırlanmış, mağaza çalışanlarına 13, müşterilereyse 8 açık uçlu soru ve görüşme sürecinde oluşan yeni sorular verilmiştir.

Verileri zenginleştirmek ve görüşmelerde toplanan verilerin doğruluğunu teyit edebilmek amacıyla görüşmelerin bir gün sonrasında mağaza dahilinde gözlem yapılmıştır. Çalışmada gözlem yöntemi olarak katılımcı olarak gözlem kullanılmıştır. Araştırma konusu olan mağaza dahilinde yapılan gözlem katılımcılarla yapılmış görüşmeleri takip eden gün yapılmıştır ve bir iş günü boyunca sürmüştür. Bu nedenle gözlem sırasında katılımcılar araştırmacının kimliği ve amacı hakkında bilgiye sahiptirler. Gözlem sırasında araştırmacı tarafından iş gününün farklı saatlerinde iki kez alışveriş yapılmış ve tüm fijital uygulamalar denenmiştir. Gözlem sırasında toplanılan tüm veriler araştırmacı tarafından not alınmıştır.

D. Araştırmanın Örnekleme

Bu araştırmada amaçlı örnekleme yöntemi olan ölçüt örnekleme kullanılmıştır. Araştırmanın katılımcıları İstanbul ilinde yerleşen bir fijital perakende mağazasının çalışanlarından, marka dahilinde bu projeyi oluşturan kişilerden ve bu mağazanın müşterilerinden seçilmiştir. Ölçüt olarak fijital alışveriş deneyimini sunan ve deneyimleyen kişiler seçilmiştir. Görüşme yapılan altı kişinin gerçek isimleri yerine takma isimleri Oya, Cem, Ada, Gül, Eda ve Can olarak kodlanmıştır. Katılımcılarla yapılan görüşmeler esnasında katılımcıların demografik bilgileri belirlenmiştir. Bu bilgiler Tablo 1'de gösterilmektedir.

TABLO 1
Katılımcılara Ait Bilgiler

Katılımcı	Yaş	Pozisyon	Deneyim Süresi/Yıl
Oya	26	Alan müdürü	6.5
Cem	37	Fijital dönüşüm ve Dijital inovasyon direktörü; CEO danışmanı	15
Ada	24	Müşteri danışmanı	1.5
Gül	36	Bölge müdürü	14
Eda	42	Mağaza müşterisi	-
Can	25	Mağaza müşterisi	-

E. Geçerlik ve Güvenirlik

Bu araştırmada inandırıcılık, aktarılabilirlik, tutarlık ve teyit edilebilirliği etkileyen faktörleri azaltmak için çeşitli önlemler alınmıştır [16], [17], [18].

Araştırmanın inandırıcılığını sağlamak için uygulama öncesinde görüşme formunun araştırmaya uygunluğu ve soruların okunabilirliği açısından incelenmesi için uzman görüşlerine başvurulmuştur. Ardından katılımcılardan bir kişiye araştırma formu okutulmuş ve anlaşılabilirlik açısından değerlendirmesi istenmiştir. Elde edilen veriler bağlamında araştırma formu tekrar incelenmiş ve gerekli düzeltmeler yapılmıştır. Katılımcılarla görüşmeler öncesinde sorularda geçen kavramlarla ilgili açıklamalarda bulunulmuş ve araştırmacı ve katılımcı arasında doğal sohbet ortamının oluşmasına çalışılmıştır. Görüşmeler 20-60 dakika aralığında sürmüştür. Toplanan verilerin analizi yapıldıktan sonra (1 gün sonra) katılımcıların cevapları tekrar edilerek teyit edilmiştir. Ardından görüşmelerde toplanan

verilerin gözlem yoluyla karşılaştırılması yapılmıştır. Son olarak katılımcı gizliliğinin korunması adına marka ismi ve mağazanın yerleştiği alışveriş merkezinin ismi belirtilmemiştir.

Araştırmanın aktarılabilirliğini sağlamak için çalışma konusu olan örnek olay ve firma hakkında detaylı bilgi, katılımcıların demografik bilgileri, verilerin nasıl toplandığı, araştırma deseni ve bulguların nasıl düzenlendiğiyle ilgili detaylı betimlemeler yapılmıştır. Aktarılabilirliği kısıtlayan etken olarak katılımcılar içerisinde müşterilerin sayının iki ile sınırlı olması gösterilebilir. Araştırmanın tutarlılığını sağlamak için veri doygunluğuna ulaşılan kadar veri toplanılmaya devam edilmiştir. Bu bağlamda bazı katılımcılarla ikinci ve üçüncü kez görüşmeler yapılmıştır. Görüşmelerde ses kayıt cihazı kullanılmıştır. Araştırmanın teyit edilebilirliğini sağlamak için ise bulgular sonuç kısmında tartışılmış ve varılan sonuçlarla ham veriler arasında tutarlılık kontrol edilmiştir.

F. Veri Analizi

Bu çalışmada veri analizi tekniği olarak içerik analizi kullanılmıştır. Katılımcılardan yarı yapılandırılmış görüşmeler sonucu toplanan veriler perakendeciler ve tüketiciler açısından dijital konsepti dahilinde incelenmiş ve kodlar oluşturulmuştur. Kodlar verilerden çıkarılan kavramlara göre oluşturulmuştur. Ortaya çıkan kodlar, tema ve kategoriler altında bulgular bölümünde verilmiştir.

G. Araştırma Kapsamındaki Firma ile İlgili Bilgiler

Araştırma kapsamındaki firma 2003 yılında kurulmuş ve faaliyetlerine 2005 yılında açtıkları ilk perakende mağazasıyla başlamıştır. Firma şu anda 30 ülkede 500’ün üzerinde mağaza ve bunlardan 200’ün üzerinde yurtdışı mağazası ve 14000’in üzerinde çalışan sayısı ile global bir moda markası olarak çalışmalarını sürdürmektedir. Firmanın 6 alt markasıyla birlikte 100’ün üzerinde ülkede ürünleri tüketiciyle buluşmaktadır. Markanın vizyonunun 180 ülkede hizmet veren bir dijital hızlı moda markası olmak olduğu görülmektedir. Bu vizyon bağlamında 2019 yılında Türkiye’de ilk dijital perakende mağazası sözü geçen firma tarafından açılmıştır. Bu mağaza Türkiye’nin İstanbul ilinde yerleşen bir alışveriş merkezinde 200 metrekarelik bir alanda faaliyetine başlamış ve devam etmektedir. Araştırmada katılımcı olarak rol alan kişilerin deşifre olmaması amacıyla alışveriş merkezinin ismi ve araştırma kapsamındaki firmanın ismi gizli tutulmuştur.

H. Bulgular

Görüşmeler sonucunda katılımcıların açık uçlu sorulara verdikleri cevaplar araştırma sorularına cevap bulunması adına incelenmiş ve bu cevaplara göre kodlar, kategoriler ve temalar oluşturulmuştur. Katılımcıların bazı sorularda belirttikleri ifadeler birden fazla kodun altına alınmıştır. Görüşme verileri perakendeciler tarafından ele alındığında ilk ana tema olan “Perakende mağazacılığında dijital kavramı” teması oluşturuldu. Dijital mağazaların perakendecilere getirdiği avantaj ve dezavantajları görmek ve perakendecileri dijital kavramını nasıl ele aldıklarını incelemek için “Dijital mağazanın avantajları”, “Dijital mağazanın dezavantajları” ve “Markanın dijital yaklaşımı” başlıklı kategoriler oluşturuldu. Görüşme verileri müşteri gözüyle ele alındığında ise ikinci ana tema olan “Alışveriş Deneyiminde Dijital Kavramı” teması oluşturuldu. Dijital mağazaların tüketici deneyimine kattığı avantaj ve dezavantajları görmek için “Dijital alışveriş deneyiminin avantajları” ve “Dijital alışveriş deneyiminin dezavantajları” başlıklı kategoriler oluşturuldu.

IV. Sonuç

Bu kısımda dijital alışveriş deneyimini sunan ve deneyimleyen kişiler ile gerçekleştirilmiş yarı yapılandırılmış görüşme verilerinin ve araştırmacı gözleminin analizi sonucunda, dijital alışveriş deneyimlerine yönelik görüşlerde elde edilmiş sonuçlar araştırmanın üç ana sorusuna cevap bulunacak şekilde incelenmiş, literatürde mevcut diğer araştırmalarla karşılaştırılarak tartışılmıştır.

Araştırmada ilk olarak “Perakende mağazacılığında dijital kavramı nasıl anlaşılmalı, ele alınmakta ve uygulanmaktadır?” sorusuna cevap aranmıştır. Perakende mağazacılığında dijital kavramı, dijital araçlarla çevrimiçi ve çevrimdışı alışveriş deneyimlerinin müşteriler tarafından görülen üstün yönlerini fiziksel mağazalarda bir araya getiren ve müşteriye kişiselleştirilmiş bir deneyim sunan bir perakendecilik yöntemidir.

İlgili literatür incelendiğinde diğer araştırmacıların da perakende mağazacılığında dijital kavramı ile ilgili benzer tanımlamaların yapıldığı görülmektedir [19], [1], [10]. Van Tichelen perakende mağazacılığında dijital kavramını, dijital ve fiziksel dünyaları birleştiren ve kişiselleştirilmiş ve ilgi çekici bir deneyim yaratan kavram olarak tanımlamıştır [19]. Belghiti ve diğerleri tarafından perakende mağazacılığında dijital kavramı, fiziksel ve dijital dünyaları aynı satış noktasında birleştiren, müşteriler için benzersiz deneyimler sunan bir perakendecilik yöntemi olarak tanımlanır [10]. Bu tanımlamalar oluşturduğumuz perakende mağazacılığında dijital kavramının tanımını destekler niteliktedir.

Araştırma konusu olan markanın kendilerini global bir moda markası olarak tanımlarken fijitalleşme sürecine girdikten sonra kendi söylemlerini değiştirerek kendilerini global bir fijital moda markası olarak tanımladıkları ve fijitalleşmeyi uzun vadede var olmanın zorunlu koşulu olarak ele aldıkları görülmektedir. Mağaza içinde müşteri danışmanlarının müşteri geribildirimlerini yönetime bildirmek, müşteriye teknoloji kullanımında yardımcı olmak ve müşteriye geleneksel alışverişin yerine fijital alışveriş yapmaya yönlendirmek gibi rolleri olduğu görülmektedir. Müşteri deneyimlerini kişiselleştirmede ve fijital alışveriş oranını yükseltmede müşteri danışmanlarının önemli ölçüde katkı sağladığı sonucuna varılmıştır. Alan yazın incelendiğinde Belghiti ve diğerleri tarafından yapılan araştırmada müşteri danışmanlarının fiziksel ve dijital dünyalar arasında köprü rolünü üstlendiklerini ve müşterileri fijital öğeleri kullanmaya teşvik ettiklerini görmekteyiz [10]. Belghiti ve diğerlerinin belirttiği bu durum çalışma sonucu ile benzerlik göstermektedir.

Müşteri danışmanlarının pozitif etkilerinin yanı sıra negatif etkilerinin de olduğu görülmektedir. Müşteri tarafından yönlendirilen herhangi bir soru veya sorunun danışman tarafından cevaplanamaması halinde bu durumla karşılaşan müşteride fijitale karşı negatif bir düşüncenin oluşabileceği tespit edilmiştir. Bu nedenle, fijital mağazalarda çalışan müşteri danışmanının fijital alışveriş süreciyle ilgili tüm bilgiye sahip olması gerektiği görülmektedir. Bu bağlamda marka tarafından danışmanlara verilen eğitimin fijitalleşme sürecine önemli katkı sağladığı sonucuna varılmıştır.

Araştırmada ikinci soru olarak “Fijital mağazaların perakendeci ve tüketici tarafından avantajları ve dezavantajları nelerdir?” sorusuna cevap aranmıştır. Fijital mağazaların geleneksel mağazalara karşı çok daha küçük metrekarelerle açıldığı ve mağaza dahilinde çalışan kişi sayısının da çok daha az olduğu görülmektedir. Bu bağlamda fijital mağazaların daha düşük kira ödemesi ve daha az sayıda çalışan kişi sayısına bağlı daha düşük maaş maliyeti olması nedeniyle fijital mağazaların uzun vadede geleneksel mağazalara karşı daha düşük maliyetli olduğu sonucuna varılmıştır. Uzun vadeli maliyetlerin aksine, yüksek teknoloji ve yazılım maliyetleri nedeniyle fijital mağazaların yüksek yatırım maliyetlerinin olduğu görülmüştür. Yüksek yatırım maliyetlerinin markaların fijitalleşmeye yönelmesine karşı bir engel olduğu sonucuna ulaşılmıştır. Alan yazında da Van Tichelen fijital mağazaların yüksek yatırım maliyetlerini küçük ve orta büyüklükteki işletmelere bir finansal engel olduğunu tespit etmiştir [19]. Bu tespit çalışma sonucu ile paralellik göstermektedir.

Fijital mağazada müşteriye akıllı kiosklar vasıtasıyla NFC teknolojisiyle ödeme, QR kodla ödeme, kredi kartı ve nakit ödeme yöntemlerinin sunulduğu görülmektedir. Alan yazında ödeme yöntemlerinin müşterinin satın alma duygusuna etkisiyle ilgili birçok araştırmayla karşılaşılmıştır. Prelec ve Simester’in oluşturduğu çalışmada kredi kartıyla yapılan ödemelerin maliyet algısını etkilediği ve ödeme sürecini daha az acı verici hale getirdiği bulunmuştur [20]. Atalay ve Pisani’ye göreyse cep telefonu ve akıllı saatler vasıtasıyla NFC ödeme yöntemini kullanmak kredi kartlarına nazaran daha az acı vericidir [21]. Johnson ve Barlow’a göre mağazalarda ödemenin daha soyut hale gelmesi müşteride ödeme acısını azaltır ve daha fazla satın alma yapmasına neden olur [2]. Araştırmacılar tarafından bulunan bu sonuçlara rağmen araştırmamızda ödeme yöntemlerinin satın alma üzerinde herhangi bir etkisinin olduğuna ilişkin bir sonuca ulaşamamıştır. Akıllı kioskların bir diğer özelliği ise müşteriye alacağı ürünlerin yanı sıra bu ürünle kombinleyebileceği birçok ürünü gösterebilmesidir. Görüşme verilerine dayanarak bu özelliğin mağazada satış artışına sebep olduğu sonucuna varılmıştır.

Görüşme verilerine dayanarak fijital mağazanın hızlı ve ücretsiz kargo seçeneğinin müşterilerde mağazaya karşı bağlılık hissini oluşturma yönünde olumlu etkiye sahip olması sonucuna varılmıştır. Alan yazınına bakıldığında, Johnson ve Barlow’un yaptığı araştırmada müşterinin ürünü sipariş vermesiyle onu elde etmesi arasındaki zamanın kısa olması ve bu gönderimin ücretsiz olması satın almayı etkileyen unsurlar olarak gösterilmektedir [2]. Bu bulgu araştırma sonucumuzla benzerlik göstermektedir.

Mağazada oluşturulan sistemin müşteri sunduğu özelliklerden bir diğeryse mağazanın tam otonom şekilde çalışabilmesidir. Müşterinin mağaza içinde istediği bir ürünü kimseye ihtiyaç duymadan deneyip, kiosk üzerinden ödemesini yapıp, siparişini tamamlayabileceği bu sistemin sosyal iletişim kurmada zorluklar yaşayan müşterilere daha az rahatsız edici bir alışveriş deneyimi sunduğu sonucuna varılmıştır. Alan yazında da bu sonucu destekler nitelikte sonuçlara ulaşıldığı görülmektedir [22], [2]. Ferrel ve arkadaşlarına göre, fijital uygulamalar sayesinde müşteri alışverişini bitirmek için herhangi bir kasa memurunu veya kasa sırasını bekleme zorunda kalmaz veya iletişim sıkıntısı yaşayan bir müşteri bir danışmandan yardım isteme utancıyla karşılaşmaz [22].

Araştırma konusu mağaza ilk açıldığında çevre koruma adına hiç kâğıt kullanmadığı görülmektedir. Moravcikova ve Kliestikova’ya göre de fijital mağazalar düşük düzeyde kâğıt, su ve karbondioksit kullanımı nedeniyle çevreyi koruyabilecek sistemlerdir [3]. Ama Türkiye’de mağazaların fiziksel olarak fiş kesmesi gerekmektedir ve bu regülasyon nedeniyle Türkiye’deki perakende mağazalarında kâğıt kullanımının tamamen sıfıra indirilmesinin imkânsız olduğu sonucuna varılmıştır.

Araştırma konusu olan mağazada bir süre müşterilere farklı kıyafetlerin üzerlerinde nasıl duracağını gösteren ve artırılmış gerçeklik teknolojisini barındıran akıllı aynaların kullanıldığı ama bir sıra zorluklardan dolayı sözü geçen uygulamanın kaldırıldığı görülmüştür. Alan yazında artırılmış gerçeklik teknolojisinin tüketici satın alma niyeti üzerindeki etkilerini araştıran birçok çalışmanın olduğu görülmektedir. Uçkun ve Sağtaş'ın 221 katılımcıyla, Avcılar ve diğerlerinin ise 400 katılımcıyla yaptığı çalışmalarda artırılmış gerçeklik teknolojisinin tüketicinin satın alma niyeti üzerinde pozitif etkisinin olduğu sonucuna varılmıştır [23], [24]. Artırılmış gerçeklik teknolojisinin tüketicinin satın alma niyeti üzerinde pozitif etkisinin olmasına rağmen hızlı giyim sektöründe bu teknolojinin kullanılmasını kısıtlayan problemler olduğu tespit edilmiştir. Görüşme verilerine göre, her bir insanın vücut yapıları farklı olduğundan dolayı algoritmanın modelleme yapması daha zor oluyor. Ayrıca, markanın 13000'in üzerinde ürün çeşidinin olması ve bu sayıda ürünün modellenmesinin zorluğu da artırılmış gerçeklik teknolojisinin kullanımını kısıtlayan engellerden bir diğeri. Bu nedenlerden dolayı artırılmış gerçeklik teknolojisinin hızlı giyim sektöründe uygulanabilirliğinin düşük olması sonucuna varılmıştır.

Mağazada oluşturulan sistemin yaşlı tüketicilerin ve düşük dijital okuryazarlığa sahip kişilerin alışveriş deneyimini olumsuz etkilediği görülmektedir. Sözü geçen kişilere de hizmet sunmada mağazaların tamamen fijitalleşmesinin aksine daha hibrid yapıda olması ve geleneksel yöntemlerle de alışveriş yapabileme şansının tanınması gerektiği sonucuna varılmıştır.

Fijital mağazada RFID teknolojisi, 360 derece açığa sahip tavan kameraları ve akıllı kiosklar sayesinde markanın müşteri profili hakkında detaylı veri toplayabildiği görülmektedir. RFID teknolojisi sayesinde kabine en çok hangi ürünlerin girdiği ve bu ürünlerden en çok hangilerinin satın alındığı öğrenilebilmektedir. 360 derece açığa sahip kameralar sayesinde mağazada ısı haritaları çıkarılabilmekte ve bu sayede müşterilerin en çok hangi alanlarda vakit geçirdiği öğrenilebilmektedir. Akıllı kiosklar sayesinde müşterilerin kendi rızalarıyla demografik bilgilerine ulaşılabilir. Bu uygulamalar sayesinde marka sözü geçen mağaza için müşteri profilini daha derinden tanıyabilir ve bu müşteriler için daha kişiselleştirilmiş bir mağaza deneyimi sunabilir. Bu nedenle fijital uygulamaların müşteri deneyimini kişiselleştirdiği sonucuna varılmıştır.

Görüşme verilerine dayanarak müşterilerin geleneksel ve fijital mağaza arasında fijital mağazayı seçeceklerini söyledikleri görülmektedir. Ayrıca, müşteri danışmanlarından alınan verilere göre mağazanın müşteri portföyünün bir kısmını devamlı bu mağazadan alışveriş eden müşteriler teşkil etmektedir. Bu nedenlerle fijital uygulamaların mağazayla müşteri arasında bağlılığı geliştirdiği ve müşteri sadakati oluşturduğu sonucuna varılmıştır. Alan yazında da Mishra ve diğerleri, Moravcikova ve Kliestikova ve Johnson ve Barlow fijital çalışmaların müşteri sadakatini güçlendirdiği sonucuna varmışlardır [11], [3], [2].

Mağaza içinde yapılan araştırmacı gözlemine dayanarak bir sıra teknolojik hataların ve bazı noktalarda teknolojinin yavaş çalışmasının ve markanın internet sitesinde kayıtlı olmayan müşterilerin kayıt işlemlerinin uzun sürmesinin müşteri deneyimini negatif etkilediği sonucuna varılmıştır. Son olarak araştırmada "Fijital uygulamalar alışveriş deneyimini nasıl etkilemektedir?" sorusuna cevap aranmıştır. Müşterilerin geleneksel veya çevrimiçi mağazaları seçmesine neden olan bir sıra özelliklerin fijital mağazada toplandığı görülmektedir. Ayrıca, geleneksel ve çevrimiçi mağazalarda yaşanan bir sıra problemlerin de bu mağazada çözüldüğü görülmektedir. Bu özelliklere ve çözülen problemlere örnek olarak, ürünü görme ve deneyebilme, sosyalleşme, yüksek ürün çeşitliliği ve stok sayısı, çevrimiçi alışverişe özel fiyatlardan yararlanabilme, ürün hakkında etikette yazandan daha fazla bilgiye ulaşma, sipariş verdiği ürüne karşı güveninin olması, uzun kasa sıralarının yerine ödemeni kiosklar üzerinden yapabileme, kabinde denenilen ürünü değiştirmek için kabin hizmeti, hızlı ve ücretsiz kargo seçeneği ve güvenilir ve çeşitli ödeme yöntemlerinin olması gösterilebilir.

Fijitalleşmenin müşteriler tarafından genel olarak beğenildiği görülse de tamamen fijitalleşmenin bir kısım müşterinin alışveriş deneyimini olumsuz etkilediği görülmüştür. Bu nedenle mağazaların tamamen fijitalleşmesinin yanı sıra daha çok hibrid bir yapıyı benimsemeleri ve geleneksel satış yöntemlerinden de yararlanmaları önerilmektedir. Bu çalışmada sadece fijital mağaza incelenmiştir, gelecek çalışmalarda bir markanın hem geleneksel mağazası hem çevrimiçi mağazası hem de fijital mağazası karşılaştırarak incelenebilir.

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Performance Analysis of BRICS-T Countries within The Scope of Logistics Performance Index with Entropy Weighted TOPSIS Method

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Abstract— The acceleration of the liberalization trend in trade and transportation around the world has enabled the logistics sector to be seen as a strategic sector. Turkey has the potential to become an important base in the world both in terms of its strategic location in the world, its young population structure and its investments in the logistics sector. The success of logistics activities can be determined by the logistics performance of organizations and countries. In this context, logistics activities should be effective and efficient in order to improve the logistics performance of countries in general. Today, with the disappearance of geographical borders in terms of transportation, logistics activities have come to the fore more. In this context, in the first part of the study, the concepts and definitions related to the subject were made, then internal and external literature review about LPI was made, then the logistics performance ranking of the BRICS-T (Brazil, Russia, India, China, Republic of South Africa and Turkey) countries with TOPSIS method. has been made. The situation of Turkey has been examined comparatively with the BRICS countries, and the potential of Turkey and its situation on a global scale have been tried to be revealed. The data used in the study were selected from the data in the LPI 2018 report published internationally by the World Bank International Trade Unit, and the weights of the 6 criteria belonging to this index were calculated by the Entropy method and included in the study. Finally, the country rankings and weighted criterion weights tables were created and the findings obtained were examined in comparison with Turkey in the conclusion part and some suggestions were made for future studies. According to the results obtained from the study; The most affecting logistics performance is the "customs" criterion, and the least affecting it is the "timing" criterion. According to the TOPSIS ranking result, China is in the first place, followed by South Africa, India, Turkey, Brazil and Russia.

Keywords— Performance Analysis, Logistics performance index, BRICS, TOPSIS.

I. INTRODUCTION

Today, it has become mandatory for companies to use performance measurement techniques in order to compete in a healthy way. It is important for organizations to know themselves, to shape their organizational behaviour in line with the demands of customers, and to make a healthy performance evaluation through feedback.

Performance measurement is of great importance in determining the success of the whole process, such as the evaluation of the quality of logistics services, the efficiency of the resources used, the perceptions of the customers about the services they receive, the experiences in the product or service delivery process. Performance measurement is a necessity both for the institution and for determining the place of a country in the competitive market in general. The reason for performance measurement is to measure the efficiency and quality of the work done (Li, 2005: 54).

The World Bank, which tries to develop logistics reform programs to measure the international competitiveness, has created the Logistics Performance Index (LPI) together with business professionals and some academic partners. The aim of this study is to reveal the extent of competition between countries (Yapraklı & Ünalın, 2017). The LPI measurement of countries was first published by the World Bank in 2007, while seven criteria were determined while making the measurements, six criteria were used by subtracting the local logistics costs criterion in the measurements made in the following 2010, 2012, 2014 and 2016. In the first report, 100 countries, then 115 countries in 2010 and 2012, and 160 countries in the measurements made in 2014, 2016 and 2018 were included in the study.

LPI is an interactive benchmarking tool created to identify the challenges and opportunities that countries face in their commercial logistics performance, and what they can do to improve their

performance. LPE is based on a survey organized by the World Bank, which provides feedback on the compliance of countries with commercial logistics activities with logistics principles, and shows the activities carried out around the world (Pinar and Diken, 2020).

The success of logistics activities can be determined by the logistics performance of organizations and countries. In this context, logistics activities should be effective, effective and efficient in order to improve the logistics performance of countries in general. In addition, organizations and countries should differentiate from their competitors by making different methods, strategies and practices while continuing their logistics activities, and accordingly, they should maintain their grip in the customer environment (Fugate et al., 2010). By measuring the logistics performance, countries can plan their logistics activities better, and accordingly, it is possible to know the deficiencies and advantages of their countries. In addition, thanks to the logistics performance data they follow in the next logistics processes, countries will be able to compensate for their deficiencies in logistics and ensure that methods, strategies and applications are more effective, effective and efficient in their next activities (Altıntaş, 2022).

In this study, the situation of the logistics sector in Turkey will be examined in comparison with the BRICS-T countries, and the potential and global situation of Turkey will be tried to be revealed. For this, Turkey's performance and position were examined based on the LPE data, which shows the logistics performance of the countries and published internationally by the World Bank. In addition, thanks to the Global LPE reports, the situation of the BRICS-T countries was revealed and inter-country comparisons were made.

II. LITERATURE REVIEW

Sofyalıoğlu and Kartal (2013) in this study, the logistics performance indexes of Turkey and Eurasian Economic Community (EurAsEc) countries were compared and discussed what could be done to improve logistics activities in the region within the framework of mutual cooperation. According to the findings from the study, it has been argued that better logistics infrastructure should be available across EurAsEc countries and it is essential to adopt transit and improve information technology infrastructure by EurAsEc countries to speed up customs clearance.

Ayaydın, Durmus and Pala (2017) in this study, information about the development and importance of the logistics sector in Turkey was given and performance measurements were carried out with the Grey Relational Analysis (GIA) method by using the financial ratios of ten companies operating in the logistics sector. According to the results of the study, the best performing companies and their rankings were determined according to the GIA analysis method. In general, it was stated that the results of the GIA method used in the study did not completely overlap with the rankings made by other methods, and different rankings were obtained.

Yapraklı and Unalan (2017) in this study, based on the 2007-2016 LPE reports; analysed the global situation of logistics on the basis of countries and Turkey's position in the international market. As a result of the study, Turkey has made some progress in terms of logistics performance in the last ten years, but there is no significant change in its place in the world ranking, its ranking in 2007 was 34, this ranking did not change in 2016, and the best period in terms of both index score and ranking was 2012, It has been argued that the highest improvement is in the infrastructure criterion and the lowest improvement is in the logistics quality and competence criterion.

Gok Kisa and Aycin (2019) in this study, they evaluated the logistics performance of OECD countries by using multi-criteria decision making methods in an integrated manner. The importance weights of the logistics performance criteria in the study were calculated by the SWARA method, and the logistics performances of the countries were calculated by the EDAS method. According to the results obtained from the study, the most important criteria are respectively; logistics service quality, infrastructure and international shipment criteria. It has been suggested that the countries with the highest logistics performance are Germany, the Netherlands and Sweden, respectively.

Candan (2019) in this study, the logistics performance of 10 OECD member countries was first calculated with the fuzzy AHP method and then the logistics performance ranking of the countries was made using the grey relational analysis (GIA) method. As a result of the study, it has been argued that the logistics performance of the countries primarily depends on the import and export delivery times, and then on the quality of the infrastructures they use. In the study, it was determined that the country with the highest performance was Australia, followed by Austria, Germany, Belgium, United Kingdom, Turkey, Italy, Greece, Spain and the Czech Republic, respectively.

Orhan (2019) in this study, using the 2018 logistics performance index data published by the World Bank, the logistics performances of Turkey and EU countries were compared with the ENTROPY-weighted EDAS method. As a result of the study, the order of importance of the criteria; customs, infrastructure,

logistics competence, cargo tracking and traceability, scheduling and international shipments. In addition, it has been suggested that Turkey should prioritize the three most important criteria (customs, infrastructure and logistics competence) and develop its competencies in order to rank higher in logistics performance comparisons.

Pinar and Thorn (2020) in this study, according to LPE 2018 data, Turkey's situation regarding logistics bases was analyzed comparatively with some countries and suggestions were made about what should be done in order for our country to become better in the sector. As a result of the study, it has been argued that all processes in global logistics bases that create an advantage should also be carried out professionally in Turkish logistics bases. In addition, it has been commented that the logistics sector, which was examined in line with the results of the LPE report, and subsequently the logistics bases, are among the most popular areas in terms of creating a competitive advantage for Turkey.

Acar (2021) in this study, the logistics efficiency of Turkey and EU member countries were analysed comparatively by DEA and Malmquist method. As a result of the study, Turkey's efficiency value has fluctuated over the years when compared to EU member states, necessary technical and legal arrangements should be made in order to improve all sub-dimensions of LPE, Turkey's "international shipment", "tracking/tracking" and In the criteria of "timeliness", it has been suggested that he should improve himself.

Altintas (2022) in this study, the importance degrees of the components that determine LPE and the logistics efficiency and productivity performances of the G7 countries were tried to be determined by the Entropy-based EATWIOS method. As a result of the study, the importance degrees of the components that determine the logistics performance of the countries; international shipping, customs, tracking and tracing, logistics quality and competence, timing and infrastructure.

III. ANALYSIS OF THE PERFORMANCE OF BRICS-T COUNTRIES

The performance analysis and the results obtained according to the Logistics Performance Index data of BRICS-T (Brazil, Russia, India, China, South Africa and Turkey) countries are shown below, respectively.

A. Method and Data Set Used in the Study

In the study, the world-wide data in the LPE 2018 report published by the World Bank International Trade Unit were used and the weights of the criteria were calculated using the Entropy method, which is one of the MCDM techniques, which is frequently used and accepted in similar studies in the literature, in order to analyse the performance of 5 countries called BRICS countries and Turkey. Then, the performance rankings of the countries were made with the TOPSIS method. There are 6 criteria used in performance analysis and these are; Customs, Infrastructure, International Shipments, Logistics Quality and Competence, Tracking and Monitoring, Timing criteria. Data regarding the six criteria of the BRICS-T countries taken from the LPE report are shown in Table 1 below.

TABLE I
BRICS-T COUNTRIES LPE SCORES

Countries	Customs	Infrastr ucture	International transporta tion	Logistics Quality and Compet.	Trackin g and Monito ring	Timely Delivery of Shipments to the Buyer
Brazil	2,41	2,93	2,88	3,09	3,11	3,51
Russia	2,42	2,78	2,64	2,75	2,65	3,31
India	2,96	2,91	3,21	3,13	3,32	3,50
Chinese	3,29	3,75	3,54	3,59	3,65	3,84
South Africa	3,17	3,19	3,51	3,19	3,41	3,74
Türkiye	2,71	3,21	3,06	3,05	3,23	3,63

According to the data shown in Table 1; It is seen that China has the highest scores in all criteria, the country scores are relatively lower in terms of customs criteria, and the scores of countries other than Russia are close to each other in terms of logistics quality and competence.

B. Calculation of Countries' Criterion Weights by Entropy Method

In this part of the study, the weights of six criteria for LPE 2018 will be calculated. In the literature on the subject, in some of the examples (Demireli, 2010; Saldanlı & Sırma, 2014), the weights are determined by giving equal weights to the criteria (1/number of criteria), while in others, they are determined by Entropy or AHP methods. In general, it is seen that these methods have been used successfully in many studies. Therefore, in this study, it was decided that it would be appropriate to weight the criteria using the Entropy method.

The criterion weighting process is generally done in two ways as objective and subjective weighting. While the choices or judgments of the decision makers are important in the weighting method performed with the subjective method, mathematical-based models such as Entropy method or multi-objective programming are used without considering the choices of the decision makers in the objective methods (Deng et al., 2000: 965; Shemshadi et al., 2011: 12161). In the entropy method, the data is directly used to find the objective weights of the criteria and only the decision matrix is needed. This practice increases the validity of the method as it is not affected by the personal thoughts and decisions of the decision makers (Işık, 2019: 204; Meyliana et al., 2015: 1684).

In Table 2, the weight calculations (W_{ij}) of the 6 criteria of the BRICS-T countries according to the Logistics Performance Index of 2018 were made using the Entropy method, and these calculations are made in four stages. The weights of the six criteria obtained as a result of the calculations are shown in Table 2.

TABLE II
 CALCULATION OF WEIGHT VALUES OF THE CRITERIA

	K₁	K₂	K₃	K₄	K₅	K₆
W_{ij}	0,276	0,188	0,200	0,116	0,175	0,044

As seen in Table 2, it is seen that all weight values of the criteria are between 0 and 1. In addition, the sum of these values is equal to 1.00. According to this result, it can be stated that the calculated weights are correct. According to the weights obtained, the "customs" (K1) criterion affects the logistics performance of the BRICS-T countries the most. It is the criterion of "international shipments" (K3) that affects logistics performance in the second place. Among the criteria, the one that has the least effect on the logistics performance of the countries is the "timing" (K6) criterion.

C. Innovation Performance Ranking of BRICS-T countries by TOPSIS Method

TOPSIS is one of the multi-criteria decision making methods that sorts the preference according to the similarity to the ideal solution. TOPSIS tries to rank the alternatives by calculating their distances from the ideal solution and the negative ideal solution, and simultaneously selects the optimum alternative that should have the closest distance to the ideal solution and the longest distance to the negative ideal solution (Demireli and Tükenmez, 2012: 7; Pangaribuan and Beniyanto, 2018: 2; Chen, 2021: 1).

TOPSIS method; It is used in many fields such as economy, management, accounting, finance, marketing, planning, production, health, transportation, education and engineering. The advantage of the method; each variable or alternative takes its own value, so that realistic results can be reached by making healthier and more reliable interpretations of the differences between alternatives and criteria. TOPSIS method consists of 6 steps. In the first step, decision matrices are created with the help of ratios, while the decision matrix is created, rows and columns express different concepts. While the rows show the decision points used to determine the advantages, the columns show the evaluation factors used to sort, make a selection and briefly make the final decision (Esmer & Bağcı, 2016: 27). In the decision matrix shown below, the m rows represent the alternatives and the n values in the columns represent the criteria (Tzeng & Huang, 2011).

First step: It consists of determining the objectives, defining the evaluation criteria and creating the decision matrix. Calculations are made using equation 6 and the decision matrix in Table 7 is created.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & a_{mn} \end{bmatrix} \quad (6)$$

TABLE III
 ESTABLISHMENT OF DECISION MATRIX FOR LPE CRITERIA OF BRICS-T COUNTRIES

Alternatives	K ₁	K ₂	K ₃	K ₄	K ₅	K ₆
Brazil	2,41	2,93	2,88	3,09	3,11	3,51
Russia	2,42	2,78	2,64	2,75	2,65	3,31
India	2,96	2,91	3,21	3,13	3,32	3,50
China	3,29	3,75	3,54	3,59	3,65	3,84
South Africa	3,17	3,19	3,51	3,19	3,41	3,74
Turkey	2,71	3,21	3,06	3,05	3,23	3,63
Criteria Weights	0,276	0,188	0,200	0,116	0,175	0,044

Table 3 shows the decision matrix formed from the data of the BRICS-T countries created for the 6 criteria in the LPE. On the bottom line of the table, there are the weight values of the six criteria calculated by the Entropy method.

Second step: The performance values in the decision matrix were obtained according to different criteria. Since it has different units or expresses different sizes, the decision matrix should be standardized before proceeding to the evaluation process. Formula 7 is used for the standardized operation of the decision matrix. Necessary calculations were made in Excel and the values indicated by r_{ij} were obtained. R standardized decision matrix consisting of standardized values was obtained as shown in equation 8.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^m a_{kj}^2}} \quad (7)$$

At the end of the calculations, the R_{ij} matrix consisting of r_{ij} elements is shown in the form of equation 8.

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \quad (8)$$

The normalized decision matrix, which consists of the values obtained as a result of the calculations made in the Excel environment with the formulas numbered 7 and 8, is shown in Table 4.

TABLE IV
 NORMALIZED DECISION MATRIX FOR INNOVATION PERFORMANCE

Alternatives	K ₁	K ₂	K ₃	K ₄	K ₅	K ₆
Brazil	0,3455	0,3804	0,3725	0,4014	0,3915	0,3989
Russia	0,3470	0,3609	0,3414	0,3572	0,3336	0,3761
India	0,4244	0,3778	0,4152	0,4065	0,4179	0,3977
China	0,4717	0,4869	0,4578	0,4663	0,4595	0,4364
South Africa	0,4545	0,4142	0,4540	0,4143	0,4293	0,4250
Turkey	0,3886	0,4168	0,3958	0,3962	0,4066	0,4125
Weights	0,276	0,188	0,200	0,116	0,175	0,044

After the decision matrix in Table 4 is created, the square of each value in the matrix is taken and the total values in the matrix consisting of the sum of these values are found. The normalized standard decision matrix is obtained by dividing the sum of the column with each value by the square root.

Third step: After the weight values of the six criteria to be used in the analysis are found by calculating with Entropy, the weighted standard decision matrix in Table 5 is obtained by multiplying the weights with each value in the matrix as shown in equation 9.

$$V_{ij} = \begin{bmatrix} w_1r_{11} & w_2r_{12} & w_n r_{1n} \\ w_1r_{21} & w_2r_{22} & w_n r_{2n} \\ \vdots & \vdots & \vdots \\ w_1r_{m1} & w_2r_{m2} & w_n r_{mn} \end{bmatrix} \quad (9)$$

TABLE V
 WEIGHTED STANDARD DECISION MATRIX FOR INNOVATION PERFORMANCE

Alternatives	K ₁	K ₂	K ₃	K ₄	K ₅	K ₆
Brazil	0,0954	0,0715	0,0745	0,0466	0,0685	0,0176
Russia	0,0958	0,0679	0,0683	0,0414	0,0584	0,0166
India	0,1171	0,0710	0,0830	0,0472	0,0731	0,0175
China	0,1302	0,0915	0,0916	0,0541	0,0804	0,0192
South Africa	0,1254	0,0779	0,0908	0,0481	0,0751	0,0187
Turkey	0,1072	0,0784	0,0792	0,0460	0,0712	0,0182

In Table 5, after the weighted standard decision matrix calculated for the 2018 logistics performances of the countries was created, each criterion value obtained as a second step was multiplied by the weight criterion ratio of the matrix and the results obtained are shown.

Fourth step: This is the stage where Ideal (A*) and Negative Ideal (A-) analyses are made. The ideal solution (A*) consists of the best performance values in the weighted normalized decision matrix, while the negative ideal solution (A-) consists of the worst values in the matrix. For ideal solutions, calculations are made using equations 10. In both equations (number 10), J represents the benefit (maximization), and J' represents the cost (minimization).

$$A^* = \{(\max v_{ij} | j \in J), (\min v_{ij} | j \in J')\}, \quad A^- = \{(\min v_{ij} | j \in J), (\max v_{ij} | j \in J')\} \quad (10)$$

TABLE VI
 OBTAINING IDEAL AND NEGATIVE IDEAL SOLUTION VALUES

Alternatives	K ₁	K ₂	K ₃	K ₄	K ₅	K ₆
Ideal Decision Point	0,1302	0,0915	0,0916	0,0541	0,0804	0,0192
Negative Dec. Point	0,0954	0,0679	0,0683	0,0414	0,0584	0,0166

As seen in Table 6, the ideal solution ranges, that is, the largest value in each criterion column, are taken from the values obtained in the previous step. For negative solution values, the results obtained by taking the smallest values in the solution are written.

Fifth step: While calculating the separation measures, the distance of the J alternative from the ideal solution, the ideal separation (S_i^{*}) and the distance from the negative ideal solution, the negative ideal separation (S_i⁻), values are calculated with the help of the formula 11 and shown in Table 7.

$$S_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2} \quad S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \quad (11)$$

TABLE VII
 DISTANCES OF COUNTRIES TO IDEAL AND NEGATIVE IDEAL POINTS

Countries	Ideal Distance	Negative Ideal Distance
Brazil	0,0458887	0,0134864
Russia	0,0542253	0,0003957
India	0,0277049	0,0308662
Chinese	0,0000000	0,0544774
South Africa	0,0165685	0,0428954
Turkey	0,0317428	0,0235666

In Table 7, while determining the distances to the ideal and negative ideal points, firstly, each value in the weighted decision matrix row is subtracted from its ideal and negative ideal values. In the second step, the extracted values were squared, and in the third step, all the rows were summed, the square root of the collected values were calculated and the results of the operation were shown in Table 11.

Sixth step: In this step, logistics performance scores (C) of BRICS-T countries are found by means of discrimination measures. These scores vary between 0 and 1. Equation 12 is used to calculate C scores.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \quad 0 \leq C_i^* \leq 1 \quad i = 1 \dots n \quad (12)$$

After the decision matrix was obtained, six-step formulas were applied for the TOPSIS method. As a result, the performance rankings of the BRICS-T countries according to the 2018 LPE are made and shown in Table 8.

TABLE VIII
 LOGISTICS PERFORMANCE TOPSIS RANKINGS AND SCORES OF BRICS-T COUNTRIES

Rank	Countries	Scores
1	Chinese	1,00
2	South Africa	0,72
3	India	0,53
4	Türkiye	0,43
5	Brazil	0,23
6	Russia	0,01

As a result of the study, the ranking of the BRICS-T countries according to their innovation performance was obtained by using the 2018 logistics performance index data.

In Table 9 below, alternative countries are ranked according to the weighted criteria, and then the advantages and weaknesses of the countries in the ranking according to the criteria are interpreted.

TABLE IX.
 RANKINGS ACCORDING TO WEIGHTED CRITERIA VALUES

Countries	Customs	Infrastructure	International transportation	Logistics Quality and Com.	Tracking and Monitoring	Timely Deliv. Ship.Buyer
Brazil	6	4	5	4	5	4
Russia	5	6	6	6	6	6
India	3	5	3	3	3	5
Chinese	1	1	1	1	1	1
South Africa	2	3	2	2	2	2
Türkiye	4	2	4	5	4	3
Criter Weight	1	3	2	5	4	6

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As seen in Table 9, China is in the best position in terms of all criteria, South Africa is in the second place in terms of 5 other criteria, except for the Infrastructure criterion (3rd place), and India is in the third place.

IV. CONCLUSION AND RECOMMENDATIONS

The success of logistics activities can be determined by the logistics performance of organizations and countries. In this context, in general, countries should be effective and efficient in logistics activities in order to ensure logistics performance. In addition, organizations and countries should differentiate among their competitors by providing different methods, strategies and practices from other competitors in the process of providing logistics activity (Fugate et al., 2010). Thanks to the measurement of logistics performance, countries can plan their logistics activities better, and accordingly, it is possible to know the deficiencies and advantages of their countries. In addition, countries can overcome their deficiencies in logistics and ensure that new methods, strategies and applications are more effective, more effective and efficient in their next logistics activities, thanks to the data they obtain from follow-up and analysis.

In this study, it is aimed to make an economic analysis of the sector by examining the situation of the logistics sector in Turkey and to reveal the global situation of Turkey's potential. For this purpose, the performance and position of the BRICS countries and Turkey have been comparatively examined based on the LPE data published at the international level by the World Bank, which shows the logistics performance of the countries.

According to the results obtained from the study; The "customs" criterion, which affects the logistics performance the most, belongs to the "timing" criterion with the lowest weight. Alternative countries were ranked according to the weighted criteria weights and according to this, China is in the best condition and first in all criteria. According to the criteria weights, Turkey is in the best position in the "infrastructure" criterion and in the weakest position in terms of the "logistics quality and competence" criteria. According to the evaluation to be made in terms of criteria weights, it will be the most appropriate strategy for Turkey to take some measures to eliminate the weakness in the "customs" criterion and strengthen it, in terms of increasing its logistics performance.

According to the TOPSIS ranking made using the 2018 logistics performance index data, China (1.00) is in the first place, followed by South Africa (0.72), India (0.53), Turkey (0.43), Brazil. (0.23) and Russia (0.01). According to this ranking, the logistics performances and criteria superiority-weakness aspects of the countries are evaluated and their interpretations are presented below.

Among the BIRICS-T countries, China achieved a high value and ranked first in the logistics performance ranking. Looking at the LPE data, it is seen that China has the highest scores in the "customs" and "international shipments" criteria, which have the highest weights.

South Africa took the second place in the overall ranking with a remarkable difference of points compared to other countries. When the LPE data are analysed, it is the weakest "infrastructure" criterion and ranks third in terms of this criterion. According to this result, the country's infrastructure improvement works are necessary and prioritized in terms of increasing its performance.

India is in the third place in the overall ranking, with a difference of almost 50% less than the first country in the ranking. Since this country is in a weaker position in two of the six criteria (infrastructure and timing), it would be appropriate to first improve the "infrastructure" criterion and then the "timing" criterion.

Turkey is in the fourth place in terms of logistics performance score, more than 50% apart from the first in the general ranking. In terms of criteria, it is in the second place in terms of infrastructure criteria and third in terms of timing criteria. It is worse (5th place) only in terms of logistics quality and competence. In order to increase the performance of this country according to the priority of criterion weights, it would be the right strategy to make improvements first in the "customs" and then in the "international shipments" criteria.

Brazil is in the fifth place overall. However, it is slightly better (4th place) in terms of "infrastructure", "logistics quality and competence" and "timing" criteria. It is in the worst situation among the 6 countries ranked in terms of the "Customs" criterion. In this case, it would be appropriate for the country to make improvements in the "customs" criterion, primarily in terms of criterion weights.

Russia underperforms by a large margin compared to the first and ranks sixth in the overall ranking. In terms of criteria, it is the worst among the six countries, except for the "customs" criterion. In order for this country to improve its logistics performance, it would be more appropriate to make improvements, starting with the criteria of "international shipments" and "infrastructure".

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Pharmacy Segmentation Based on RFM Model via Clustering Approach

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Abstract— A go-to-market (GTM) strategy is an action plan of an organization that clarifies how a company establishes a strategy to target customers and achieve a competitive advantage. GTM Strategy for all businesses aims to enhance customer experience via defining market, customer, distribution model, product positioning and price. Over-the-counter (OTC) products represent nonprescriptive products available for sale in pharmacies. For OTC products, the company has the right to make promotions, establish product stands in the pharmacies and do other marketing activities. In Turkey, pharmaceutical companies' prescription drugs are not allowed to make any of these activities. For that reason, representatives of pharmaceutical companies need to determine the target pharmacies for their companies' needs and strategies. In this study, the recency, frequency and monetary (RFM) approach, which is crucial for customer segmentation and clustering, is applied to clustering pharmacies. Clustering pharmacies are essential for establishing GTM strategy for its business partners according to their common features.

Keywords— Pharmaceutical Industry, Go-to-Market Strategy, RFM, Clustering, K-Means Clustering,

I. INTRODUCTION

The Turkish Pharmaceutical Industry, with more than 35 thousand employees, offers more than 11 thousand products to our country's growing and aging population and exports products to more than 160 countries. Approximately 500 organizations are operating in the Turkish pharmaceutical sector, 81 pharmaceuticals and 11 raw material production facilities [1]. Pharmacies serve as a potential sales network for pharmaceutical and FMCG firms. As in consumer markets, it is vital that businesses select the right product mix and set up the right pricing strategy. It is also crucial to understand customers' potential in both markets and invest money in developing long-term relationships. In addition to that, it is not only generating products and services for generating income for the pharmaceutical industry but also crucial for the effectiveness of the business strategy such as; segmentation strategy, targeting the right customer with relevant portfolio and information, efficient and sizeable sales forces, plus targeted market strategy and implementation of this strategy – that brings success across all these product categories to the pharmacy channel. According to Caldwell, Fitzgerald and Occhetta [2], there are five leading indicators of success in the pharmacy channel. These are; a description of the product portfolio and market analysis, segmentation and targeting, sales force sizing, establishing go-to-market strategy, and implementation of the segmentation and targeting strategy. This study's goal is to assist pharmaceutical firms' trade marketing, sales, or marketing departments in selecting the pharmacies that medical sales representatives should visit and creating promotional materials and presentations that consider these pharmacies' traits. Put another way, building a model for pharmaceutical corporations to choose which pharmacy to invest in increases the company's profit.

II. LITERATURE REVIEW

Customer segmentation is a significant commercial issue for marketing teams. To determine the best technique for this task, a number of different strategies have been investigated. The RFM method is one of the most popular segmentation techniques since it can be applied to many situations, especially those where the marketing team requires support. Direct marketers have successfully employed recency, frequency, and monetary values as segmentation criteria in marketing databases since the 1930s [3].

Direct advertisers have a measurable way to distinguish between the best and worse clients on paper, thanks to RFM-based segmentation. The best way to divide a consumer base based on past interests is by purchasing behavior. Based on the following characteristics, the RFM models evaluate and rank three properties for the customers; Recency: the amount of time that has passed since the last transaction, and the present moment. Higher recency values imply a higher likelihood of repeat business from customers.

Frequency: The total number of transactions made during a specific time frame. Higher frequency numbers imply more devoted customers. Each transaction's purchase amount is described by its monetary value. The corporation pays more attention to the more this customer's buy is worth [4].

RFM analysis is possible with classification techniques like cluster analysis. Cluster analysis is used to analyze the results of the RFM analysis so that the segmentation may be done in accordance with the consumers who earn similar scores in similar groupings—these techniques aid in accurately determining and applying RFM analysis results [5].

Instances belonging to the same category are identical, which indicates that each cluster is homogenous, and each cluster should differ from the others in some ways are the two main criteria that clustering methods utilize to group the instances identified into clusters [6].

K-means clustering is a sample-based technique for dividing an N-dimensional population into k-sets, according to MacQueen [7]. The approach typically provides partitions in the form of variance inside the class that are reasonably productive. Thanks to the K-Means algorithm's practical optimization and low processing cost, massive volumes can be studied on a computer.

The K-Means algorithm's benefits include ease of use, speedy results, and ease of understanding of the clustering findings. The initial values of the cluster centers are likely to be selected improperly, and the number of clusters is predetermined from the start. Extreme value data also contribute to the incorrect locations of this cluster, which is another issue. A metric that can assess if clusters are generated appropriately is required to determine the ideal number of clusters. However, since natural clusters are desired to be drawn, there are no precise reference data due to the nature of the issue [8].

III. PROPOSED METHODOLOGY

Two datasets used in this study are taken from the company. One is data used for reconciliation, which contains accounting records that have been mutually confirmed between the corporation and the pharmaceutical warehouse. This guarantees that the payment is made in accordance with the data that was agreed upon between the two parties' obligations and receivables. Reconciliation data includes the business product invoices that drug distribution centers sold to pharmacies in 2018. It includes data like invoice date, total sales, etc., essential for building an RFM model. The second set of information reveals how frequently a certain drugstore was visited throughout 2018. The organization uses certain IT systems to maintain this data. The descriptions of these two datasets are shown in Table 1 and Table 2.

TABLE XVII
 RECONCILIATION DATA DESCRIPTIONS

Metrics	Description
Depo Name	Indicates which pharmacy warehouse the pharmacy bought products from
Pharmacy ID	Indicates a unique identity number that has been created for each pharmacy in Turkey
Pharmacy City	Indicates in which city pharmacy is located
Pharmacy State	Indicates in which state of city pharmacy located
Invoice Number	Shows unique invoice number for each trade between pharmacy and pharmacy warehouse
Invoice Date	Invoice Date: shows the date of purchase for trades between pharmacy and pharmacy warehouse
Brand Name	Indicates which brand the product sold belongs to
Product Name	Name of product which belongs to one of the three brands
Unit Sold	Indicates how many products are sold without a campaign
Free Good	Shows how many units of product sold free of charge
Total Unit	Indicates the sum of units sold and free goods.
List Price	Indicates the price of the product issued by the manufacturer
Total Sales	Indicates list price multiplied by total unit, gross sales

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TABLE II
 VISIT DATA DESCRIPTIONS

Metrics	Description
Date of Visit	Shows at which date sales representative visited a pharmacy
Pharmacy ID	Indicates a unique identity number that has been created for each pharmacy in Turkey
Total Visit	Indicates how many times the pharmacy is visited by sales representatives of the company during 2018.

It is required to clean the data before implementing the model. When the data was first obtained, it included 26.850 distinct pharmacy total sales records for the three brands of the pharmaceutical company, with average sales of 8400 TL, maximum sales of 1.017.466 TL, and minimum sales of -23.918 TL (data consists of the return of products as negative sales). Data rows that were unnecessary and lacking were first eliminated. Following this operation, there are 25.062 distinct pharmacies in the data, with average sales of 4.550 TL, a maximum of 270.459 TL, and a minimum of 7 TL. 69,4% of all business revenues are generated by 21% of pharmacies. These pharmacies are the focus of the visit data company's current efforts, but the frequency and recency numbers will undoubtedly have an impact on how we categorize these pharmacies in our model to develop more successful business plans.

The company's product portfolio's characteristics should be considered before beginning to design the RFMV model. Products that are comparable in terms of price and inventory turnover are those that are included in this study. The pricing of the products is crucial for the monetary worth, even though the stock turnover rate is essential for the frequency and recentness of product purchases. To properly develop the model analysis, these two requirements must be taken into account. No additional analysis was done because the three preferred brands in this survey have similar stock turnover and average product pricing. The RFMV model can be created for each product group (items/brands with similar stock turnover rates and prices), and segmentation outputs can be interpreted and analyzed in accordance with this if it is not the case in other research. Using the weighted RFM model, weights can also be determined based on the values that converge for each product group.

The sales data was gathered in a single column by multiplying each product's sales records with equal weight for each pharmacy in this study to calculate the financial value of the three goods that the company actively promotes through its sales representatives. Based on Khajvand et al. [9], the dataset is transformed by converting the sum of pharmacy expenditures into a monetary value (M) by dividing the sum by the number of invoice dates. Following the conversion of the total number of purchases made by each pharmacy into a frequency (F) value, the last transaction date for each pharmacy was identified, extracted from December 31, 2017, and divided by 7 to produce a recency (R) value that ranks between 1 and 53, from worst to best, respectively.

Table III shows the initial version of the data and the transformed version of the data as R, F, M, and V values.

TABLE III
 TRANSFORMATION OF DATA INTO R, F, M, V VALUES

Initial Data					Transformed Data			
Pharmacy ID	Total Sales	Last Purchase Date	Count of Invoice Date	Visit	M	R	F	V
1	935	24.04.2018	1	1	935	17,14	1	1
2	168	4.12.2018	7	1	24	49,14	7	1
3	86	11.05.2018	1	1	86	19,57	1	1
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25060	544	25.05.2018	1	1	544	21,57	1	1
25061	7397	21.11.2018	14	1	528	47,20	14	1
25062	1139	17.12.2018	30	1	38	51,00	30	1

Table IV also shows us the descriptive statistics of R, F, M, and V values.

Normalization is another crucial step for machine learning, and the min-max method is used in the methodology section. According to Jayalakshimi [10], "This approach rescales the features or outputs from one range of values to a new range of values". The characteristics are typically rescaled to fall between the values of 0 and 1 or between -1 and 1 [10]. A value is produced by min-max normalization by solving the equation. The equation is shown in Equation 1.

$$(x)^l = (x_{max} - x_{min}) \times \frac{x_i - x_{min}}{x_{max} - x_{min}} + x_{min} \quad (1)$$

TABLE IV
 DESCRIPTIVE STATISTICS OF R, F, M, V

	R	F	M	V
Mean	45	13	584	10
Standard Deviation	10	13	1392	11
Sample Variance	105	173	1936372	115
Minimum	1	1	7	1
Maximum	53	202	27046	61
Count	25062	25062	25062	25062

Linear transformation of original data is applied where X_i is the original value of an attribute, i and X_i is normalized value. X_{min} and X_{max} minimum and maximum values of attribute. To rescale values from 1 to 10 formula in Equation 2 is used where b stands for 10 and a for 1.

$$(x)^l = a + \frac{(x - \min(x))(b - a)}{\max(x) - \min(x)} \quad (2)$$

Finally, all R, F, M and V values are settled for each pharmacy. Table V shows normalized descriptive statistics for each value.

TABLE V
 NORMALIZED DESCRIPTIVE STATISTICS OF R, F, M, V

	R	F	M	V
Mean	8,67	1,52	1,19	2,3
Standard Deviation	1,78	0,59	0,46	1,6
Sample Variance	3,15	0,35	0,21	2,6
Minimum	1	1	1	1
Maximum	10	10	10	10
Count	25062	25062	25062	25062

The marketing division's goal in conducting this research is to group clients who are interested in the same benefits from a product together. Businesses employ K-Means clustering in various ways to group customers, documents, professional players, etc. To maximize the sales force's performance, it is intended to cluster pharmacies that exhibit similar purchasing patterns into similar sales strategies.

Unsupervised learning (unattended learning) and clustering are both done using the K-Means technique [11]. The primary justifications for using unsupervised learning in this study are that it uncovers a variety of previously undiscovered patterns in the data, identifies traits that can be used for categorization, and makes it simpler to obtain unlabelled data from the computer than tagged data that needs manual intervention.

Using R, F, M, and V variables, K-Means clustering is intended to be performed. According to Khajvan et al. [9], multiple values ranging from 4 to 10 were explored to identify the number k. For k=8, the ideal solution is assessed. Before this study, the company's GTM model primarily used four segments and actively covered 6,000 pharmacies. This means that the organization will be able to implement its marketing strategy to 25.000 customers with just eight segments. The following step is choosing centroids. Even if choosing a centroid randomly from the data is correct, a good clustering performance can be achieved by running the clustering algorithm numerous times and choosing values measured by the shortest average distance between centroids using the sum of [12].

The final phase involves analyzing each segment by taking into account R, F, M, and V values to decide on an effective sales plan. The frequency for the first segment, which consists of 178 pharmacies, is 1,11, which is lower than the average frequency for all segments. Given that they don't have the practice of shopping frequently, this could mean that those 178 pharmacies are ordering bulk volumes. Money value and its mean differ significantly, and I mean that in a good way. The reason why the monetary value is so much higher than its mean is that 178 pharmacies account for 5% of the company's total sales.

A higher visitation value might signify that the company's sales personnel have solid customer loyalty. Investments should be made in the pharmacies in Segment 1 to maintain positive relationships and safeguard the company's interests. These pharmacies are essential and valuable to the company and should be among the most often frequented pharmacies. Based on the differences between the mean (MD) values for the R, F, M, and V indicators, all the K-Means clustering findings are compiled in Table VI.

TABLE VI
K-MEANS CLUSTERING ALGORITHM RESULTS

Segments/ Variables	1	2	3	4	5	6	7	8	Average
Mean R	6,74	9,20	6,29	9,33	9,64	7,98	5,35	2,23	8,67
Mean F	1,11	1,64	1,16	1,67	1,66	1,22	1,13	1,05	1,52
Mean M	4,54	1,54	1,55	1,21	1,07	1,14	1,17	1,33	1,19
Mean V	3,90	6,30	4,83	3,73	1,35	1,45	1,61	1,81	2,30
Cluster Size	178	1481	938	4840	11276	4372	1093	884	3133
Total Spend K (TL)	6244	27521	6748	33398	26932	9756	1850	1310	14254

IV. CONCLUSION

Pharmacies must be properly segmented since doing so allows pharmaceutical companies to better understand their target market by putting together pharmacies with comparable needs, preferences, and habits. By gathering the GTM model and pharmacy sales data for the pharmaceutical sector and transforming them into thorough analyses, this thesis intends to shed light on customer segmentation for businesses in the pharmaceutical industry. Companies should consider the best market coverage approach based on their resources, the service provided, and the market's diversity [13].

It is up to the corporation to choose the pharmacies they will best support because it is practically challenging to satisfy every customer. As a result, companies might identify profitable pharmacy sectors and create marketing plans and business strategies specifically for those pharmacies. This study advises using the RFM model with K-Means clustering to divide pharmacies.

This study responds to inquiries about key pharmacy segmentation issues. What clustering algorithm ought to be chosen? How many segments need to be taken into account, and which strategies should be targeted at each section based on business advantages? A marketing manager can create a successful plan for each area thanks to this study. It defines ways to draw people in and explains how organizations can choose the most lucrative segments using the RFM model with K-Means clustering.

By incorporating the V value into the RFM model, this study attempted to make the model acceptable for usage by businesses in the pharmaceutical industry. The V value was added to more accurately examine the sales agents' one-year interactions with the pharmacy. This number is crucial for closing down

ineffective pharmacies that have been visited for a year but have not generated revenue for the business. After applying the models, eight distinct segments were identified, and marketing strategies were selected for each section.

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Set Covering Approach to the Selection of Cargo Delivery Point: Real Case Study

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Abstract— Urban package delivery has become a bottleneck with the growth of E-commerce volume in the pandemic. Cargo delivery firms have sought solutions so that they can reduce their logistics costs and compete in market conditions. One of the practices that started especially in metropolises in Turkey and could arise in smaller settlements, later on, is the assigning of delivery points to the neighborhoods. The main issue related to the selection of hub points is to allocate hubs to regions that have intense cargo demand. This article aims to develop a new perspective on the set covering problems by focusing on the selection of Cargo hub points. We introduced a different solution to the classic set covering model by adding the demand constraint which ensures assignment to the regions where demand is high. The demand-weighted assignments provide the assignment to a location close to the intense demand locations to optimize the undeliverable cargo percentage and logistic costs. The effectiveness of the developed model is illustrated with a case study with data taken from the Istanbul region of a cargo company. The mathematical model was solved with the help of Lingo 17.0 software and the results were evaluated. The numerical results showed that 19 delivery points were assigned to minimize the cargo operations of 980 neighborhoods in the Istanbul region and a 19.18% improvement was achieved compared to the current situation.

Keywords— Last Mile Logistic, Assignment model, Optimization, Cargo industry, Cargo Hub Location.

I. INTRODUCTION

In recent years, the demand for online shopping has increased gradually with the growth of e-commerce development, innovation, and the effect of social media on customer behavior. The trend toward e-commerce channels has affected package distribution companies' operations in urban areas considerably [1]. Especially, with pan-demic urban package delivery has become a bottleneck with the growth of E-commerce volume. Therefore, last-mile delivery, which accounts for 13 to 75% of the total supply chain costs, has also become a notable concept in recent years. Last mile logistics covers the last part of the supply chain operation from the final distribution center to the buyer's requested destination. Last mile distribution operation is very important from many aspects which are distribution system reliability, non-delivery cost of cargo, package size, traffic congestion as well as the cost and time of delivery [2]. Only with the right location can ensure the reliability and efficiency of the entire supply chain, as the issue of cargo distribution requires it to consider economic factors, the availability of infrastructure and the stochastic nature of traffic. Therefore, one of the important methods that positively affect the transportation costs and distribution process in the city is hub and spoke networks [3]. Hubs are transshipment points that ensure that each flow is routed to its desired destination and it is used in many areas such as cargo, airline and telecom industries [4]. Hub locations can be determined according to problem parameters such as demand, unit transportation cost, discount factor between hubs and allocation strategy [5].

This study aims to contribute to solving the cargo hub allocation problem in two aspects. First, this study constructs a mathematical model for the cargo agency assigning problem, which simultaneously considers the demand intensity and transportation efficiency. Second, a real-world case study was conducted to examine the trade-offs between the objectives of demand and transportation efficiency and validate the effectiveness of the proposed approach.

The rest sections of this paper are constructed as follows. In Section 2, previous research on related studies is reviewed. The methodology framework and the mathematical model are constructed in Section 3. Computational results obtained from the model are discussed and the performance analyses are made to compare the results with the current situation in Section 4. Finally, conclusion remarks and future research suggestions are presented in the last section.

II. LITERATURE REVIEW

With the increase in e-commerce volume, customers' expectations from cargo companies have begun to change towards faster and safer cargo distribution. For this reason, time has become one of the most important sources of concern in this sector and to increase customer satisfaction competition has begun [6]. Academics and experts working on this subject have contributed many important studies to the literature on the optimization of cargo distribution activities. There were present many studies such as route optimization which aim to reduce the logistic cost and to use resources more efficiently [7-10], cargo allocation optimization to optimize the storage process of cargo and to increase the efficiency of shelf stability [11-12], cargo stowage to ensure the maximum utilization of the weight and volume capacity of the cargo and truck etc [13]. Besides these studies, hub location problems (HLP's) also has become the most basic elements of strategic planning for cargo companies in the optimization process of cargo operations [14]. First, O'Kelly defined hub location problems in 1986 and addressed two types of allocation methods of hub to spokes network which is single and multiple. In addition, the formulated objective function for one hub was demonstrated to be equivalent to Weber's least-cost location model [15]. Shang et al. presented a mixed integer model which has two separate objectives that will minimize the maximum delivery time and the costs by taking into account multiple transportation modes and different types of hubs [16]. Research by Hu and Huang proposed a hybrid integer programming model for two hub-and-spoke networks and solve it with a genetic algorithm [17]. Pašagić et al. has shown that the most successful method in solving the capacitated single allocation hub location problem is genetic algorithms, which can be applied both for statistical and dynamic models [18]. Alumur and Kara has formulated a single allocation hub and spoke network model that serves within a time-bound [6]. Research by Aktal and Ozger represented a model which is modified Ebery et al.'s (2000) multiple allocation version of the capacitated hub location problem and offers a solution for establishing air cargo hub and spoke networks with mixed-integer linear programming [19]. Research by Danchuk et al. developed a method based on the optimal planning method of radiation therapy for malignant tumors, which determines the optimal number and location of depots, taking into account their capacity and distance to consumers [20]. It has been noticed that the hub location problem studies in the literature are mostly aimed at minimizing the total costs, but time is also a substantial factor as well as total cost and there is a gap in the studies which aimed at positioning the centers closer to the demand locations. Therefore, this study presents a set covering problem that aims to find the number of cargo hub points and hub locations by focusing on intense cargo demand.

III. METHODOLOGY

A. Methodological Framework and Case Study Background

This study includes a case study and solution that can be an example for many cargo and distribution companies. The company, which is the subject of the case study, distributes newspapers and magazines to all neighborhoods in the Istanbul region in Turkey. The company has 19 distribution centers in different regions of Istanbul and is responsible for the newspaper and magazine distribution logistics of 980 neighborhoods.

A methodological framework was presented in Figure 1 for the cargo hub location problem. In the first stage, the problem definition was made and the cargo literature was reviewed. Then, the demand and location data of the neighborhoods were obtained from the company database which covers the period from January 2022 to March 2022. Finally, mathematical model was created and the mathematical model was solved with the help of Lingo 17.0 software the results were evaluated and performance analysis was made by comparing the results with the current situation.

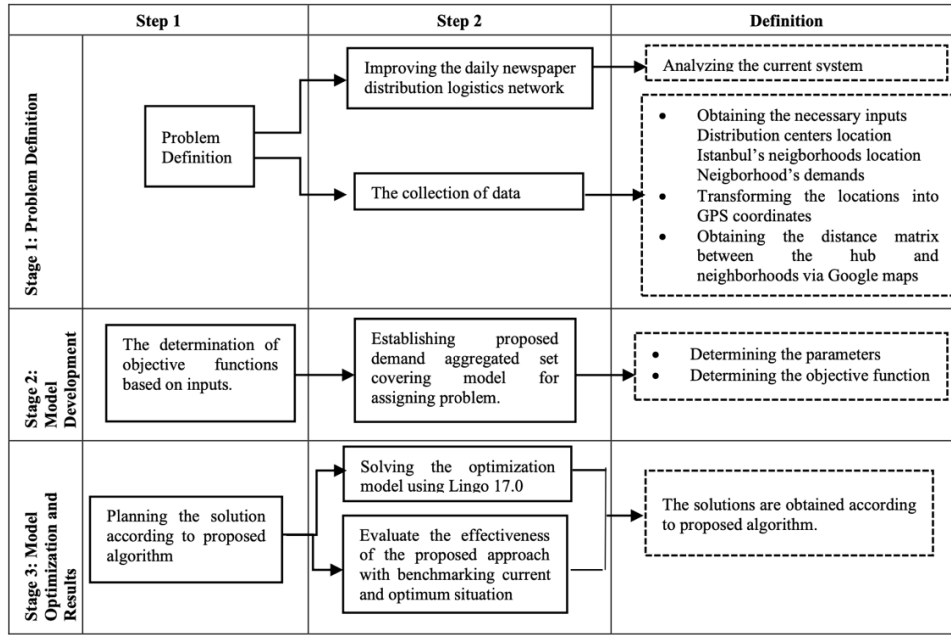


FIGURE 1
 A METHODOLOGICAL FRAMEWORK FOR THE DISTRIBUTION CENTER ALLOCATION PROBLEM

B. Mathematical Model

In this section, we present a mathematical model for detailing the hub points of a cargo company that will cover all neighborhoods in the metropolis. Our aim is to find the location of appropriate hub nodes near the intense cargo demand neighborhoods and allocate the demand nodes to the located hub nodes. The parameter X_{ij} represents a cost (traveling distance in this problem) between demand node $i \in I$ and hub node $j \in J$. The parameters D_i , UB and LB are the demand of the neighbourhoods, maximum and minimum capacity of the hub node respectively. The binary variable Y_{ij} present the status of if demand node i is allocated to hub node j ; it takes the value of 1 otherwise, it takes the value of 0. The parameters of the mathematical model are as follows:

Inputs and Sets:

- I = set of demand nodes $i: 1 \dots 1082 / i \in I$
- J = set of candidate hub nodes $j: 1 \dots 20 / j \in J$
- D_i : Demand of node $i \in I$
- UB_j : Maximum capacity of hub node $j \in J$
- LB_j : Minimum capacity of hub node $j \in J$
- X_{ij} = Distance between demand node $i \in I$ and candidate hub node $j \in J$
- $Y_{ij} = \begin{cases} 1 & \text{if demand node } i \in I \text{ is allocated to hub node } j \in J \\ 0 & \text{otherwise} \end{cases}$

$$\text{Min } Z = \sum_{i,j} X_{ij} * Y_{ij} * D_i \tag{1}$$

$$\sum_{i=1}^I Y_{ij} = 1 \quad \forall j \in J \tag{2}$$

$$\sum_{j=1}^J Y_{ij} * D_i \leq UB_j \quad \forall i \in I \quad (3)$$

$$\sum_{j=1}^J Y_{ij} * D_i \geq LB_j \quad \forall i \in I \quad (4)$$

$$X_{ij} > 0 \quad \forall i \in I \quad \forall j \in J \quad (5)$$

$$Y_{ij} \in \{0,1\} \quad \forall i \in I \quad \forall j \in J \quad (6)$$

Equation 1 represents the objection function of the problem which is minimizing aggregate demand times distance and ensuring the hub has been established at the location where has intense demand. Constraint 2 ensure that each neighborhood is assigned to a cargo agency. Constraint 3 ensure that the total demands in the neighborhoods assigned to the cargo agency are less than the maximum capacity. Finally, constraint 4 ensure that the total demands in the neighborhoods assigned to the cargo agency are higher than the minimum capacity.

IV. COMPUTATIONAL RESULTS

The case study is solved by using the Lingo 17.0 software with the proposed demand-weighted set covering mathematical model by adapting the basic set covering model. All neighborhoods have been assigned to a distribution center and the results are given in Table 1. According to the objective functions of the optimum results and current situation, 19.18% improvement was achieved.

TABLE XVIII
OPTIMIZATION RESULTS

Distribution Center	Current Situation		Optimum Situation		Improvement
	Number of Districts	Current demand * distance	Number of Districts	Optimum demand*distance	
DC1	20	67227.11	12	28262.68	57.96%
DC2	30	63722.88	21	56341.72	11.58%
DC3	21	51306.03	51	84818.25	-65.32%
DC4	56	106702.57	43	78231.59	26.68%
DC5	23	33814.86	30	48495.18	-43.41%
DC6	38	47994.15	60	70982.07	-47.90%
DC7	59	62512.13	56	50151.67	19.77%
DC8	57	32605.55	48	44900.40	-37.71%
DC9	55	68601.49	37	30905.00	54.95%
DC10	110	134102.55	98	69073.70	48.49%
DC11	37	113158.32	27	105302.15	6.94%
DC12	13	16642.37	21	32274.42	-93.93%
DC13	21	77037.29	31	60702.06	21.20%
DC14	87	65618.09	113	84116.61	-28.19%
DC15	40	94705.59	53	98048.67	-3.53%
DC16	51	113837.94	53	98048.67	13.87%
DC17	132	269623.49	101	142471.99	47.16%
DC18	89	153553.88	72	83972.22	45.31%
DC19	41	78347.27	51	67468.09	13.89%
Total	980	1650113.56	980	1333703.94	19.18%

In Figure 1, the neighborhoods where the cargo hub center is different from the current situation in the optimum situation are depicted on the map of Istanbul's neighborhoods. The orange colored areas show the regions where the distribution center has changed and the black colored areas remain the same. As a result of the optimization, it has been noted that the 308 neighborhood's distribution centers have changed.

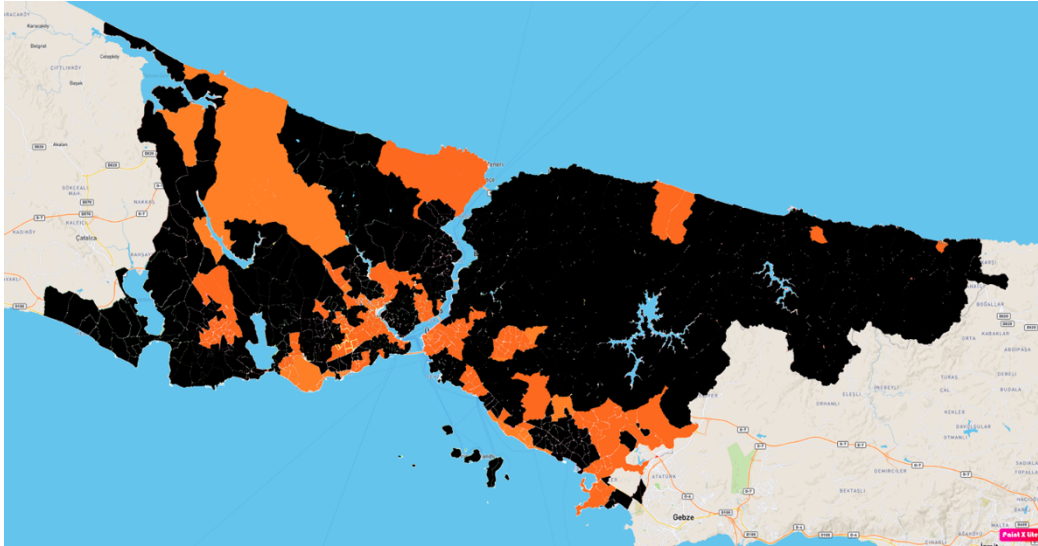


FIGURE 1
DISPLAY OF NEIGHBORHOODS ON THE MAP WHOSE DISTRIBUTION CENTER HAS CHANGED AS A RESULT OF OPTIMIZATION

V. CONCLUSIONS

Last-mile delivery has strategic importance, especially in urban areas. In order to reduce logistics costs, save time, reduce the amount of undelivered cargo and compete in market conditions, cargo companies need to choose distribution centers and assign regions to centers wisely. Based on this problem, this paper presents a real-world case study for the cargo distribution center assigning and a different solution approach to this problem. As a result of the optimization with the proposed demand-weighted model, it was ensured that all neighborhoods where the distributor company is responsible for distribution in the Istanbul region were assigned to the most suitable distribution centers, and it was found that there was a 19.18% improvement in the optimum demand*distance compared to the current situation. This study might help logistic companies in optimizing the allocation of distribution centers to regions, and with this knowledge, organizations can take appropriate steps to minimize costs. In future studies, different notations can be added by developing the model and its solution with metaheuristic methods may contribute to the literature.

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Shelf Space Allocation and Layout Optimization in Retail Management

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Abstract— Shelf space in retail management is both expensive and one of the most limited resources. For this reason, the effective use of shelf space management results in high profits for the retailer, while it also combines with the satisfaction of the store customers. The main questions of this problem are the decisions of how much shelf space will be allocated to which product and on which shelves the products will be placed. In addition to existing traditional studies, there are many optimization models, metaheuristics, and heuristic approaches for this problem in the literature. Different models have been developed by considering many factors such as stochastic or deterministic demand, cross-elasticity and space-elasticity, consumer behaviour, and substitution effect. This article examines existing problems and solutions for shelf space allocation and layout optimization. First, the problems under the shelf space allocation title and their solutions are mentioned, then the store layout problem and its solutions are discussed. A brand new mathematical optimization model will be developed according to the inferences obtained from these studies and this developed model will be implemented for a pilot store. While this designed model aims to gain and maintain the loyalty of customers for a company, it will also respond to the retailer's desire to increase its profit, which is its objective function.

Keywords— retail management, shelf space allocation, layout optimization, market basket analysis, NP-Hard problem, cross selling effect, Gross Margin Return on Footage (GMROF), customer flow

I. INTRODUCTION

Shelf space is one of the most expensive and scarce resources in the retail industry [1]. It is mentioned in the researches made from the past to the present that the space allocation is not used effectively, the dysfunction of the existing software tools, the factors such as customer requests, seasonality, cross-selling possibilities are not taken into account in the location decisions of the product and product categories. Besides, planograms are software tools that provide detailed graphical instructions to store employees. However, changes can be made in planograms according to the needs of the employees [2]. Shelf space allocation and layout optimization are very important in the retail industry. The shelf location decision of the products and product categories to be exhibited in the store, the shelf location where the products are displayed have a significant impact on product sales. Space allocation in retail stores should be prepared in a way that will increase customer satisfaction and profitability [3].

First of all, retail management is examined under two main headings as shelf space allocation and layout optimization in this study. Detailed analysis and classification of the studies in the relevant literature were carried out. The studies, models, algorithms and approaches were examined and scanned in chronological order. Then, by determining the deficiencies of the existing literature studies, a mathematical model will be developed that will provide shelf space allocation and layout optimization in retail management, and with this model, significant sales losses will be prevented and customer loyalty will be ensured.

II. LITERATURE REVIEW

The place of shelf space allocation is important in retail management. Most of the various studies applied involve models and algorithms focused on maximizing the retailer's profits. In the approaches of the studies,

many variables such as customer traffic, number of facings, space elasticity and substitution effects are examined. Irion, Al-Khayyal, Lu and Tsao [4] extended Corstjens and Doyle's model to examine the shelf space allocation problem at the product level. In this expanded shelf space allocation optimization model, in-store core costs are included, while space and cross-elasticities are also taken part in it. Tsai and Huang [5] mentioned a three-stage data mining approach for the shelf space allocation problem. In this approach, they have taken into account customer purchasing and moving behaviours. In the first step, they collected the purchasing behaviour of customers from records of previous transactions and their moving behaviour via RFID. In the second step, they tried to identify the frequently sold products by applying the Apriori algorithm. In the last step, they dealt with the location preference matrix to assign the small products to the most suitable shelf. As a result, cross-selling opportunities could increase for both large and small products. Hübner, Düsterhöft, and Ostermeier [6] argue that shelf segment sizing and product allocation are interrelated. For example, if the allocated products are small in size, the height of the segment may decrease because the products cannot be stacked. They propose an integrated approach to shelf segment sizing and product allocation with the Binary Integer Program (BIP) formulation. Evaluating this approach through a case study they applied, they achieved a 7% increase in the retailer's profit margin.

Layout optimization is another important in retail management. In the approaches, integrated models and algorithms have been developed by considering customer preferences and transaction data in general. Fernie, Sparks, and McKinnon [7] emphasized that out of stock (OOS) situations and poor on shelf availability (OSA) cause customer dissatisfaction and, as a result, loss of market share. Yapicioglu and Smith [8] defined the layout problem in the retail sector as reaching a result within a limited space in order to optimize performance criteria such as minimizing the total traffic cost between departments and maximizing the adjacencies between departments. Cil [9] proposed an integrated structure in the study, for the store layout problem through association rule mining and multidimensional scaling. By using association rules mining and the Apriori algorithm, market basket analysis was performed to extract the information to be used in store layout design. Elberts [10] suggested that customers should be able to see the maximum possible number of aisles during their time in the store, and layout optimization should be provided in this direction. Ghoniem, Flamand, and Haouari [11] emphasized that in their case analysis, an attempt is made to assign the item set to the backpacks, determine the segment assignments, and determine the total allocated space within the lower/upper limits. A very large scale neighbourhood search (VLNS) is developed, which reduces the computational difficulty by using the mixed integer formulation. It is mentioned that the developed VLNS algorithm can be monitored step by step with the help of mixed-integer programming (MIP) formulation. In their research, Guthrie, and Parikh [12] aim to analyze how the customer interacts with the shelves during their time in the store, to determine the hot-warm-cold spots and to allocate the products to the best location.

III. METHODOLOGY

Irion, Al-Khayyal, Lu and Tsao is extended version of Corstjens and Doyle's model could be described in a detailed manner in terms of extension its with the piecewise linearization technique. This model, which is based on the model developed by Corstjens and Doyle, considers in-store base costs while also regarding space and cross-elasticities. This model is a combination of NLP and MIP and is called MNLP [4].

The basic linearization process is applied for the nonlinear terms in the objective functions and constraints, and as a result, it is turned into the MIP problem.

$$\Omega = \sum_{i=1}^N \left[\alpha_i F_i^{\beta_i} \prod_{\substack{j=1 \\ j \neq i}}^N F_j^{\delta_j} \left((P_i - C_i - CP_i)t_i - \left(\frac{CR_i}{G_i} \right) o_i \right) - \left(\frac{C_i I G_i}{2} \right) w_i - CF_i z_i \right] \quad (1)$$

Data mining tools help organizations make proactive information-driven decisions by predicting future trends and behaviour. Automated forward-looking analysis yields far better results than analyzes of past events provided by retrospective tools [13]. By applying the association rules algorithm, the data is analyzed and synchronous relationships are found between the data, this relationship helps the retailer in decision making [14]. Market basket analysis (MBA) is involves analyzing large data sets, such as purchase history, to reveal product lines and products likely to be purchased together. It enables customer behaviour to be

characterized by concrete data. The association rules technique is based on the Apriori algorithm, which also makes use of the data mining technique. “Subsets of frequent item sets, frequent item sets; The principle that “supersets of sparse item sets represent sparse item sets” is the basic theory of this algorithm [15]. This algorithm is used to find all common item sets.

The formulations of how the algorithm works can be explained as follows;

```

L1 = {frequent items};
for (k= 2; Lk-1 !=∅; k++) do begin
Ck = candidates generated from Lk-1 for each transaction t in the database do
The count that is enclosed in t of all candidates in Ck is to be incremented
Lk = candidates in Ck with min_sup
end
return UkLk;
    
```

IV. APPLICATION

The purpose of developing the model is to try to maximize profits by using and measuring the retailer's specific KPIs. The data set was arranged by simulating the category-based turnover values, how the store area is distributed into categories, and how the categories are positioned in the current store layout, by simulating the information obtained as insight, with proportional data. The company transmitted the transaction data of the store which is covering thirty-one days. The data contains 35 unique items. The product set of the store has been examined in 6 main categories and these are Woman, Man, Baby Girl, Girl, Baby Boy, Boy. There are column names with two which are Transaction ID and Items and each line represents a transaction. Data comprises of 8089 observations, that is, the number of rows is 8089. Different KPI calculations were made using the variables in the data set. Gross Margin Return on Inventory Investment (GMROI) and Gross Margin Return on Footage (GMROF), Week of Supply (WOS), Mark up, Department Capacity LCM, Annual Turnover Return values which are among the most important performance indicators used especially in retailing, were calculated in terms of TL unit.

The purpose of calculating the total flow distance of the existing settlement is to determine the movement of customers between departments. By developing an alternative layout plan, it is desired to minimize the customer flow distance between departments according to the layout, to increase the time the customer spends in the store, and to ensure that more products are seen by the customer. It is multiplied the Manhattan distance and customer flow values between main-categories to obtain the total flow distance value calculated as 19227.382, and it is reached the current total flow-distance value with following Manhattan distance formula.

$$\begin{aligned}
 d(x, y) &= \sum_{i=1}^n |x_i - y_i| \tag{2}
 \end{aligned}$$

In this context, the basket analyzes of the buyers shopping at the store in the mall were made and the relations between different products and the habits of the customers were examined. In this analysis, the R software language was used and Apriori algorithm is applied. As a result of the discovery of these relationships, it is aimed to enable retailers to develop a strategy in their business by considering the products that customers buy frequently and together, and to provide helping retailers boost business by analyzing the products that customers buy together. Strategies that could be enhanced are changing the store layout according to trends, customer behaviour analysis, cross-marketing in stores, etc. Individual items that are frequently seen in the database, namely fashion items, can be determined with the Apriori algorithm, and these determined item sets that appear frequently enough continue to be expanded to larger item sets thanks to this algorithm. Before starting to implement the Apriori algorithm, it is necessary to determine the rules. These rules are the cornerstone of the algorithm and pass through determining the minimum support and minimum confidence parameters [16]. In this application, which it has been done as a preliminary preparation for this optimization model, the minimum support value is taken as 0.02 and the minimum confidence value is taken as 0.1. In this application, where it is restricted the minimum length to 2, the Apriori algorithm was run with all these parameters. There are total of 68 rules and most of the rules are 2 items long. As a result of the applied algorithm, some sample outputs from 68 rules were sorted by lift (Figure 1). The lift parameter also represents the relationship between the products. For values where the lift is higher than 1, it can be said that these products are more likely to be purchased together.

Ihs	Relationship Between Items	rhs	Support	Confidence	Coverage	Lift
{BOYFIVETHIRTEENAGE}	=>	{WOMANCASUAL}	0.02447466	0.4008097	0.06106304	2,7714108
{WOMANCASUAL}	=>	{BOYFIVETHIRTEENAGE}	0.02447466	0.1692308	0.14462299	2,7714108
{MANVISION}	=>	{WOMANCONVENTIONAL}	0.02682324	0.4419552	0.06069221	2,6328553
{WOMANCONVENTIONAL}	=>	{MANVISION}	0.02682324	0.1597938	0.16786156	2,6328553
{WOMANCLASSIC, WOMANMODEST}	=>	{WOMANDENIM}	0.02360939	0.4961039	0.04758962	2,3132453
{WOMANCLASSIC}	=>	{WOMANDENIM}	0.06674907	0.4812834	0.13868974	2,2441400
{WOMANDENIM}	=>	{WOMANCLASSIC}	0.06674907	0.3112392	0.21446230	2,2441400
{WOMANVISION}	=>	{WOMANMODEST}	0.03053152	0.4574074	0.06674907	2,1352717
{WOMANMODEST}	=>	{WOMANVISION}	0.03053152	0.1425274	0.21421508	2,1352717
{WOMANDENIM, WOMANMODEST}	=>	{WOMANCLASSIC}	0.02360939	0.2756133	0.08566131	1,9872651
{MANCLASSIC, WOMANCONVENTIONAL}	=>	{MANDENIM}	0.02088999	0.5232198	0.03992583	1,9669369
{MANDENIM}	=>	{MANCLASSIC}	0.07292954	0.2741636	0.26600742	1,8860402
{MANCLASSIC}	=>	{MANDENIM}	0.07292954	0.5017007	0.14536465	1,8860402
{WOMANDENIM}	=>	{WOMANMODEST}	0.08566131	0.3994236	0.21446230	1,8645916
{WOMANMODEST}	=>	{WOMANDENIM}	0.08566131	0.3998846	0.21421508	1,8645916
{MANDENIM, WOMANCASUAL}	=>	{WOMANCONVENTIONAL}	0.02088999	0.3100917	0.06736712	1,8473065

Figure 1. Relationship between items

For example, the high lift and confidence level between "woman classic" and "woman modest" graphically highlights the high probability of getting these two together. Although it has a relatively lower lift value, it is also emphasized on the chart that the darkest color has a high confidence value, and the combination of "man classic" and "man denim" purchasing by the consumers is high.

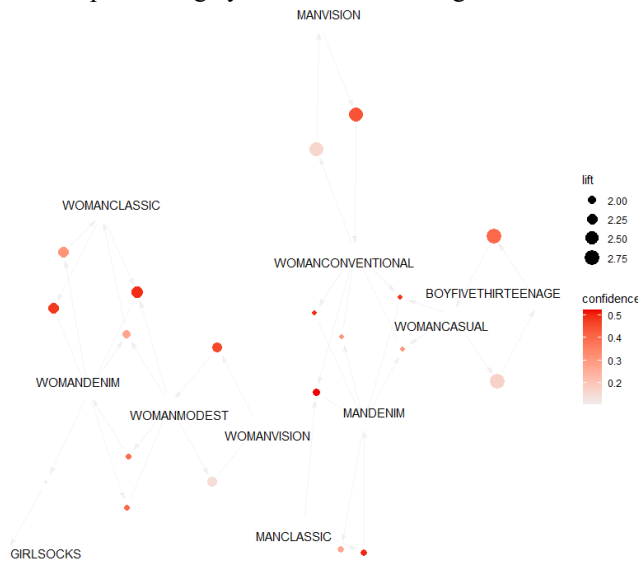


Figure 2. Graph-based visualization with items and rules as vertices in the light of lift and confidence.

Considering the main features of the developed shelf space allocation and layout optimization model, studies in this field for the clothing industry are limited. Previous models have focused on only one of the variables such as profitability, competition and seasonality. In the developed model, a more comprehensive model was created by taking into account the GMROF, customer flow and cross-selling effect. The store plan is placed on the coordinate system and divided into zones on a certain scale. While assigning values to the zones, entrances, cashiers and visible zones are scored between 1 and 5. By assigning valuable sub-categories to valuable fields, maximum efficiency has been tried to be achieved.

The notations used in the model structure developed for the shelf space allocation and layout optimization problem for the store; $i = 1, 2, \dots, n$ set of subcategories, $k = 1, 2, \dots, e$ set of shelf areas as follows:

- L_i Lower zone assignment limit of sub-category i
- U_i Upper zone assignment limit of sub-category i
- GM_i Gross profit of sub-category i
- W_k Weight score value of zone k
- F_{ij} Cross-selling between sub-categories i and j
- S_{km} Closeness between zone k and m

$$X_{ik} \begin{cases} 1, & i. \text{ Sub-category, if assigned to zone } k. \\ 0, & \text{otherwise} \end{cases}$$

The objective function of the model is given in equation (3). In the first part of the objective function, the flow similarity value is calculated. Similarity is calculated with the formula $1/1+Distance$. The reason for converting distance to similarity is that the objective function is reduced to a single unit. This unit is expressed in TL, on profit basis. The distance between similarity and zones was added to the model by expressing it as closeness. Customer traffic data between sub-categories was created by creating a customer flow matrix. Then, in order to convert this flow matrix to TL value, the amounts of the subcategories were taken from the transaction data and included in the matrix. Thus, the values it has been defined as F in the equation have emerged.

In the second part of the objective function, GMROF values are taken into account and in addition to this, weight values in the range of 1-5 are assigned to the zones allocated in the store in order to assign valuable categories to the valuable area. Thus, a result with TL value will be obtained as in the first part of the equation.

With the objective function, it is aimed to maximize the retailer's profit by considering criteria such as cross selling effect, GMROF values, assigning a valuable category to a valuable area.

$$MAX Z = \sum_{i=1}^n \sum_{\substack{j=1 \\ j \neq i}}^n \sum_{k=1}^e \sum_{\substack{m=1 \\ m \neq k}}^e X_{ik} X_{jm} S_{km} F_{ij} + \sum_{k=1}^e \sum_{i=1}^n X_{ik} GM_i W_k \quad (3)$$

The model constraints can be expressed as:

$$\sum_{k=1}^e X_{ik} \leq U_i, \quad \forall i \quad (4)$$

$$\sum_{k=1}^e X_{ik} \geq L_i, \quad \forall i \quad (5)$$

$$\sum_{i=1}^n X_{ik} = 1, \quad \forall k \quad (6)$$

$$X_{ik} \in \{0,1\}, \quad \forall ik \quad (7)$$

When i sub-category is assigned to k zone with equations (4) and (5), it specifies the lower and upper limit of the zone to which each subcategory will be assigned. Equation (6) expresses the necessity of assigning a subcategory to each zone. Equation (7) expresses the binary assignment variable.

In the shelf space allocation and layout optimization model mentioned in the study, the objective function is nonlinear, the thing that creates this nonlinearity is the multiplication of four variables. In addition to the objective functions, the decision variables mentioned in the model are binary. Such situations complicate the problems and make the problems unsolvable in polynomial time. The problem working on the study is also a hard class problem and is called NP-Hard problem from the NP class. In general, classical solutions cannot be proposed for these problems and global optimum cannot be found. The study problem was run in Lingo software, but the global optimum could not be found. In such NP-Hard problems, as the number of decision variables such as the number of categories and zones increases, the solution space grows and these problems cannot be solved with classical optimization programs. Global optimum is the best of feasible solutions, providing all solutions. Each of these solutions is called a feasible solution. Where a global optimum solution cannot be found, the software offers local optimum as a solution. This problem is an NP-Hard problem, it is aimed to find local optimum results in the model by dividing the main categories in terms of decision variables and reducing the store zones.

In the model, which descends from the main category level to the subcategory level, there are 6 main categories: Woman, Man, Girl, Boy, Baby Boy and Baby Girl. Each of these main categories is run through sub-category and zone assignment matrices within itself, and local optimums are solved with Lingo software as the state is feasible.

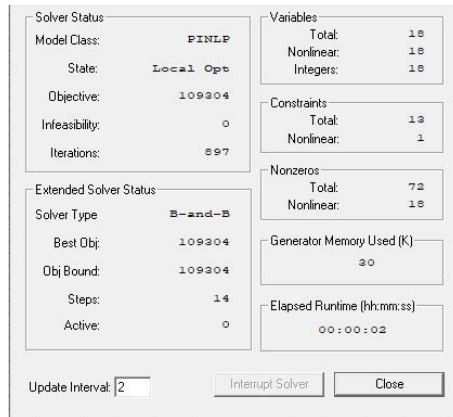


Figure 3. Lingo solver status for baby girl category

For example, the lingo solution for the Baby Girl category was run for 6 zones and 3 subcategories. In the lingo code, 879 iterations were made and the solvent local optimum solution was reached. Model class is PINLP. State local is optimum. In the model, the objective function consists of 2 objectives. The objective function, which tries to maximize the total profit, takes into account the flow similarity value in the first part, while it considers the GMROF and zone weight values in the second part. Equal weights are given to both parts of the model. In order to present a different perspective to the model, the model was re-executed separately for two different objectives. The result of the assignment table that emerges when the two objectives are taken into account simultaneously and the result of the assignment table that comes out when two separate objectives are taken into account separately are different in terms of the number of zones to which the categories are assigned and the zone locations.

The current store plan is divided into 157 zones. The zones with subcategories in the layout were determined and the assignment matrix was filled in accordance with the plan. Then, when the current store plan is analyzed in the lingo solver, the objective function value is found to be 5.503.364. Since the objective function expresses the profit of the store in the designed model, this value is in TL. After the subcategory assignments formed by the constructed model, the assignment matrix was rearranged in accordance with the results. Then, when the proposed layout was analyzed in the lingo solver, the objective function value was found to be 7.653.692 TL. As a result, when the objective function values of the proposed layout and the current store plan are compared, an improvement of 39,07% is seen in the profit of the store.

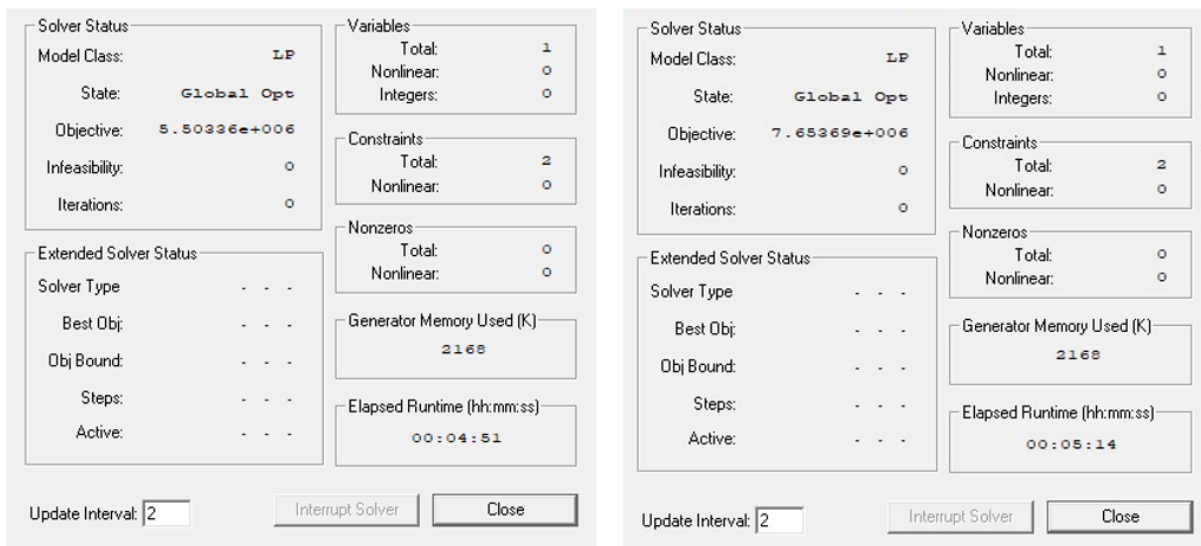


Figure 4. Lingo solver status for the objective function of current layout and proposed layout

V. CONCLUSIONS

Throughout the literature review and methodology research, models based on variables such as customer traffic, number of facings, space elasticity, product variety, demand for substitution, out of stock and cross elasticity were examined. As stated in the study, the model was built on textile retailing, which is rarely studied in the retail sector. An integrated model was created by considering the cross selling effect, GMROF, similarity, customer flow, and sub-category prices variables in the model. In the objective function, these variables have been converted to TL and an objective function has been designed to maximize the retailer's profit. If the working principle of the model is to be summarized, first of all, the existing store layout is divided into the optimal zone number according to its square meter. Then, by editing the transaction data, the Apriori algorithm is run and the association rules between subcategories are determined. At this stage, the price values of the sub-categories are revealed. The distance matrix is created by finding the distance between the zones with the data taken from the store layout, but the distance matrix is converted to the similarity matrix in order to index the objective function to a single unit. Flow matrix is created with customer flow information. Subcategory prices are included in this flow matrix and this matrix is converted to TL for use in the objective function. In addition, weight values between 1-5 are assigned to zones in order to assign valuable categories to the valuable area. In addition, the GMROF values that will be included in the objective function are determined on a subcategory basis. An objective function has been created using these mentioned variables. Objective function consists of two parts. The first part is non-linear, the second part is linear. Both parts are of equal weight. Then the objective function was run to create the proposed layout. The results are reflected in the assignment matrix. Based on these results, the proposed store layout is visualized. In order to compare with the current store plan, the objective function is run again for the current zone assignments. When the results for the proposed layout and current layout are evaluated, it is concluded that the proposed layout is a more profitable store layout than the current layout, and the enhancement in profit has been determined as 39.07%.

VI. FUTURE STUDY

The shelf space allocation and layout optimization problem discussed throughout the study is an NP-Hard problem. The model created to solve this problem was run on Lingo Solver and could not be solved in a reasonable time. Therefore, it is suggested to analyze the model using metaheuristic algorithms in future studies. In addition, the problem is a large-scale problem, so it is recommended to find near-good solutions in a reasonable time with metaheuristic algorithms mentioned in the literature such as genetic algorithm, tabu search and simulated annealing. The objective function of the model consists of two different objectives and the effects of these objectives on the objective function are of equal weight. In addition, the first part of the objective function is nonlinear and the second part is linear. As a suggestion for future studies, different weights can be based on these two objectives and linearization can be applied to the first part of the objective function. In this way, more realistic results can be obtained. While creating the model, decision variables detailed in the study such as GMROF, Similarity, Customer Flow, cross selling effect and sub-category prices are included, and a model can be created in which shelf space decision and inventory decisions are integrated as a suggestion in future studies. Finally, as a result of the literature review, the low number of studies conducted in this direction in the textile sector attracted attention, and it is recommended to increase and diversify the studies to be done in this field.

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Stock Market Performance Evaluation of Listed Food and Drink Companies in ISE via MCDM Methods

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Abstract— The stock market performance ratio analysis of the food and drink industry is fundamental for investors and fund managers when making their investment decisions due to being a major part of the whole ISE index and contributing more than half of GDP. This study aims to rank these companies based on some stock market performance ratios which are price-earnings, market-to-book, earning per share, dividend yield, and dividend payout as the decision criteria. DEMATEL and CRITIC methods are applied to assign criteria weights. 3 different academic experts in the field of finance are consulted for the expert opinion required by DEMATEL application. The total performance of the firms in all the criteria is evaluated by EDAS combining the importance weights obtained by both the DEMATEL and CRITIC methods. DEMATEL method resulted as EPS has the highest, dividend payout has the lowest importance weights while CRITIC method has resulted as M/B ratio has the highest and EPS is the lowest importance weights. A sensitivity analysis including 10 different scenarios is conducted to reveal how the alternative ranking changes. It proved that in almost each scenario Firm 4 is the best stock and Firm 18 is the worst stock. However, middle-ranking alternatives have high volatility in each scenario. In conclusion, sensitivity analysis shows that the best resulting alternative should be included in and the worst resulting one should be excluded from the investment portfolio. However, the selection of stocks among the middle-ranking alternatives exposes the portfolio to high uncertainty due to the lack of probability information for each scenario.

Keywords— Stock market performance, EDAS, DEMATEL, CRITIC, financial ratios, sensitivity analysis.

I. INTRODUCTION

The food and drink sectors are two of the most important industries since it covers a major part of the Gross Domestic Product of the Turkish industry [1]. It is very beneficial to evaluate the stock market performance of food and drink companies by conducting a financial ratio analysis since they generate a major part of the investment options on Istanbul Stock Exchange (ISE). The main goal of this study is to help individual investors and fund managers to select the best companies in this sector for their investment portfolios. In this paper, an evaluation of the stock market performance of Turkish food and drink companies listed on ISE was conducted by a cross-sectional financial ratio analysis for the year 2021. The stock performance of these companies is measured by some stock performance indicator ratios that are P/E (price/earnings ratio), M/B (market value/book value ratio), EPS (earnings per share), Dividend Yield, and Dividend Payout as the evaluation criteria. A Multi-Criteria Decision Making (MCDM) method called Evaluation Based on Difference from Average Solution (EDAS) is utilized to compare the stock market performance of each company and prepare a ranking for the best investment options. Evaluation criteria which are 5 stock performance indicators are weighted by Decision-Making Trial and Evaluation Laboratory (DEMATEL) which is a subjective evaluation method and also Criteria Importance Through Inter-Criteria Correlation (CRITIC) which is an objective evaluation method. For DEMATEL, 3 academic experts were consulted to analyze the influence relationship between the criteria based on their subjective judgments. Sensitivity analysis is applied by creating 10 different scenarios of DEMATEL-EDAS and CRITIC-EDAS assessment combinations. Since we have 5 criteria for each assessment combination, it results in 10

different scenarios. The alternatives are 27 food and drink companies listed on ISE and the main goal is to rank them depending on several stock market performance ratios. Annual financial reports for the fiscal year 2021 and stock prices on the 6th of June 2022 were reached via Yahoo finance to conduct the financial ratio analysis.

II. LITERATURE REVIEW

MCDM is a part of operations research (OR), and it is the most commonly used decision-making method, having applications in virtually every research, industrial, government, and engineering domain [2]. MCDM is categorized into two by Hwang and Yoon (1981) to conduct a systemic study in the field of decision making: Multi-Objective Decision Making (MODM) is interested in decision issues within a continuous decision space while Multi-Attribute Decision Making (MADM) is concerned with situations having a discrete set of choice alternatives [3]. MADM exponents include SAW, WSM, WPM, AHP, TOPSIS, PROMETHEE, ELECTRE, EDAS, etc.

Our contribution to the literature with this study is the application of the MCDM methodologies to assist managers in creating an investment portfolio based on the ranking of the food and drink companies according to the stock market performance performances criteria. We used EDAS to evaluate the companies' overall stock performance across all categories by combining the importance weights determined by the DEMATEL and CRITIC techniques. The MCDM methodologies applied gives the option of negative (exclusionary) portfolio screening which refers to exclusion of worst resulting stocks from the investment portfolio.

Academic and professional groups have paid careful attention to the use of MCDM techniques in a range of commercial and financial scenarios due to the diversity and complexity of their judgments. Within this area of operations research, value-based and outranking relation-based methodologies are two of the most effective instruments for decision-makers and analysts to deliver accurate predictions and consistent evaluations of financial decision-making difficulties [4].

The purpose of this part is to offer a description of some MADM-based financial applications:

- Considering financial performance analysis as a crucial task for all enterprises, from small start-ups to large ones, Bağcı and Yerdelen Kaygın [5] evaluated the financial performance via ARAS and WASPAS.
- Investing in companies' IPO (initial public offering) is risky and complex as investors must consider and evaluate unconfirmed information, incomplete data, and contradictory criteria throughout the decision-making process. Kumaran [6] applies MCDM to support financial decision-making and improve the returns on chosen investments. IPO firms listed on the Saudi Stock Market were ranked through a combined approach of CRITIC and VIKOR, thus allowing investors to identify leading firms as well as enabling them to make comparisons among firms, ultimately facilitating the decision-making process.
- The goal of Baydaş and Eren [7] is to look into a range of MCDM techniques over a 5-year period using share price data from 131 manufacturing companies listed on BIST (2014-2018). Another point of contention in this sector is to determine the best MCDM and weighting technique to utilize in assessing financial success. The methodologies used were WSA, TOPSIS, and PROMETHEE.
- Yıldırım and Meydan [8] conducted the study with the aim of measuring the financial performance of seven companies in the retail sector, which are publicly traded in BIST, within the 2017-2019 period by employing an intuitionistic fuzzy EDAS (IF-EDAS) approach with ten financial ratios which are universally used for determining a company's performance.
- Ünvan [9] conducted a study of Turkey's seven biggest banks by total assets to analyze and measure their financial performance between 2014 and 2018 with TOPSIS and Fuzzy TOPSIS methodologies. Certain financial ratios were selected to be used as performance criteria, which reflect different aspects of banks' financial status, such as assets, liquidity, profitability, and income/expense. They found that TOPSIS approach is more viable for yearly assessments, whereas fuzzy TOPSIS is more suited for evaluations over a few-year period.
- No et al. [10] analyzed and ranked 51 branches of the Iranian bank based on their performance. The criteria for performance evaluation were selected using the CAMEL methodology, which is widely used for the assessment of banking institutions. The criteria weights were assigned through a combined method of expert opinions and Shannon's entropy. The authors proposed a modification to the classical EDAS approach since the data used in the study is of interval type. The proposed method is also compared with the interval TOPSIS method, which yielded similar results.

III. PROPOSED METHOD

A. DEMATEL Method

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach, established between 1972 and 1976 by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva, was used to explore and solve complex and interrelated problems [11]. It is concerned with examining the interdependencies of components and identifying the key ones using a visual structural model. The steps of DEMATEL are as follows:

Step 1: *Generate the group direct influence matrix Z:* Before creating the matrix, assume that l experts in a decision group are asked to assess the direct effect of factor F_i on factor F_j on an integer scale of "no influence (0)," "low influence (1)," "medium influence (2)," "high influence (3)," and "very high influence (4)."

Then, the individual direct influence matrix $Z_k = [z_{ij}^k]_{n \times n}$ provided by the k^{th} expert can be formed, where all principal diagonal elements are equal to zero and z_{ij}^k represents the judgment of the decision-maker E_k on the degree to which factor F_i affects factor F_j . The Z matrix would be created by averaging the same factors in each of those matrices.

$$z_{ij} = \frac{1}{l} \sum_{k=1}^l z_{ij}^k \quad i, j = 1, 2, \dots, n. \quad (2.1)$$

Step 2: *Establish the normalized direct influence matrix X:* Group direct influence matrix Z is normalized by using

$$X = \frac{Z}{s} \text{ where } s = \max(\sum_{j=1}^n z_{ij}, \sum_{i=1}^n z_{ij}) \quad (2.2)$$

All elements in X are complying with $0 \leq x_{ij} < 1$; $0 \leq \sum_{j=1}^n x_{ij} \leq 1$; at least one i such that $\sum_{j=1}^n z_{ij} \leq s$

Step 3: *Construct the total influence matrix T:* The total influence matrix $T = [t_{ij}]_{n \times n}$ is produced by adding the direct and indirect effects to the normalized direct influence matrix X :

$$T = X + X^2 + X^3 + \dots + X^h = X(I - X)^{-1} \quad (2.3)$$

when $h \rightarrow \infty$, and I represents the identity matrix.

Step 4: *Produce the influential relation map (IRM):* In this phase, the parameters R and C representing the sum of the rows and columns of T are calculated by the following formulas:

$$R = [r_i]_{n \times 1} = [\sum_{j=1}^n t_{ij}]_{n \times 1} \quad (2.4)$$

$$C = [c_j]_{1 \times n} = [\sum_{i=1}^n t_{ij}]_{1 \times n}^T \quad (2.5)$$

We calculate $(R+C)$ called "Prominence" denoting the degree to which the factor is essential to the system, and $(R-C)$ called "Relation" illustrating the net influence that the factor has on the system.

- If $(r_j - c_j) > 0$, the factor F_j has a net influence on the other factors and may be put into the cause group;
- If $(r_j - c_j) < 0$, the factor F_j is influenced by the other factors as a whole and can be grouped into the effect group.

A threshold value can be determined for drawing the Influence Relation Map (IRM). IRM is built using matrix T information to describe the factors' structure and relationships. In the literature, the threshold value θ is usually determined by the average of all elements of T .

Step 5: *Calculate the weights for each criterion:* This step computes the weights of criteria based on the prominence values by using the following normalization-based formula:

$$w_i = \frac{r_i + c_i}{\sum_{i=1}^n r_i + c_i} \quad (2.6)$$

B. CRITIC Method

Criteria Importance Through Intercriteria Correlation (CRITIC) method was developed by Diakoulaki et al [12]. Its goal is to determine the objective criteria weights without considering expert judgments.

Step 1: *The Decision Matrix:* A decision matrix is built by utilizing information about the available alternatives.

$$\begin{matrix} \begin{matrix} r_{11} & \cdots & r_{1j} & r_{1,j+1} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ r_{i1} & \cdots & r_{ij} & r_{i,j+1} & \cdots & r_{in} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mj} & r_{j,m+1} & \cdots & r_{mn} \end{matrix} \end{matrix} \quad (2.7)$$

where $i = 1, 2, \dots, m$; $j = 1, 2, \dots, n$ and r_{ij} is the element of the decision matrix for i^{th} alternative and j^{th} attribute.

Step 2: Normalized Decision Matrix: For the benefit attributes, we use this equation:

$$x_{ij} = \frac{r_{ij} - r_i^-}{r_i^+ - r_i^-} \quad i = 1, 2, \dots, m ; j = 1, 2, \dots, n \quad (2.8)$$

and for the cost ones, we apply:

$$x_{ij} = \frac{r_i^- - r_{ij}}{r_i^- - r_i^+} \quad i = 1, 2, \dots, m ; j = 1, 2, \dots, n \quad (2.9)$$

where x_{ij} represents the normalized values and $r_i^+ = \max (r_1, r_2, \dots, r_m)$, $r_i^- = \min (r_1, r_2, \dots, r_m)$.

Step 3: The correlation coefficient between attributes:

$$\rho_{ij} = \frac{\sum_{i=1}^m (x_{ij} - \underline{x}_j)(x_{ik} - \underline{x}_k)}{\sqrt{\sum_{i=1}^m (x_{ij} - \underline{x}_j)^2 \sum_{i=1}^m (x_{ik} - \underline{x}_k)^2}} \quad (2.10)$$

where \underline{x}_j and \underline{x}_k are the means of j^{th} and k^{th} attributes. \underline{x}_j is obtained by:

$$\underline{x}_j = \frac{1}{n} \sum_{j=1}^n x_{ij} \quad ; i = 1, 2, \dots, m \quad (2.11)$$

Step 4: Sample Standard Deviation:

$$\sigma_j = \sqrt{\frac{1}{n-1} \sum_{j=1}^n (x_{ij} - \underline{x}_j)^2} \quad ; i = 1, 2, \dots, m \quad (2.12)$$

Step 5: The Index C:

$$C_j = \sigma_j \sum_{k=1}^n (1 - \rho_{ik}) \quad ; j = 1, 2, \dots, n \quad (2.13)$$

Step 6: The weights of attributes:

$$W_j = \frac{C_j}{\sum_{j=1}^n C_j} \quad (2.14)$$

C. EDAS Method

Keshavarz Ghorabae et al. [20] introduced EDAS approach in 2015. In settings with contradicting features, this approach is particularly useful, and the best choice is picked by calculating the distance of each alternative from the average value. Criteria in EDAS can be independent or dependent and the qualitative data should be transformed into quantitative ones [13]. EDAS has previously been steadily focused on addressing many MCDM issues, such as engineering and financial problems. Unlike some existing MCDM methods like VIKOR and TOPSIS, the EDAS approach eliminates the phase for complicated computation of ideal solutions [2]. The basic philosophy of EDAS is described by measuring the geometric difference between the average solution (AS) and the alternatives. To determine this distance, two measures, PDA (positive distance from average) and NDA (negative distance from average) are employed to evaluate the attractiveness of each alternative. The nature of the criteria, whether it is beneficial or cost, is utilized to quantify these distances. Higher PDA and/or lower NDA values for an alternative indicate that it is superior to the average solution. The following are the steps of EDAS:

Step 1: Choose the most relevant criteria, which describe decision alternatives for specific decision problems.

Step 2: Construct the decision matrix (X)

$$X = [x_{ij}]_{n \times m} \quad \text{where } x_{ij} \text{ signifies the } i^{th} \text{ alternative's performance value on the } j^{th} \text{ criteria} \quad (2.15)$$

Step 3: Calculate the average solution based on all criteria.

$$AV_j = \frac{\sum_{i=1}^n x_{ij}}{n} \quad (2.16)$$

Step 4: Calculate the PDA and NDA vectors based on criteria (benefit and cost) as stated below:

- Benefit criteria:

$$PDA_{ij} = \frac{(0, (x_{ij} - AV_j))}{AV_j} \quad (2.17)$$

$$NDA_{ij} = \frac{(0, (AV_j - x_{ij}))}{AV_j} \quad (2.18)$$

- Cost criteria:

$$PDA_{ij} = \frac{(0, (AV_j - x_{ij}))}{AV_j} \quad (2.19)$$

$$NDA_{ij} = \frac{(0, (x_{ij} - AV_j))}{AV_j} \quad (2.20)$$

Step 5: Determine the weighted sum of PDA and NDA for all alternatives.

$$SP_i = \sum_{j=1}^m w_j PDA_{ij} \quad (2.21)$$

$$SN_i = \sum_{j=1}^m w_j NDA_{ij} \quad (2.22)$$

where w_j is the weight of the j^{th} criterion.

Step 6: Normalize SP and SN values for all alternatives.

$$NSP_i = \frac{SP_i}{Max_i(SP_i)} \quad (2.23)$$

$$NSN_i = 1 - \frac{SN_i}{Max_i(SN_i)} \quad (2.24)$$

Step 7: Calculate AS (appraisal score) for each alternative.

$$AS_i = \frac{1}{2} (NSP_i + NSN_i) \quad (2.25)$$

where $0 \leq AS_i \leq 1$

Step 8: Rank the alternatives in decreasing order of AS. The alternative with the greatest AS is the best decision. We may rank the alternatives based on this score.

IV. APPLICATION

A. Problem Definition

In the study, 5 stock market performance ratios that investors consider while making their investment decisions are involved. These ratios are P/E, M/B, EPS, dividend yield, and dividend payout ratios. 27 companies listed on ISE Food and Beverage Index are evaluated. In Index, 33 companies exist. However, 27 companies' annual financial reports for the year 2021 were available. Ratios were calculated by our analysis through annual 2021 balance sheets, income statements, and daily closing and current stock prices for the date 6th of June, 2022. Table I presents decision matrix showing companies' financial ratios determined with respect to each criterion.

Price/Earnings Ratio: The P/E ratio is calculated by dividing the stock market price per share by the earnings of the company per share. The stock market price is meant to be the last closing price of the stocks per share, and the earnings per share (EPS) is the company's net profit divided by the number of shares outstanding [14]. This ratio is an indicator of investors' expectations of the future growth of the company. A high P/E also indicates that stocks are overvalued and that is not desirable for the investor [15]. P/E ratio is accepted as a cost criterion.

Market Value/Book Value Ratio: Market Value is acquired by the multiplication of the stock price per share and the total number of shares outstanding. Book value is total equity in the balance sheet, which is at the same time the accounting value of the company's net assets [16]. The ratio of Market to Book value shows how many times companies' stock price is more or less valuable than its equities in monetary terms, which means these stocks are overvalued or undervalued. It is much more preferable for investors to find undervalued stocks to invest in since the market value of undervalued security is expected to increase in accordance with the real value of its net assets. This ratio is accepted as a cost criterion.

Earnings Per Share Ratio: This ratio is obtained by the division of the company's net profit by the number of outstanding shares. The higher it results, the more it tends to be preferred. It is a measure of the profitability degree of a company's stock per share basis. It is accepted as a beneficial criterion.

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 İstanbul Technical University & Bahçeşehir University

Dividend Yield Ratio: It is calculated by the division of companies' earnings per share by the market price per share [17]. This ratio shows the potential dividend per share, which is not obligatory for the company to pay these earnings to the shareholders, instead, this amount could be used for capital appreciation. This ratio is accepted as a benefit criterion.

Dividend Payout Ratio: It is obtained by the division of the total dividend by the net profit [18]. It shows the percentage of a company's earnings that is paid to its shareholders, instead of being retained by the company to provide capital appreciation. A high ratio indicates low growth potential for the company. This ratio is accepted as a cost criterion.

TABLE I
 THE RESULTS OF RATIO ANALYSIS

<i>Alternatives</i>	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
1	15,597	0,426	1,804	0,064	0,912
2	15,108	1,902	0,125	0,065	0,000
3	109,431	8,434	0,951	0,009	0,000
4	14,437	2,226	8,929	0,068	0,267
5	12,916	9,940	0,274	0,077	0,000
6	3,800	1,760	1,650	0,263	0,000
7	26,929	4,425	0,697	0,036	1,077
8	75,537	3,509	0,054	0,013	0,000
9	16,286	2,511	0,387	0,060	0,000
10	14,499	1,900	0,677	0,069	0,167
11	18,819	5,005	0,384	0,048	0,000
12	122,835	5,787	0,055	0,007	0,000
13	47,331	2,664	0,680	0,021	0,000
14	211,823	1,851	0,017	0,005	0,000
15	143,263	3,162	0,124	0,007	0,000
16	35,549	3,167	0,070	0,029	0,000
17	23,046	1,362	0,198	0,042	0,000
18	210,163	0,807	0,113	0,005	11,457
19	-18,506	2,225	-0,281	-0,053	0,000
20	7,760	0,659	3,680	0,129	0,107
21	8,742	1,638	0,482	0,114	0,000
22	-55,494	2,684	-0,139	-0,018	0,000
23	9,134	2,481	1,641	0,105	0,129
24	5,035	2,106	3,734	0,195	0,086
25	23,311	4,915	0,731	0,039	0,000
26	-11,748	1,272	-1,358	-0,085	-0,596
27	6,251	1,852	0,610	0,161	0,000

B. DEMATEL Application:

Before applying the EDAS method, we chose DEMATEL to determine the criteria weights as it is better compared to other subjective weighting methods since it provides the total degree of influence of attributes or issues, assignment of parameters into cause-and-effect groups, and creates causal links between them [19].

To create the group direct influence matrix Z, we asked three experts, two of whom are finance professors at İstanbul Technical University and one is a Bahcesehir University professor, to determine the degree of the direct effects among the criteria. The expert's direct influence matrices are summarized in Table II.

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 İstanbul Technical University & Bahçeşehir University

TABLE II
 DIRECT INFLUENCE MATRIX FOR EXPERTS

	P/E RATIO			M/B RATIO			EPS			DIV. YIELD			DIV. PAYOUT		
	Exp 1	Exp 2	Exp 3	Exp 1	Exp 2	Exp 3	Exp 1	Exp 2	Exp 3	Exp 1	Exp 2	Exp 3	Exp 1	Exp 2	Exp 3
P/E RATIO	0	0	0	3	4	2	2	4	1	4	2	3	3	2	3
M/B RATIO	1	4	2	0	0	0	2	2	1	1	1	1	2	1	1
EPS	4	4	4	3	2	2	0	0	0	4	4	4	3	2	3
DIV. YIELD	0	2	1	1	1	0	1	4	1	0	0	0	2	4	2
DIV. PAYOUT	0	2	0	0	1	0	0	2	0	0	4	0	0	0	0

Z matrix was created by averaging the same factors in each of those matrices (Table III).

TABLE III
 THE GROUP DIRECT INFLUENCE MATRIX Z

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
P/E RATIO	0,000	3,000	2,333	3,000	2,667
M/B RATIO	2,333	0,000	1,667	1,000	1,333
EPS	4,000	2,333	0,000	4,000	2,667
DIV. YIELD	1,000	0,667	2,000	0,000	2,667
DIV. PAYOUT	0,667	0,333	0,667	1,333	0,000

By applying Eq. 2.2, normalized direct influence matrix (X) was obtained (Table IV).

TABLE IV
 THE NORMALIZED DIRECT INFLUENCE MATRIX X

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
P/E RATIO	0,000	0,231	0,179	0,231	0,205
M/B RATIO	0,179	0,000	0,128	0,077	0,103
EPS	0,308	0,179	0,000	0,308	0,205
DIV. YIELD	0,077	0,051	0,154	0,000	0,205
DIV. PAYOUT	0,051	0,026	0,051	0,103	0,000

The total influence matrix T (Table V) was produced by operating Eq. 2.3.

TABLE V
 THE TOTAL INFLUENCE MATRIX T

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
P/E RATIO	0,246	0,391	0,372	0,480	0,470
M/B RATIO	0,321	0,142	0,261	0,272	0,293
EPS	0,533	0,395	0,266	0,597	0,532
DIV. YIELD	0,219	0,167	0,261	0,180	0,358
DIV. PAYOUT	0,122	0,087	0,117	0,183	0,096

R and C respectively showing the row and column sums of T were obtained by Eq. 2.4 and 2.5. Then, calculate (R+C) Prominence and (R-C) Relation values as given in Table VI.

TABLE VI
 THE VECTOR R AND C & GROUP ASSIGNMENTS

	R	C	R+C	R-C	
P/E RATIO	1,958	1,442	3,400	0,517	CAUSE
M/B RATIO	1,290	1,182	2,471	0,108	CAUSE
EPS	2,323	1,276	3,599	1,047	CAUSE
DIV. YIELD	1,185	1,714	2,899	-0,528	EFFECT
DIV. PAYOUT	0,605	1,748	2,353	-1,143	EFFECT

P/E, M/B, and EPS have an influence on the other criteria; DIV. YIELD and DIV. PAYOUT are grouped into the effects group.

IRM was built using matrix T information to describe the factors' structure and relationships. The threshold value θ is usually determined by the average of all elements in matrix T. For our case, $\theta = 0.2944$ is found. As a result, θ is specified to filter out insignificant effects. That is, only the elements of matrix T whose impact level is greater than θ are shown on IRM (Fig. 1).

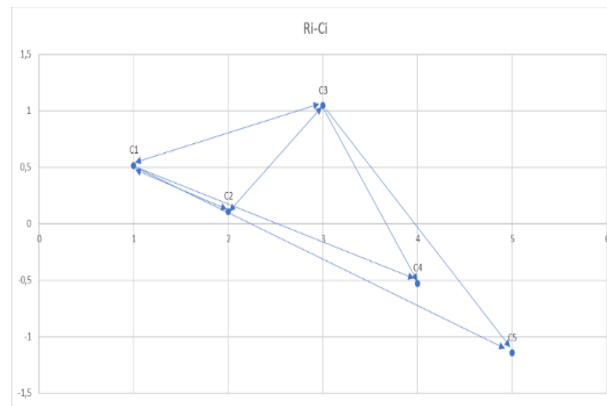


Figure 1: The influence relation map IRM.

Eq. 2.6 computes the subjective criteria weights based on (R+C) values (Table VII).

TABLE VII
 WEIGHTS OF THE CRITERIA DEMATEL

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
Weights	0,231	0,168	0,244	0,197	0,160

EPS is the most important criterion in our case.

C. CRITIC Application:

CRITIC determines the objective criteria weights. The decision matrix given in Table I was normalized by using Eqs. 2.8 and 2.9. The normalized decision matrix is given in Table VIII.

TABLE VIII
 NORMALIZED DECISION MATRIX FOR CRITIC

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
1	0,734060339	1	0,307393561	0,426673686	0,874947162
2	0,735888684	0,844850235	0,144153254	0,429735358	0,950575683
3	0,383036536	0,158335218	0,224472348	0,269442874	0,950575683
4	0,73839919	0,81081468	1	0,43933366	0,928459347
5	0,744088218	0	0,158636434	0,465975562	0,950575683
6	0,778190287	0,85979191	0,292399788	1	0,950575683

International Engineering and Technology Management Summit 2022– ETMS2022
 İstanbul Technical University & Bahçeşehir University

7	0,691667742	0,579726092	0,199717586	0,346776619	0,861252353
8	0,509829636	0,675958312	0,137268135	0,281713067	0,950575683
9	0,731482541	0,780857208	0,169598972	0,416886129	0,950575683
10	0,738165546	0,845030864	0,197767075	0,441063794	0,936681761
11	0,722005251	0,518731658	0,169340483	0,382312448	0,950575683
12	0,33289496	0,436574627	0,137349487	0,264668357	0,950575683
13	0,615345806	0,764792951	0,198088533	0,30260627	0,950575683
14	0	0,850229184	0,133620687	0,256427826	0,950575683
15	0,256476082	0,71243139	0,144043199	0,263529423	0,950575683
16	0,659420879	0,711861468	0,138828231	0,325564018	0,950575683
17	0,706192534	0,901645945	0,151269295	0,363147267	0,950575683
18	0,006213198	0,959957794	0,142954569	0,256734284	0
19	0,861635854	0,81091142	0,104674959	0,091796428	0,950575683
20	0,763376413	0,97551366	0,489750714	0,613324654	0,941663253
21	0,759703398	0,872655578	0,178810323	0,569942054	0,950575683
22	1	0,76269063	0,118466992	0,191287996	0,950575683
23	0,75823607	0,784032564	0,291534841	0,545836821	0,93983232
24	0,773570809	0,823433581	0,494996864	0,805163036	0,943463589
25	0,705201235	0,528228543	0,203055105	0,355520146	0,950575683
26	0,836352863	0,911122708	0	0	1
27	0,769022069	0,850153042	0,191247231	0,706990943	0,950575683

Then, by applying Eq. 2.10 we found the correlation matrix (Table IX). Table X presents the index matrix. Final objective criteria weights are given in Table 11.

TABLE IX
CORRELATION MATRIX

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
P/E RATIO	1	0,101119173	0,165791886	0,269336642	0,515307073
M/B RATIO	0,101119173	1	0,146008407	0,147628841	-0,199340525
EPS	0,165791886	0,146008407	1	0,434081143	0,048266422
DIV. YIELD	0,269336642	0,147628841	0,434081143	1	0,111502288
DIV. PAYOUT	0,515307073	-0,199340525	0,048266422	0,111502288	1

TABLE X
INDEX OF CRITERIA MATRIX

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
The standard deviation	0,242233	0,2343321	0,186939	0,210557	0,18328874
C _i	0,714210869	0,891535996	0,599297815	0,639556519	0,645958047

TABLE XI
WEIGHTS OF THE CRITERIA

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
Weights	0,204612	0,2554135	0,171691	0,183225	0,18505861

M/B RATIO is the most important criterion according to CRITIC.

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D. EDAS Application:

1) EDAS with DEMATEL weights:

A decision matrix given in Table 1 including financial analysis results was created. AV_j vector was established at the beginning of EDAS and then PDA and NDA values were calculated by Eqs. (2.17-2.20). Table XII shows PDA results while Table 13 presents NDA values.

TABLE XII
PDA MATRIX

AV _j	40,439	2,988	0,974	0,055	0,504
	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
1	0,614	0,857	0,853	0,167	0
2	0,626	0,363	0	0,186	1,000
3	0	0	0	0	1,000
4	0,643	0,255	8,170	0,247	0,471
5	0,681	0	0	0,417	1,000
6	0,906	0,411	0,695	3,816	1,000
7	0,334	0	0	0	-
8	0	0	0	0	1,000
9	0,597	0,160	0	0,105	1,000
10	0,641	0,364	0	0,258	0,668
11	0,535	0	0	0	1,000
12	0	0	0	0	1,000
13	0	0,108	0	0	1,000
14	0	0,380	0	0	1,000
15	0	0	0	0	1,000
16	0,121	0	0	0	1,000
17	0,430	0,544	0	0	1,000
18	0	0,730	0	0	0
19	1,458	0,255	0	0	1,000
20	0,808	0,779	2,780	1,355	0,787
21	0,784	0,452	0	1,079	1,000
22	2,372	0,102	0	0	1,000
23	0,774	0,170	0,686	0,925	0,743
24	0,875	0,295	2,835	2,576	0,830
25	0,424	0	0	0	1,000
26	1,291	0,574	0	0	2,182
27	0,845	0,380	0	1,951	1,000

The weighted matrices of SP and SN were built and these values are shown in Table XIV. Eqs. 2.23 and 2.24 were applied to build the vectors of NSP and NSN. Then, AS of each alternative was calculated via Eq. 2.25. The column named “Rank” in Table XIV shows the rankings of alternatives. Accordingly, Firm 4, Firm 24, and Firm 20 are the first three ranked alternative firms.

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İstanbul Technical University & Bahçeşehir University

TABLE XIII
NDA MATRIX

	P/E RATIO	M/B RATIO	EPS	DIV. YIELD	DIV. PAYOUT
1	0	0	0	0	0,809
2	0	0	0,872	0	0
3	1,706	1,823	0,023	0,834	0
4	0	0	0	0	0
5	0	2,327	0,719	0	0
6	0	0	0	0	0
7	0	0,481	0,284	0,342	1,136
8	0,868	0,174	0,944	0,756	0
9	0	0	0,603	0	0
10	0	0	0,305	0	0
11	0	0,675	0,605	0,116	0
12	2,038	0,937	0,943	0,864	0
13	0,170	0	0,302	0,623	0
14	4,238	0	0,983	0,917	0
15	2,543	0,058	0,873	0,872	0
16	0	0,060	0,928	0,477	0
17	0	0	0,796	0,238	0
18	4,197	0	0,884	0,915	21,735
19	0	0	1,289	1,965	0
20	0	0	0	0	0
21	0	0	0,505	0	0
22	0	0	1,143	1,332	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0,645	0,249	0,286	0
26	0	0	2,394	2,549	0
27	0	0	0,374	0	0

TABLE XIV
RESULTS OF DEMATEL-EDAS

	SP _i	SN _i	NSP _i	NSN _i	AS _i	Rank
1	0,527	0,129	0,228	0,973	0,601	9
2	0,402	0,213	0,174	0,956	0,565	11
3	0,160	0,870	0,069	0,820	0,445	23
4	2,313	0	1,000	1,000	1,000	1
5	0,399	0,566	0,173	0,883	0,528	18
6	1,359	0	0,588	1,000	0,794	4
7	0,077	0,399	0,033	0,918	0,475	21
8	0,160	0,609	0,069	0,874	0,472	22
9	0,345	0,147	0,149	0,970	0,559	12
10	0,367	0,075	0,159	0,985	0,572	10
11	0,283	0,284	0,122	0,941	0,532	17
12	0,160	1,029	0,069	0,787	0,428	25
13	0,178	0,236	0,077	0,951	0,514	19
14	0,224	1,400	0,097	0,711	0,404	26
15	0,160	0,982	0,069	0,797	0,433	24
16	0,188	0,331	0,081	0,932	0,506	20
17	0,351	0,241	0,152	0,950	0,551	13

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 İstanbul Technical University & Bahçeşehir University

18	0,123	4,840	0,053	-	0,026	27
19	0,539	0,702	0,233	0,855	0,544	15
20	1,390	0	0,601	1,000	0,800	3
21	0,629	0,124	0,272	0,974	0,623	7
22	0,725	0,542	0,313	0,888	0,601	8
23	0,676	0	0,292	1,000	0,646	6
24	1,585	0	0,685	1,000	0,843	2
25	0,258	0,226	0,111	0,953	0,532	16
26	0,743	1,087	0,321	0,775	0,548	14
27	0,803	0,091	0,347	0,981	0,664	5

2) *EDAS with CRITIC weights:*

The second application shows the results of the combination of EDAS with the weight results of CRITIC. Due to the page limitations, we skipped all the calculation details and gave the ranking results in Table XV. The first three ranked alternatives are Firm 4, Firm 24, and Firm 6.

TABLE XV
RESULTS OF CRITIC-EDAS

	SP_i	SN_i	NSP_i	NSN_i	AS_i	Rank
1	0,522	0,150	0,301	0,971	0,636	10
2	0,440	0,150	0,254	0,971	0,613	11
3	0,185	0,971	0,107	0,813	0,460	25
4	1,732	0	1,000	1,000	1,000	1
5	0,401	0,718	0,231	0,862	0,547	18
6	1,294	0	0,747	1,000	0,874	3
7	0,068	0,445	0,039	0,915	0,477	22
8	0,185	0,523	0,107	0,899	0,503	21
9	0,367	0,103	0,212	0,980	0,596	15
10	0,395	0,052	0,228	0,990	0,609	12
11	0,294	0,298	0,170	0,943	0,556	16
12	0,185	0,977	0,107	0,812	0,460	26
13	0,213	0,201	0,123	0,961	0,542	19
14	0,282	1,204	0,163	0,769	0,466	24
15	0,185	0,845	0,107	0,838	0,472	23
16	0,210	0,262	0,121	0,950	0,535	20
17	0,412	0,180	0,238	0,965	0,602	14
18	0,186	5,201	0,108	0	0,054	27
19	0,549	0,581	0,317	0,888	0,602	13
20	1,236	0	0,713	1,000	0,857	4
21	0,659	0,087	0,380	0,983	0,682	6
22	0,696	0,440	0,402	0,915	0,659	8
23	0,626	0	0,362	1,000	0,681	7
24	1,367	0	0,789	1,000	0,895	2
25	0,272	0,260	0,157	0,950	0,553	17
26	0,815	0,878	0,470	0,831	0,651	9
27	0,813	0,064	0,469	0,988	0,728	5

V. DISCUSSION

A. Comparison Of Results:

Usage of DEMATEL and CRITIC weighting methodologies resulted in different importance weight sets for the criteria of financial ratios. According to DEMATEL, EPS is the most important criterion while dividend payout is the least important one. However, CRITIC method resulted in the M/B ratio being the most important and EPS being the least important criterion. DEMATEL-EDAS and CRITIC-EDAS

combinations virtually obtained similar rankings that in both combinations best and worst places are taken by the same firms and there are slight changes in other ranks.

Sensitivity Check:

The sensitivity of each criterion is checked by increasing one criterion's importance by 10% and decreasing the rest of them proportionally. Since we have 2 assessment combinations as CRITIC-EDAS and DEMATEL-EDAS and 5 criteria, each combination includes 5 scenarios which are created by increasing the weight of each attribute alternately and decreasing the others proportionally, and a total of 10 different scenarios are obtained (Table XVI). The best and worst alternatives are virtually the same in each scenario, however, there are insignificant changes in the middle-ranking alternatives. Results prove to us that deciding on the best stocks to invest in and the worst stocks to eliminate from options are more solid decisions than acting according to the ranking of one created scenario. Because middle-ranking alternatives are very sensitive to slight changes in importance weights.

TABLE XVI
SENSITIVITY TABLE

	1	2	3	4	5	6	7	8	9	10
	ED- CR PO	ED- CR YI	ED- CR EPS	ED- CR MB	ED- CR PE	ED- DEM PO	ED- DEM YI	ED- DEM EPS	ED- DEM MB	ED- DEM PE
1	8	10	12	10	8	7	9	10	9	8
2	11	12	11	11	10	12	13	12	11	10
3	24	25	26	23	25	23	23	23	23	23
4	1	1	4	1	1	1	1	1	1	1
5	21	20	16	16	20	19	19	16	13	18
6	3	4	1	3	3	4	4	2	3	4
7	20	23	25	22	26	17	22	22	21	22
8	22	21	21	21	21	22	21	21	22	21
9	12	15	15	14	14	11	14	14	12	11
10	10	14	13	12	11	9	12	13	10	9
11	16	16	17	17	18	15	17	17	15	15
12	25	26	24	25	24	25	25	25	24	26
13	18	18	19	19	16	16	18	20	19	16
14	26	24	22	26	22	26	26	26	26	25
15	23	22	23	24	23	24	24	24	25	24
16	19	19	20	20	19	20	20	19	20	20
17	13	13	14	15	12	13	15	15	17	12
18	27	27	27	27	27	27	27	27	27	27
19	14	11	10	13	15	18	11	11	16	19
20	4	2	3	4	4	3	3	4	4	3
21	7	9	7	7	6	8	8	6	7	7
22	9	6	8	8	13	10	7	7	8	13
23	6	8	9	6	7	6	5	8	6	6
24	2	3	2	2	2	2	2	3	2	2
25	17	17	18	18	17	14	16	18	14	14
26	15	5	6	9	9	21	10	9	18	17
27	5	7	5	5	5	5	6	5	5	5

VI. CONCLUSIONS

DEMATEL-EDAS and CRITIC-EDAS combinations result in same as Firm 4 being the best and Firm 18 being the worst alternatives. DEMATEL method results as EPS has the highest, dividend payout has the lowest weight while CRITIC method results as M/B ratio has the highest and EPS has the lowest

importance. It is obvious that objective weighting method CRITIC and subjective weighting method DEMATEL leads to different weighting of the criteria, however these two different weight sets combined with EDAS resulted as best and worst ranked companies being the same and slight deviations through the middle ranks. Considering this deviation, a sensitivity analysis was conducted to test whether slight changes in criteria weighting increase the volatility in the rankings. Sensitivity analysis consisting of 10 different scenarios in which the criteria weights are alternately increased while the others are proportionally decreased proved that best alternative Firm 4 and worst alternative Firm 18 are found in all scenarios. However, this study has some limitations while comparing the performances of stocks among middle ranked alternatives due to the increasing uncertainty of real ranking through the middle alternatives. Therefore, this study could only suggest to include the best resulting stock and exclude the worst resulting stock. A further study should work on obtaining a certain ranking to help investors to direct the right amount of capital to the right stocks. To conclude, this study suggests best resulting alternative Firm 4 should be included while worst resulting Firm 18 should be excluded from the investment portfolio while a decision for middle ranking alternatives is exposed to high uncertainty.

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System of Systems (Sos) Approach in Defining the Boundary of Stakeholder Involvement in Smart City Governance

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Abstract— Smart city development nowadays has become a popular strategy for many countries around the world to achieve sustainable goals for economic growth and natural environment protection within urban areas. Smart city development not only requires significant technological and financial resources, but also requires the high-level involvement of various stakeholders during city development stages. Identifying the boundary of stakeholders' involvement in smart cities plays an essential role in establishing effective strategies for communication and conflict resolution. Traditional approaches to stakeholder involvement provide static procedures for stakeholders' identification and assessment; however, there needs to be a new approach to capture the dynamics of stakeholders in practice. In line with this need, this study proposes the use of five established characteristics of System of Systems (SoS) as follows; autonomy, belonging, connectivity, diversity, and emergence, in order to assess the independency level and interrelationships between key stakeholders. This promising approach provides a blueprint for capturing dynamic interactions between key stakeholders that could be used effectively for decision-making scenarios during smart city development stages.

Keywords— Smart City Governance; Stakeholder Involvement; System of Systems

I. BACKGROUND

The number of people residing in urban areas is expected to increase from 50% in 2010 to more than 75% by 2050 [1]. Given that more people are choosing to live in urban areas, municipal governments are faced with an increasing range of technical, social, physical, and organizational issues that arise due to diverse groups of people living in limited spaces. Growing urbanisation creates many problems that result in a reduced quality of life, such as inequality, insecurity, and pollution [2]. When urbanisation is rapid, there is an urgent need for governments to find more optimal ways to respond to the challenges; for example, traffic congestion, pollution, increased crime rates, and problems concerning waste management [3, 4]. The reasons behind the attraction to the smart city concept are many and varied. One major goal is improving the quality of life of citizens. Other goals are around investment and sustainability using intelligent solutions [5]. Desire to generate additional wealth is another clear motivator [6]. Higher service expectations is another factor putting pressure on governments [7]. Promoting knowledge-based industries within the smart city, in order to attract and retain highly qualified people is emphasised by other authors [8].

The concept of the “smart city” was first aired in the 1990s as a way of addressing some of the problems arising from rapid urbanization, and this often focused upon information and communication technology (ICT) [9]. Many studies have defined the smart city concept in a variety and contexts [10-12]. When considering technology, some authors have highlighted the many advantages that smart technologies can bring to urban systems, such as transport and traffic regulation systems and highly developed energy technologies (smart grids). ICT is often viewed as the anchor for smart city definition. Some later definitions have moved away from the focus on ICT and focussed instead upon trying to find an equilibrium between technology, people and institutions [13].

Some research has focused on smart people as the backbone of smart cities, defining smart cities as areas where a large number of the population hold a university degree, which is a driver of urban growth [14]. People will be attracted to live in cities that a higher quality of education because wages and quality

of life are often increased. Other research focuses on the connection between technology and social structures. The smart city idea can be viewed as a user-centred development of other more technological city concepts [15]. Constructive interactions between technical systems and people can create a synergy where there are open data and open innovation, and collaboration between stakeholders will be foundational for this approach [4].

One key characteristics of the smart city is smart governance [16]. This includes citizens' participation in decision-making, as well as in service provision and developing policy [17]. Through the utilisation of smart city governance, the city can better understand citizens' problems and can manage these through sophisticated ICT. Smart governance is present when stakeholders are given the opportunity to be fully engaged in decision-making [18]. Such technologies as social media and open data strengthen the possibilities of cooperation between governments and their citizens [19], ensuring that services and operations are truly citizen-focused [20]. The rapid development of ICT can reshape city governance into "smart governance" by permitting governments to operate more efficiently and effectively [8, 21]. ICT provides great opportunities to encourage new forms of communication between governments and citizens [19].

II. RESEARCH METHOD

The research was conducted through two main processes: a literature review on 'smart city', and investigation of system of systems (SoS) application in practice. The literature review was undertaken in three phases. In the first phase, a range of papers was retrieved using an advanced search query in Web of Science, Scopus and Science Direct. The search term 'smart city' AND 'governance' AND 'stakeholder' were used to retrieve articles, conference proceedings books, book chapters and doctoral theses. In the second phase, the literature review was refined through analysis of abstracts and introduction sections; and this second phase produced a sample of 57 research outputs. Finally, papers selected in the second phase were read carefully and those relevant to the research question retained in the database and subjected to a qualitative content analysis. The final database contained 27 papers published in international journals, books, conference proceedings or other research outputs. The content of these papers provides insights on smart city governance and the stakeholders involved in the smart city system.

In terms of System of Systems (SoS), we focused on the application of SoS for complex systems via real cases and investigated whether the SoS approach is useful for identifying the involvement boundary of key stakeholders in smart city governance. The results show that SoS has potential for identifying key stakeholders in smart city governance and recognizing the interactions among them.

III. RESULTS AND FINDINGS

A. Smart City Governance Conceptions

The literature review indicated the presence of several views of smart city governance as follows: (1) smart city government; (2) smart decision-making; (3) smart administration; and (4) smart urban collaboration. The first type is quite straightforward and means governance of a smart city, with no need for significant changes in processes and structures. Smart governance concerns making the right policy choices, implementing them effectively, and these actions can be accomplished within the existing structures [22]. Smart governance is a characteristic associated with the management of a smart city. The second view concerns smart decision-making [23], as in the need for innovative approaches to decision-making and implementation of the decision. There is no need here to restructure organisations or governmental institutions. Decision-making processes can be improved through the use of network technologies, and smart governance can be brought about by collecting data using sensors.

The third view focuses upon smart administration. These days, governments need to be more innovative but in the context of reducing costs, they must make decisions in a highly connected world, where stakeholders have high expectations about being consulted. The application of ICT within government has become a way to reform administration, and digital government is viewed as a transformational effort aimed at improving service delivery and efficiency, transforming practices and functions by placing the citizen at the centre, increasing decision transparency, promoting openness, and reducing the possibility of corruption [24]. The fourth view suggests that smart governance really is a repositioning of government. The internal organisation needs to be transformed. This is a more community-based approach. In this view there is a need for the government of a smart city to encourage participation and involvement in a proactive fashion. Bătăgan [20] indicates that 'smart governance means collaborating across departments and with communities, helping to promote economic growth and at the most important level making operations and services truly citizen-centric'. Pereira, et al. [24]

examined the use of ICT to enhance the efficiency of administration, to focus on the citizen and on service delivery. ICT is now a facilitator of new relationships, wherein the citizens' concerns become more important in policymaking. We can now develop smart governance when governments coordinate the efforts of the various stakeholders involved. Technology thus enables the transformation of governments and their interactions with businesses and people.

B. Stakeholder Involvement in Smart City Governance

Tawfik Mohamed, et al. [25] presents various definitions of stakeholders, including the classic definition by Freeman in 1984 that stakeholders are: “those groups or individuals who could affect or be affected by the achievement of the firm’s objectives.” Since that time there have been various definitions, including the idea that stakeholders are people who have an interest in the project and who could affect the outcome [26] and that of Bourne [27] that stakeholders have an interest or some aspect of rights or ownership of the project and can contribute to or be impacted by project outcomes. Various typologies of stakeholders have been presented, with many of them concerned about issues of power, legitimacy, proximity and urgency [28] [29]. Stakeholder management has been picked up as an important area of strategy building. Managers need to pay attention to various wide-ranging groups of stakeholders and do this in a strategic fashion [30]. There are usually many groups of stakeholders that need to be considered. When we consider the range of stakeholders involved in developing and running a smart city, the group is indeed wide and varied. The list below shows the range of agents who will want to have a say and some buy-in within the unfolding of a smart city project. They will have a variety of different interests, and these will have to be somehow understood, integrated and negotiated [31]. When we consider smart city development, key stakeholders will include the following groups: ICT representatives, local governments, local citizens, investors, infrastructure suppliers, media, business organisations, and non-profit organisations. It is going to be challenging to encourage and mediate the involvement of such widely differing groups of people.

Non-profit organisations will include, for example, academic researchers, who are concerned with the impact of smart city living on people, including increasing their quality of life and the efficiency and sustainability of the smart city [32]. Local governments are also key stakeholders and, according to Fernandez [32], their major concerns are about the nature of the governance of the smart city and the environment it provides. Sustainability is important to this group, as is efficiency. It is local government that has the major role of establishing the basis for development of the smart city. Business organisations and private providers, according to Fernandez, are focused upon mobility and efficiency, as well as connection and innovation. They focus upon the urban aspects of the city and management solutions that can improve its efficiency. According to a literature review by Marrone and Hammerle [31], news media consider as priorities the following factors: Internet of Things, technology, infrastructure, urban planning, energy, transportation, and innovation. IoT was the top scorer for all types of literature except for government reports where it was not often mentioned. Within academic literature, the most frequent topic was smart mobility, which is linked with communication and system integration through technology. Within government reports, the most important mention was the smart economy. The authors conclude that the perspectives of citizens themselves are often ignored within smart city development, and citizens could be regarded often as an inferior party when compared with other stakeholders. ‘Smart people’ were not mentioned in this literature survey.

Another literature review by Jayasena, et al. [33] highlighted the importance of stakeholder engagement and management in the domain of the smart city. Engagement of stakeholders is necessary at every stage of the development of a sustainable smart city, say these authors, who identified the following list of stakeholders to be considered: academia and research institutions; local and regional administrations; financial suppliers/investors; energy suppliers; ICT sector representatives; citizens; government; property developers; non-profit organisations; planners; policymakers; experts and scientists; political institutions; and media. They note the growing interest in the concept of the smart city as reflected within academic research and the importance of considering such stakeholders in planning and developing smart city strategies. Local and regional administrations need to be actively involved in the initiation, promotion, and support of such projects. Investors are very important for obtaining the extensive funding required and investors will be interested in their return on investment for such a project. Energy suppliers are important because smart cities consider sustainability as a priority; and so a sustainable energy policy is key. ICT representatives are also key stakeholders because during the initiation and operational stages, technological factors are essential requirements. Citizens are major stakeholders who can give their feedback regarding their experience of urban spaces and any inefficiencies or negative views in the initiation and rollout of such projects. Government is a key stakeholder because smart cities give many solutions to challenges

currently faced. Property developers are important stakeholders and quite diverse in nature, and they may often have conflicting interests. Property developers are invested in innovation and technological advances. Non-profit organisations are interested in the outcomes of smart city implementation and continual learning through the development stage. Planners are interested because the smart city concept can help to achieve sustainable development. Policymakers are focused upon transparency and accountability within the smart city through the goal of achieving sustainable development. Experts and scientists are interested in the planning processes and contribute to innovation at that stage. Political institutions are important stakeholders because sharing experiences helps with future projects. Finally, the public media can influence project in both positive and negative ways.

It can be seen from this summary that while there are some overlaps in stakeholder interests, there are also many differences, and it is important for the success of a smart city project that the interests of all groups of stakeholders are actively assessed, monitored, and appropriately managed.

C. SoS Approach to Identify the Stakeholder Involvement Boundary of Smart City Governance

Within traditional cities, the constituent systems are mostly standalone, and they do not really interoperate with other city systems. However when a smart city is designed, a major goal is to interconnect the various systems and subsystems together in order to produce benefits of emergence: thus in this paper the smart city is considered through the lens of systems theory [34]. In reality, considering the smart city as a closed system is not suitable. Urban issues are offer highly interconnected, and the various elements of the smart city need to be considered together taking a holistic framework. Smart governance can only occur through the coordination of the many agencies with their specific responsibilities. Combining the various levels of governance, from the community level up to the top levels of government, will require the integration of top-down expertise and the input of all stakeholders through open governance. This will enable the government to respond quickly to social challenges. Communities are demanding greater engagement in the planning and envisioning of their city, and therefore the traditional approach of expert master planning must be combined with planning driven by the local community. This more integrated holistic solution, which is more suitable to addressing the complex challenges of urban planning, is enabled by today's technological innovation.

The concept of the System of Systems (SoS), with its defining nature of openness to the environment, presents a holistic vision of the system as a whole, combined with the complicated interactions between the constituent systems. This vision is much more aligned with the contemporary concept of smart cities. According to Jamshidi [35], SoS consist of large scale, integrated, heterogeneous systems that can operate independently, while at the same time being networked so as to achieve a common goal. Five characteristics of SoS initiatives are commonly used to assess whether they are SoS projects or not. The first of these five characteristics is autonomy. Each individual system can make independent choices in pursuing its own purpose. A second characteristic is belonging, in which a system accepts that it needs to change to forge new relationships with other autonomous systems in seeking the overall purposes of the whole SoS. Connectivity of SoS is considered as a third characteristic. Elements of a SoS create connections to seek interoperability with all the components. A further essential characteristic of a SoS is diversity; a variety of views, processes, technologies and functionalities used in the SoS are different from those present in other systems [35]. The fifth characteristic of SoS is the emergence of new properties during development or evolution.

A smart city integrates various stakeholders, some of them public and some of them private, including a wide range as noted above: citizens, business sectors, investors/developers, ICT representatives, infrastructure suppliers, non-profit organisations, and media. Each of these systems is complex. One important issue is how to identify and understand the motivations of the key stakeholders. It is also important to identify the interactions between these key groups. Clearly key stakeholders need to be considered as constituent systems of the greater whole, sharing the same overall mission in smart city development. However, key stakeholder groups may also have different purposes (power and interests) in smart city development, so it is important to identify their role in the SoS. Based on the five typical characteristics of SoS, the boundaries of key stakeholders involved in smart city development are assessed and presented in Table 1. This table uses the five distinguishing characteristics of SoS to assess the intensity and involvement of eight groups of stakeholders relevant to smart city development.

International Engineering and Technology Management Summit 2022– ETMS2022
İstanbul Technical University & Bahçeşehir University

TABLE 1

RETHINKING STAKEHOLDER INVOLVEMENT BOUNDARY THROUGH SOS CHARACTERISTICS ASSESSMENT

List	Key Stakeholders	Autonomy	Belonging	Connectivity	Diversity	Emergence
1	ICT Representatives	This group can exercise their own decision-making while at the same time taking account of the need to conform to some smart city governance rules	This group choose to belong to the smart city entity, so the belonging characteristic is tending towards decentralisation	Highly interconnected with other stakeholders	This group comes from many different backgrounds and can behave differently	New forms and properties can emerge as a result of unpredictability
2	Local Governments	Medium on autonomy: local government can make some of their own decisions but at the same time some need for conformance	A tendency toward centralized, given the need of local governments to conform to regulations	Network centric: their policies and rules have wide impact	This group can vary in terms of size, jurisdiction, and policies	Emergence is lower in this group because government is based upon predefined policies to a large degree
3	Local Citizens	Highly autonomous	Decentralised; open to having their opinions changed	Network centric: many connections with different businesses	Highly diverse in interests and attitudes	While some aspects of people's behaviour are foreseen, the majority is unpredictable because people tend to not follow rational decision-making
4	Investors such as property developers and banks	This group can make their own managerial and operational decisions	This group can exercise their right to be part of the smart city and choose to invest	Highly interconnected among themselves and with other stakeholders involved	Investors vary based on size, policies, entities, organisational structures, the nature of their investments and returns et cetera	Because this group has an appetite for returns, greater uncertainty and risk means greater opportunity
5	Infrastructure Suppliers such as energy, water and building suppliers	Somewhat conformant to regulations and therefore decision-making is restricted	This group needs to be controlled centrally for a variety of reasons including standardisation, safety, et cetera	Network centric: connected to many parts of the SOS	Homogeneous within their own categories yet heterogeneous amongst categories	Typical operations tend towards foreseen but there are always crises and unexpected circumstances where emergence can occur
6	Media including newspapers and broadcasters	Medium on autonomy depending on the jurisdiction. In some countries this group are highly autonomous in exercising their own decision-making.	Medium on belonging, not highly controlled in free societies although in some countries there will be strong government control	Highly connected with other stakeholders in the search for information	Heterogeneous to meet the market's needs and preferences	Quite adaptable and can change direction quickly
7	Business Organizations , supplying business services such as services including consumables	This group of stakeholders can make their decisions autonomously and work independently	Medium on belonging, somewhat centralised	Highly connected with a range of stakeholders: network centric	Highly diverse because there are many needs within the SOS	Emergence can be translated into high risks, opportunities, and innovation

8	Non-profit organizations such as educational institutions, community organisations	This group need to be autonomous in their decision-making to give unbiased information	Decentralised and open to the SOS in the search for connections and opportunities	Network centric with many connections throughout the SOS	Heterogeneous representing many different views	Emergence can occur through new technology or sudden changes and unleash greater value for their audience
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In considering table 1, it can be seen that these different groups of stakeholders have quite different motivations in their operation within the smart city. While some are highly autonomous and independent in the way they operate and in the range of actions that they can choose to undertake, others are somewhat constrained by regulations and requirements. Some stakeholders have a high need to belong to the SOS for various reasons and are therefore accepting of a degree of control. Some stakeholders are heterogeneous in nature, and others are not. Some stakeholders are more tolerant of uncertainty. Table 1 shows that all these stakeholders appear to have the characteristic of network centrality because of their ability to link with other systems in the SOS.

The table shows that relevant stakeholders for the smart city context have different intensities of involvement. This level of intensity can be a mechanism by which the governing body can identify relevant stakeholders involved, and also the relationships among them. Some stakeholders are more involved and more active than others. The richer these defining characteristics are, the more active is that group of stakeholders. Passive stakeholders should be managed differently from active stakeholders: active stakeholders need careful consideration and management. Interdependencies among stakeholders may not always be visible, but interconnectedness and entanglement are indicators of participation and commitment. The greater the dependence on any particular group of stakeholders, the more effort should be placed on managing that group. Within management there is always a need to prioritise resources. This approach helps such prioritisation when more efforts will be allocated to those stakeholders that are more embedded in the SOS through richer involvement through stronger intensity, as revealed by their assessments on the five distinguishing characteristics. In fact, intensity occurs along a spectrum providing a more accurate description of how to assess stakeholder involvement and manage their requirements.

IV. CONCLUSION

Identifying the boundary of stakeholders' involvement in smart city governance plays a crucial role in establishing effective strategies for stakeholder engagement during development stages of smart cities. In this paper, we have provided a new approach to stakeholder involvement assessment via the use of five characteristics of System of Systems (SoS). Five typical characteristics of autonomy, belonging, connectivity, diversity, and emergence were applied to investigate the interdependencies (inner and outer interactions) between key stakeholders, as well as to identify the involvement boundary of key stakeholders. The findings indicated that local citizens are a central group within smart city governance, given their high levels of autonomy and diversity with many connections within a network-centric structure. ICT agencies in smart cities have an important role in improving the feedback mechanism via advanced technology. In line with the improvement of the connectivity characteristic in smart cities, other stakeholders have significant impacts regarding diversity, autonomy, and connectivity in real life. The interaction among stakeholders is nonlinear and dynamic; and the traditional approach to stakeholder involvement has limitations when applied to complex projects such as smart cities, so it is important to use the five typical characteristics of SoS for interaction assessment. As part of future research, the authors plan to assess the relationships among stakeholder groups based on these SOS characteristics using dynamic models such as system dynamics. Ultimately, stakeholder management needs to be conducted in a holistic fashion because often the relationships between stakeholders are non-linear. It will be useful to understand how managing one group of stakeholders may have an impact on other groups. Optimizing the management of one stakeholder group may not always be the best way to go. A more advanced understanding of stakeholder management is necessary when considering such complex systems as smart cities.

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The Impact of Digital Technology on Capacity and Operations Planning of the Transport Sector

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Abstract— The Transport sector is of pivotal importance for the economy and development of the countries. Recently, different digital technologies have been used to enhance the efficiency and competitiveness in transportation. In light of this context, this paper investigates the impact of digitalization in the transport sector by employing the input received from digital tools to enhance the planning of transit capacity and allocate buses to different routes. Therefore, a mathematical model to optimize the trip cycle time including both the travel time and the dwell (loading/unloading) times is presented.

Keywords— Digitalization, Transport sector, Optimization, Linear Programming, Bus Allocation

I. INTRODUCTION

In the last decade, there has been a growing interest in the concepts of digitization, digitalization and then on digital transformation. It is important to precisely define these terms which were used interchangeably in the past before being studied in the literature. According to Dobrica Savic [1] digitization reflects the conversion from analogue to digital format, while digitalization refers to the automation of various business processes and operations, along with information processing. Meanwhile, digital transformation is creating a digital company by enabling digitalization. Schwab [2] stated that we are at the beginning of a revolution that is directly change the way people live, work, and interact with each other, where technology plays a significant role in this change [3, 4].

Digital technology dramatically improves the efficiency of organization and offers applications that can improve manufacturing, organizing, buying and selling [5]. Transport sector can substantially benefit from adopting digital technology regardless of the transport mode. In fact, the transport sector was one of the first sectors to adopt digital technologies. Through digitalization, the transport sector can contribute to improve security and safety for its users, grow profitability, minimize risks, and reduce vehicle downtime [6]. Moreover, the digitalisation of the data will provide a faster and more accessible reach of the data, allowing for smoother operations such as payment process and forecasting traffic congestion. Despite these potentials, the digitalization of the transport sector is still lagging behind compared to other industrial genres. According to [7] one of the biggest challenges is the absence of a reliable and modern logistics digital platform. In addition, the transport sector generates large amounts of data; however, using this data effectively is a challenge as the data is stored in different places.

There is a constant need for evaluating the development of transport infrastructure for its importance to the economy and social welfare. This study elaborates on the role of digitizing the transport sector and highlights how digitalization can help planners and managers to improve the transportation planning and performance assessment. The remainder of this paper is organized as follows: Section 2 briefly describes the problem under study. Section 3 presents background and literature review with more focus on the digitalization aspects and manifestation of digital technology in public transport. Section 4 discusses how digitalization can help engineering managers in the transport planning and procedural/ operational improvements. It also introduces a mathematical programming model to allocate buses to the routes. Finally, section 5 concludes the paper and highlights areas for future research.

II. PROBLEM DESCRIPTION

In a modern highly competitive transport services market where transportation remains one of the main driving forces in economic growth and countries development, there is a massive need for developing digital innovative models that can cope with the recent digital transformation. The aim of this study is to

analyse the potential impact of digital technology in the transport sector. More precisely, employ the input received from digitalized data collection tools to better plan the transit capacity and allocate buses to different routes. The goal is to optimize the trip cycle time including the travel time plus the dwell (loading/unloading) times. In addition, the proposed study spotlights on how operators will benefit from having access to transportation data, where collection and analysis of data will allow them to estimate the traffic flow and demand; a case which was not easily accomplished with the traditional old transport systems.

III. BACKGROUND AND LITERATURE REVIEW

The digital transformation in the transport sector and logistic services is a trending topic with a lot of applications; it is, however, rarely explored in the literature [8]. This section briefs some of the existing work in the area of transport sector digitalization. Kolar et al. [9] discussed the issues related to digitalization on rail transport as one of the transport modes in freight distribution to emphasize the impacts of digitalization on the global economy. The author's intention is to set a research agenda that will drive the empirically-based policy and industry-oriented applied research. Mashkina et al. [6] addressed the impact of digitalization on the transport sector and studied the nature of this impact. According to the authors, digitalization takes place in the transport sector much faster compared to previous technological revolutions. In addition, digital technologies can play a significant role in determining the competitiveness of transport companies.

More recently, Ahmedova [10] examined the digitalization of transport sector enterprises in Bulgaria under the effect of COVID-19, where a survey was conducted among 76 transport companies in addition to online discussion with company managers. The authors concluded that among the main barriers facing the digitalization of the transport sector is that the business in Bulgaria has low expectations of the impact of digitalization on profit growth and ecological problems. In addition to the employee qualifications and low investment rate. Altunta et al. [11] investigated the effect of different digital tools in increasing utilization of intermodal transport. The authors designed a qualitative research approach that combines Delphi method with semi-structured interviews and a brainstorming session. The authors concluded that the digitalization of the transport sector needs further evidence to ensure its benefit. Also the findings indicated that transport customers hesitate to adopt new technology innovation and tend to maintain the traditional way of purchasing transport service despite the recent advanced technology investments.

Aspects of digitalization in public transport

Digitalization in public transportation is a very broad area that is employed in multiple stages of the mobility service. In the following, we list a group of the most significant and clear manifestations of digital technology application we are benefitting from in public transportation daily use. Fig. 1 summarizes the benefits of the new adopted digital technologies both from passengers' and service providers' perspectives.

A. Mobile applications and platforms

In combination with the improved infrastructure of public transport and the diverse means of transportation, as well as the technological and digital revolution, easily accessible and user friendly transport mobile apps are essential. Such platforms help to allow for individualization of mobility patterns. It has become easy nowadays for foreigners or tourists to travel with public transportation in a country they visit for the first time. Thanks to the mobile apps which suggest the best route and details the transfer options to reach to the final destination. These apps also allow for customized trip planning by setting a group of criteria to the user such as cost, time, and number of transfers. Updating the passengers with real valued based trip time estimations also gives more comfort and reduces the pressure of possible delays.

B. Open payment systems

In the past, passengers have usually had to decide on an exact departure and arrival location, choose the right mode of transportation and type of ticket to pay before beginning their journey. This was causing confusion about ticket types and the bottlenecks in the planning and ticketing process were causing unnecessary customer delays and problems in public transport discouraging its use. Therefore, one of the most important changes in the digitalized transportation system is replacing paper tickets with electronic alternatives offering passengers much more flexible and comfortable options. In addition, payment through smart cards provides the service providers with accurate information and updated statistics about passengers' origin and destination (O-D) stations. This helps planners to collect more information about demand and plan capacity accordingly. Furthermore, contactless transactions are nowadays preferable especially during the pandemic era.

C. GPS connected bus stops/ smart screens

Smart screens are installed in bus and train stops to display updated real-time information to the passengers. The displayed information is related to the arrival time of buses supported by the different systems that have been installed in the vehicles themselves, connected by GPS. Such software is based on feeding the time prediction system from the GPS positions of the vehicles to adjust the data of each trip. This continuously updates the information and improves its accuracy.

In addition to the aforementioned main manifestations which are clearly noticeable to the end user, other pillars of digitalization are not of less importance. These items include:

- Traffic Flow Sensor (Speed and Volume)
- Traffic Monitoring Camera
- Image Sensing System
- Portable Road Tube Counter as well as Automatic Passenger Counting (APC) System.
- MDT (Mobile Display Technology): a computerized device used in public transit vehicles
- Bus Communications System (Voice and Data Communications System)
- GPSS Technologies and CAD/AVL Systems (Computer Aided Driving/ Automatic Vehicle Location)
- Automated Annunciation And Display System (AADS)
- Ticket Vending Machine (TVM)



Figure 14 Benefits of digitalization in public transportation

IV. HOW DIGITALIZATION HELPS MANAGEMENT ENGINEERS IN TRANSPORT PLANNING AND IMPROVING

As discussed previously, digitalization offers plenty of data and useful information that can assist transport planners in their work. This can serve as an input to analytical models and quantitative methods provided by management engineers. Fig. 2 outlines these research and development areas.

A proposed bus allocation mathematical programming model.

In this section, it will be presented how to use the data collected from digital systems in mathematical transportation modelling and optimization. First, the existing bus network should be defined. At this stage Geographical Information Systems (GIS) will be a useful tool. From a mathematical programming perspective, the network will have stations represented by nodes, and bus roads connecting these stations will be represented by arcs.

A: number of nodes (Stations)

a: Station Index $\in 1..A$

s: Section Index $\in 1..S$

$D_{s,h}$: Passenger demand at section s at time (hour) h where $h \in 1..24$

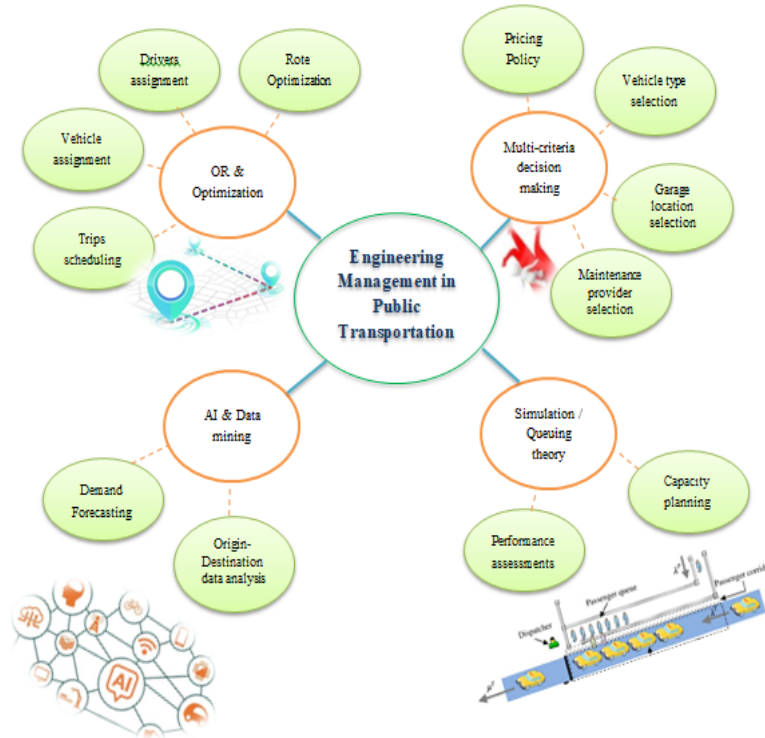


Figure 15: Engineering Management in Public Transportation

Automated Passenger Counting systems will provide how many passengers are using each section at a specific hour. However, from a network developing/planning perspective it would be better to work with origin and destination. To determine demand from origin i to destination j , Automated Fare Collection (AFC) systems coupling with GPS technology can be used. There are studies available which show how to use smart card data to determine passenger demand and how to distribute/assign this demand on sections of the network [12-13]. There is another aspect often missed in the literature, the variability of the demand data. Therefore demand data should be calculated at multiple times at different dates with similar characteristics. Then the standard deviation of the demand $\sigma_{D(s,h)}$ for each section and hour should be determined. Thus, the capacity requirement for each section can be calculated as:

$$CR_{s,h} = D_{s,h} + 1.96 \times \sigma_{D(s,h)}$$

If the capacity requirement is met, this will guarantee 97.5% service level assuming the demand is coming from normal distribution. For a given network and fixed “ R ” bus routes, a binary matrix $Y(R \times S)$ is needed that shows if route r uses section s . shows the main challenge would be how to allocate the bus resources to the routes at demand peak times. The efficient bus allocation to the routes will make the capacity utilization evenly distributed between routes. Therefore, the main decision parameter will be:

$n_{r,h}$: Number of busses dedicated to each route for each hour $r \in 1..R$ and $h \in 1..24$

At this point the travel time data for each route for each hour can be obtained using GPS/AVL data. After processing AVL data, route cycle times should be calculated ($T_{r,h}$) in minutes. This cycle time will include both directions travel times, layover times, preparation times, dwell times (loading and unloading times) at the stations.

The headway (the time between two successive buses) for each route will be:

$$HW_{r,h} = \frac{T_{r,h}}{n_{r,h}}$$

The hourly frequency of each route:

$$F_{r,h} = 60/HW_{r,h} = \frac{n_{r,h} \times 60}{T_{r,h}}$$

While determining the allocation of buses to the network, the whole network with all sections has to be evaluated.

Loading factor which represent the capacity utilization of the section can be expressed as:

$$LF_{s,h} = CR_{s,h} / \left\{ BusCap \times \sum_{r=1}^R (Y_{r,s} \times F_{r,h}) \right\}$$

At this point decision makers can choose different minimization objectives such as average or weighted or maximum Load Factor. Also an upper limit for headway should be selected. Since each hour optimization will take differently, each hour should be optimized independently and the hour index can be removed.

BusCap: Passenger capacity of a bus

N: Total Number of buses

HW_{max}: Maximum allowed headway/time between two successive buses

For average minimization, mathematical programming model will be:

$$\min Z = \frac{\sum_{s=1}^S \frac{CR_s}{BusCap \times \sum_{r=1}^R Y_{r,s} \times \frac{n_r \times 60}{T_r}}}{S}$$

Subject to:

$$\sum_{r=1}^R n_r < N$$

$$\frac{CR_s}{\left\{ BusCap \times \sum_{r=1}^R \left(Y_{r,s} \times \frac{n_r \times 60}{T_r} \right) \right\}} < 1 \quad \dots \forall s \in \{1..S\}$$

$$\frac{T_r}{n_r} < HW_{max} \quad \dots \forall r \in \{1..R\}$$

$$n_r : \text{positive integer} \quad r \in \{1..R\}$$

However better optimization model can be obtained by minimizing maximum loading factor

$$\min Z = \max_{s \in S} \frac{CR_s}{BusCap \times \sum_{r=1}^R \left\{ Y_{r,s} \times \frac{n_r \times 60}{T_r} \right\}}$$

However, this model is non-linear and makes it very hard to solve. By maximizing the minimum of inverse load factor (can be named as section comfort levels) values will linearize the mathematical model. Linearized model will be

$$\min Z = MinLF_{Inv}$$

Subject to:

$$\sum_{r=1}^R n_r < N$$

$$\frac{BusCap}{CR_s} \times \sum_{r=1}^R \left(Y_{r,s} \times \frac{n_r \times 60}{T_r} \right) - MinLF_{Inv} > 0 \quad \dots \forall s \in \{1..S\}$$

$$BusCap \times \sum_{r=1}^R \left(Y_{r,s} \times \frac{n_r \times 60}{T_r} \right) - CR_s > 0 \quad \dots \forall s = 1..S$$

$$HW_{max} \times n_r - T_r > 0 \quad \dots \forall r \in \{1..R\}$$

$$n_r : \text{positive binary int}$$

After allocating the buses to the routes, headways will be set for each route and each hour.

The engineering management activities in public transport planning can be set as follows:

- Setting headways and trip generations: In addition to revenue generating trips, non-revenue deadhead trips from garage or between terminals will be defined.
- Blocking: Trips will be combined together so that they can be covered by only one vehicle. There would be another optimization task here which will try to minimize kilometer and required buses.
- Run-cutting: Trips or blocks will be grouped so that it can be attended by one driver. A set of tasks that will be covered by one driver can be called daily work. The optimization model will try to minimize required number of personnel.

International Engineering and Technology Management Summit 2022– ETMS2022

Istanbul Technical University & Bahçeşehir University

- Rostering: Grouping of daily work so that weekly assignments among drivers can be evenly distributed. The off days of the drivers will be set at this stage. This is also a challenging optimization task. Heuristics can be utilized at this level.
- Assigning vehicles: Using vehicle database systems assignment of buses to the blocks should be performed. Bus maintenance systems and availability will have importance at this stage.
- Assigning drivers: Employee database will be utilized which will be available and covering daily works.
- Setting Key Performance Indicators
- Controlling the operation
- Evaluating the public transport system performance and service quality assessment
- Problem/issue detection and root cause analysis
- Developing corrective actions plans

All the aforementioned activities are supported by the ITS technologies listed in the previous section. Therefore, it can be concluded that digitalization has high importance and benefit in the public transportation capacity operations planning.

V. CONCLUSION

In this paper, we investigated the impact of digital transformation in the transport sector. Thus, we have presented a mathematical model to optimize the trip cycle time including the travel time plus the dwell (loading/unloading) times. The importance of this study is expected to be recognized by operators and decision makers as it allows them to estimate traffic congestion and demand way easier than traditional old transport systems. A detailed analysis for a case study will be presented in the summit. As future research potentials, the mathematical model can be extended to include more aspects of the transport planning e.g. blocking, run cutting, rostering, ... etc.

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The Sustainability in Istanbul City

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Abstract— The rapid evolution of urban freight operations due to e-commerce, technological advancement, and population growth poses both risks and opportunities. The risks manifest mainly in the increase of greenhouse gas emissions, and traffic congestion. On the other hand, urban freight offers opportunities for economic growth and provides job offers especially for people with low qualifications. Moving toward sustainability in urban freight is essential to maintain economic growth while reducing negative externalities. The objective of this paper is to evaluate the effectiveness of different urban freight strategies in the sustainability of freight operations in Istanbul-Turkey and assess their viability.

Keywords—Urban freight, sustainability, Strategies, Road pricing, Consolidation centers

I. INTRODUCTION

In recent decades, urban freight operations have received growing interest as an important topic in the research arena, as it plays a vital role within the whole transport system and is indispensable for the growth of the economy and the development inside cities. Several factors affect the urban freight operations such as customers shopping behavior and economic factors, and with the ongoing urbanization and the consistent growth of home delivery these factors are expected to pose further challenges to the urban freight transport system. The freight activities have a direct impact on several aspects of our daily life, but mainly on the environment, since most of the vehicles used in urban freight operations are powered using non-renewable energy sources, which results in an increase in the greenhouse gas emissions (GHG) [1], air pollution [2], and noise level [3]. In order to diminish those negative impacts, moving toward sustainable alternatives and solutions has become a priority. According to Behrends et al [4] the sustainable urban freight must ensure accessibility to the urban areas, improve the efficiency and cost-effectiveness, enhance the attractiveness and quality of the urban environment, contributing in enhancing the attractiveness and quality of the urban environment, and reduce the negative impacts caused by the delivery vehicles.

To improve the sustainability of urban freight transport, researchers have introduced a number of strategies and practices, such as road pricing, urban consolidation centers, using alternative vehicles, policies and regulations [5], [6]. Many of these strategies were implemented successfully in many cities in Europe and around the world. Despite their potential in enhancing the sustainability of urban freight, there is a barrier towards working with policies in urban freight areas [7]. Minken et al [8] categorize those barriers into four main groups: legal and institutional barriers, financial barriers, political and cultural barriers, and lastly practical and technological barriers [9]. The purpose of this study is to investigate the viability of different sustainable freight distribution strategies in Istanbul-Turkey, and raise the awareness and the knowledge of urban freight sustainability and challenges faces the policy makers. This paper is organized as follows: a brief background and an overview of the literature are presented in section 2. Section 3 presents the urban freight strategies and their applicability in urban freight distribution in Istanbul-Turkey. In section 4, we present recommendations and future work.

II. BACKGROUND AND LITERATURE REVIEW

Moving toward sustainable urban freight, whether by enhancing the current system or by introducing new technologies, faces many challenges such as lack in regulation and policies. Russo and Comi [10] investigated the sustainability of urban freight in several European cities. The authors argue that the most important aspect to make urban mobility more sustainable is to promote a sustainable development strategy, which can monitor and control the different types of costs generated by freight mobility in the urban area. The results obtained also show that good results in terms of environmental goals could be reached without the need of high cost investments. According to Eleonor and Blinge [11] having awareness

about freight transport is an important factor in increasing the sustainability in urban freight transport and can help in the policy making process. The authors also raise an important issue related to sustainability; the lack of motivation and knowledge for the local authorities to deal with the problem and rarely there is anyone responsible for freight transportation, which results in postponing the sustainable inside cities. Researchers have introduced a number of strategies and practices to optimize the urban freight operations, such as road pricing, urban consolidation centers, alternative vehicles, policies and regulations are among the most common ones.

Several studies have addressed the road pricing in context of urban freight operations, Ruesch [12] presented an overview of road pricing in urban freight context. The authors implemented pricing schemes in European urban areas. They conclude that road pricing leads to more sustainable freight operations and has the ability to improve the efficiency of logistics. The authors also recommend that pricing should be linked with regulations, loading factors, and vehicle size and type. For more on this literature, see [13]–[15]. The urban consolidation centers are essentially a logistics facility located in a relatively close proximity to the geographic area that it serves [16]. According to Faure et al. [17] the effectiveness of UCC is related to their locations and numbers. In general, the urban consolidation centers have the ability to reduce the movement of vehicles inside cities, and therefore, reduce air pollution, noises and energy consumption. For more see [18, 19,20, 21]

Different regulations and policies implemented in urban freight to manage the urban freight sustainability such as setting delivery time windows, low emission zones, loading and unloading operations. The main target of those policies is to limit the vehicles access to the urban areas in a way that minimizes congestion, pollution and improves air quality. Malik et al [22] studied parking practices and problems of freight-vehicles in Gothenburg, (Sweden), and Delhi (India), through two main aspects: the causes of illegal parking by freight vehicles, and the feasibility of the available parking-management initiatives. The authors also investigated the possible impacts of imbalance between parking demand and supply. Diana et al. [23] developed a method to select a set of loading/unloading points which they applied on a dataset from real operations in the city of Turin (Italy) by processing the GPS traces of a fleet of logistic vehicles.

Using eco-friendly vehicles instead of fuel vehicles may reduce greenhouse gas emissions, pollution, and noises. Electric vehicles are among the most investigated vehicles to be used in urban freight operations to reach sustainability in urban freight operations. Mirhedayatian and Yan [24] investigate the policies supporting EVs in urban freight transport by establishing a theoretical framework combining an optimization model with economic analysis to evaluate individual company’s actions in response to policies for electric vehicles. According to the authors, there are three main policies that can support the use of electric vehicles: purchase subsidies, low-emission or congestion zones, and vehicle tax exemptions. Table 1 illustrates some of the strategies that have been implemented in different cities around the world

TABLE XIX
 DIFFERENT STRATEGIES THAT HAVE BEEN APPLIED IN DIFFERENT CITIES WORLDWIDE.

Strategies	City	Reference
Road pricing	London	[10]
	Stockholm	
	Tokyo	[25]
Consolidation centers	London	[26]
	Tenjin	[27]
Alternative fuel vehicles	New York	[26]
	Australia	[29]
	London	[30]
	Amsterdam	
Loading and unloading	Turin	[23]
Zero-Emission Zones	Rotterdam	[31]
	Shenzhen	

III. METHOD

In this paper, the synthesis is investigated based on a review of different literature reviews from domestic and international sources along with government reports. Where we included more than (71) academic

articles and scientific books, and a total of (183) references to ensure that the review is comprehensive, and covers the different aspects of urban freight operations sustainability in the city of Istanbul. However we cited here only the most significant references.

IV. URBAN FREIGHT STRATEGIES AND THEIR APPLICABILITY IN ISTANBUL-TURKEY

Istanbul is the largest city with respect to the population in Turkey, located in north-western [32]. The total area of Istanbul is 5,343 square kilometers, as of 30.12.2020 [33]. Recently, Istanbul witnessed new ground and underground projects that enhanced the performance of the urban freight transport system, and helped in evolving this sector to include more services resulting in a positive impact on the country's economy. On the other hand, the transportation activities have increased inside the city resulting in an increase in air pollution, traffic congestion, noise, and greenhouse gas emissions. Therefore, paying more attention to the efficiency and sustainability of urban freight operations has become a pressing issue due to its economic, social, and environmental importance. As many developing cities, Istanbul does not have a sustainable freight management plan, and this might be due to the conflict of authorities between different stakeholders in urban freight, lack of the awareness of the importance of the sustainability of urban freight operations, along with the nature and characteristic of the city.

Road pricing has proven its efficiency in urban freight operations over recent years as it can be obtained easily in development cities and urban areas, which applies to the city of Istanbul, where the construction of new roads is an ongoing process. The road pricing can be applied to major and congested roads within urban areas, with a potential to apply different prices during the day, where at peak periods, the prices can be higher, or it can be fixed prices all the day. The use of road pricing in Istanbul is applied on some highways and bridges for both passenger cars and urban freight vehicles. The prices for urban freight vehicles are higher than that of passenger cars, due to their sizes and the amount of CO₂ emissions they produce. The prices for freight vehicles vary between \$1.4- \$18.4 [34]. However, applying road pricing on the entire roads inside the city could be impossible, since the company's argued that adding additional costs will decrease their competitiveness with rail [35]. Therefore, an extensive study to the mechanism of pricing the road in Istanbul is required so that the environmental impacts are decreased and the companies will not be affected. Therefore, we estimate the applicability of road pricing in the city of Istanbul to be medium. It is worth mentioning that all road pricing strategies like, annual registration fee, fuel excise tax, cordon charging, and kilometer charging can be implemented successfully in Istanbul city.

Urban consolidation centers (UCC) considered as the most famous pooling solution to deal with city logistics in European cities [18] [35], despite that, most published works that considered the UCC indicate that their impact on improving the transport activity can be considerable, however their impact on environment and congestion is less significant [28]. According to Allen et al. [16] [37] many of urban consolidation centers have closed in different cities around the world, due to the absence of funding from the original operators, and low level of customer satisfaction. Similarly, Simoni et al. [38] in their research found that most urban consolidation centers had to be terminated due to their high operating costs and the need for subsidies. The transferability of urban consolidation centers in Istanbul and in Turkey in general is limited, despite its ability in reducing vehicle kilometers travelled and traffic congestion [39], which is really needed in a congested city like Istanbul. The main obstacle faces the urban consolidation centers in Istanbul is that the companies responsible for delivering the goods and services to customers are operating now without the need of UCC and in order to make them shift toward the UCC, you have to convince them of the importance of urban consolidations and provide them with incentives and subsidies. The subsidies and external funding are crucial factors in operating these centers. And since the required subsidies are economically difficult, the applicability of UCC in Istanbul is rated low [39][40][1] .

The effectiveness of using alternative vehicles in the city of Istanbul is rated medium because of their limited implementation in real life of urban freight operations, and the need for more research and development in establishing mathematical and theoretical models. Besides that, the weakness of implementing alternative vehicles in Istanbul city lies in the market penetration and the slow growth of alternative vehicles adoption rate, According to IEA (2021), 98% of the transportation sector in Turkey is still reliant on oil, therefore, shifting from fuel trucks to electric and hydrogen trucks is not an easy process especially for heavy duty trucks. On the other hand, there is a major opportunity in the electrification process for light commercial vehicles as they are used extensively in Turkey. The number of light commercial vehicles sold in Turkey between January and June was almost 84,376 vehicles, up 67.2% on an annual basis [41]. And since the light trucks are usually used in last mile deliveries where the travelled distances are relatively low, replacing them by electric vehicles will not affect their viability, since the

limited battery capacity will not be a barrier. As a result, we rated their applicability in Istanbul is also rated medium.

Urban freight operations involve more than goods movements, loading/ unloading process is one of the issues that are related to the urban freight operations. Loading/ unloading strategy may face some challenges in a city like Istanbul due to the nature of the city (narrow roads) and also the parking inside Istanbul city is shared by both passenger’s vehicles and freight vehicles. Therefore, there might be a lack of space for loading/ unloading and handling operations, however, applying time windows regulations so that loading/ unloading operations can be restricted to specific times during the day (mostly at night), plus defining special zones for freight operations loading/ unloading process can increase their applicability. In general, the loading/ unloading strategy is rated to medium in the city of Istanbul.

Low emission zones restrict the type and size of vehicles that may enter specific parts of the city, depending on their energy consumption and the amount of CO₂ emissions they produce. Istanbul is one of the few European cities that does not have low emission zones [42]. Recently, the Ministry of Transport in Turkey announced the creation of low emission zones in Istanbul city, where the entering of vehicles may be restricted, prohibited or charged. Those zones will be set close to the Bosphorus, since this region suffers from high congestion and air pollution (Daily Sabah, 2019). Despite its advantage of decreasing the greenhouse gas emissions, air pollution and noise, the low emission zones have negative impacts on the competitiveness of companies inside these zones, where the company fleets may need to be renewed to cope with the new requirements [43], and this could also affect the customers if the companies decide to increase their prices, which may lead to elimination small businesses and jobs. As a result the applicability of low emission zones in Istanbul city is rated low. Table 2 shows different strategies used in urban freight operations, their effectiveness based on the literature, including government reports, and academic publications, and their applicability in the city of Istanbul based on our assessment.

TABLE XX
 STRATEGIES FOR URBAN FREIGHT TRANSPORT AND THEIR EFFECTIVENESS AND APPLICABILITY IN THE CITY OF ISTANBUL.

Strategies	Effectiveness	Applicability in Istanbul
Roading price	High	Medium
Consolidation centers	Low	Low
Alternative vehicles	Medium	Medium
Loading and unloading	High	Medium
Low-Emission Zones	High	Low

V. RECOMMENDATIONS AND FUTURE WORK METHOD

In response to climate change, cities have experimented different strategies and regulations for urban freight operations in order to diminish the negative impacts. There is a lack of studies on the impact of regulations and policies in the city of Istanbul. The above analysis shows an assessment of different urban freight strategies that could enhance the sustainability in urban freight operations in Istanbul-Turkey. Some strategies are promising options to be implemented and experimented for better management of urban freight operations inside the city; road pricing, alternative vehicles, loading/unloading are among the most applicable strategies to be used in the sustainability of urban freight inside Istanbul city. For future research, there is a need for a comprehensive evaluation of existing policies and regulations in Istanbul and a need to develop them to enhance the sustainability inside the city. Plus research on optimization methods that can be applied in real life situations supported by real data is needed.

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Tramvay Durakları Hizmet Performansının Çok Kriterli Karar Verme Yaklaşımı ile Ele Alınması

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Özet — Şehirlerin biçiminin, büyüklüğünün şiddetli şekilde etkilenmeye başladığı sanayi devriminden bu yana, doğaya ve insan yaşamına duyarlı toplu ulaşım sistemlerinin şehirlere entegre edilmesi fikri ön planda tutulan bir olgudur. Kent içi raylı toplu ulaşım sistemleri ise büyüyen ve biçim değiştiren şehirlerin ihtiyacını karşılamada, otobüs minibüs gibi diğer toplu taşıma modlarına göre daha çok tercih edilen ulaşım sistemleri olarak metropol ve kentlerde 20. yüzyıl başlarından bu yana uygulanmaktadır. Raylı ulaşım modlarının istasyonlarının ve duraklarının şehrin bu değişen ihtiyaçlarını karşılaması da bir başka beklentidir. İstasyonlara göre nispeten daha küçük tasarlanan duraklar genel olarak hafif raylı sistem ve tramvay hatlarının ana unsurlarıdır. Potansiyel kullanıcıların raylı sistem tasarımı ilk deneyimlediği yerler olarak karşımıza çıkan durakların tasarımları, kullanıcılara sunulan hizmetin kalitesinde önemli bir belirleyicidir. Tramvay duraklarının hizmet performanslarının değerlendirilmesi, durak tasarımlarının şehrin ihtiyaçlarına uygun bir şekilde geliştirilebilmesi için oldukça önemli bulgular sunacaktır. Bu çalışmada, tramvay duraklarının hizmet performansının durak hizmet alanı, durak erişim güvenliği, durak güvenilirliği ve durak konforu ölçütleri altında incelenmesi ve ilgili kriterlerle birlikte, hizmet performans değerlendirmesinin çok kriterli karar verme problemi olarak ele alınabilmesi için bir metodoloji önerisi sunulmuştur. Metodolojinin, belirli tramvay hatları üzerindeki durakların hizmet performansının değerlendirilmesi ve iyileştirilmesi konusunda önemli bir altyapı sunacağı düşünülmektedir.

Anahtar Kelimeler — Hizmet Performansı, Durak Güvenilirliği, Durak Güvenliği, Durak Hizmet Alanı, Durak Konforu

I. GİRİŞ

Raylı sistem taşıtları, hareketlerini sabit raylar yardımı ile yapan, karayolu taşıtlarından daha çevre dostu ve düşük enerji kullanımı ile yüksek miktarda yolcu taşıyabilen araçlardır. Bu özelliklerinden dolayı raylı sistemler, nüfus yoğunluğu yüksek şehirlerde, toplumun artan ulaşım talebini daha verimli olarak karşılayabilmektedir [1]. Kent içinde kullanılan raylı sistem taşıtları tramvaylar, bölgesel demiryolu, metro, hafif raylı sistem ve monoraylardır. Bu sistemlere kullanıcının erişimini sağlayan durak ve istasyonlar da topluma sunulan hizmetin kalitesinde belirleyicidir [2-4]. İstasyonlar, duraklara nazaran daha yüksek yolcu kapasitesine sahip raylı sistem hatlarında kullanılmaktadır. İstasyonlar, yer altı veya yer üstünde inşa edilebilirler ve karmaşık bir altyapıya sahiptirler. Duraklar ise genellikle yer üstünde olmak üzere şehir içi yollarda konumlandırılmışlardır ve istasyonlara göre nispeten daha basit bir altyapıya sahiptirler.

Kent içi raylı sistemlerinden birisi olan tramvay sistemleri, yollarını diğer toplu ulaşım modları, özel araçlar (bisiklet, özel araba vb.), yayalar gibi diğer kullanıcılar ile paylaşmak zorunda kalabildiği için çevresi ile etkileşim içindedir. Dolayısıyla, tramvay duraklarında ve tramvay hatlarında, hat boyunca ve duraklarda kullanıcıya kaliteli hizmetin verilebilmesi amacıyla, diğer ulaşımdan görece olarak ayırma, yayalaştırma, hatta giriş kısıtlaması, duraklara erişimin düzenlenmesi gibi uygulamalar yapılmaktadır. Bu düzenlemeler ile tramvayın zaman çizelgesine uyumu (güvenilirlik), kaza risklerinin azaltılması (güvenlik), durakların yolcu yoğunluğunun düzenlenmesi (konfor) ve durakların potansiyel kullanıcılarının artırılması (hizmet alanı) hedeflenmektedir [5].

Kent içi raylı ulaşım hizmetlerinin geliştirilmesi, hizmet sunucu açısından daha fazla kullanıcının sisteme çekilmesi ve potansiyel kullanıcıların yönünden yolculuk deneyiminin iyileştirilmesi ve ulaşım ihtiyaçlarının daha iyi karşılanması açısından önemlidir [6, 7]. Kent içi raylı ulaşımın performans analizleri, ulaşım moduna [7], güzergâha [8, 9], durak konumuna [10] ve konforuna [11], zaman çizelgesine uyuma [12], erişim kolaylığına [3, 4], güvenliğe [2, 3], hat bilgisine ulaşabilme imkânına [11], şehir ile uyuma [7], ücretlendirmenin diğer toplu taşıma ücretlendirme sistemi ile uyumuna [11, 13] bağlı olarak yapılmaktadır.

Durak ve istasyonlar üzerinde yapılan araştırmalar ise durak konumunun belirlenmesi [10], durak güvenliği [2, 3], durağa erişim koşulları [3, 4] gibi konulara odaklanmıştır.

Yapılan çalışmalardan da anlaşılacağı üzere raylı sistem durakları ve hatları şehrin ulaşım ihtiyaçlarına ve potansiyel yolcuların taleplerine göre şekillenmektedir. Duraklar ise yolcu ile ilk temasın sağlandığı noktalardır ve genel olarak hizmet performansları aşağıda verilen ölçütler doğrultusunda değerlendirilmektedir.

- Durak hizmet alanı: Durağın çevresinde bulunan nüfustan durağı kullanmayı seçebilecek potansiyel yolcu sayısı.
- Durak güvenilirliği: Taşıtın duraktan kalkış zamanının önceden belirlenmiş olan zaman çizelgesine uyumu.
- Durak erişim güvenliği: Durak çevresinde yolcunun durağa erişimini kolaylaştıran ve kaza riski üzerinde etkisi bulunan unsurlar.
- Durak konforu: Yolcunun durağa geliş anından taşıta binişine kadar geçen bekleme sürecinde yolcunun duraktaki konforu.

Bu çalışmada, tramvay duraklarının hizmet performans değerlendirmesinin yapılabilmesinde belirleyici olacak kriterlerin sayısal analizlerde kullanımını sağlayacak tanımlamaları ve durakların bu ölçütler altında çok kriterli karar verme yaklaşımı ile ele alınabilmesine yönelik bir metodoloji sunulmuştur. Ayrıca çalışmada, tramvay duraklarının hizmet performansında önemli rolü olan güvenlik, hizmet alanı, konfor ve güvenilirlik ölçütlerinin sayısallaştırılarak çok kriterli karar verme yöntemleri ile değerlendirilmesi ve elde edilen bulgular doğrultusunda sistem performansının iyileştirilmesi için uygun stratejilerin geliştirilmesine katkıda bulunmak amaçlanmıştır.

II. HİZMET PERFORMANSI İNCELEMESİ

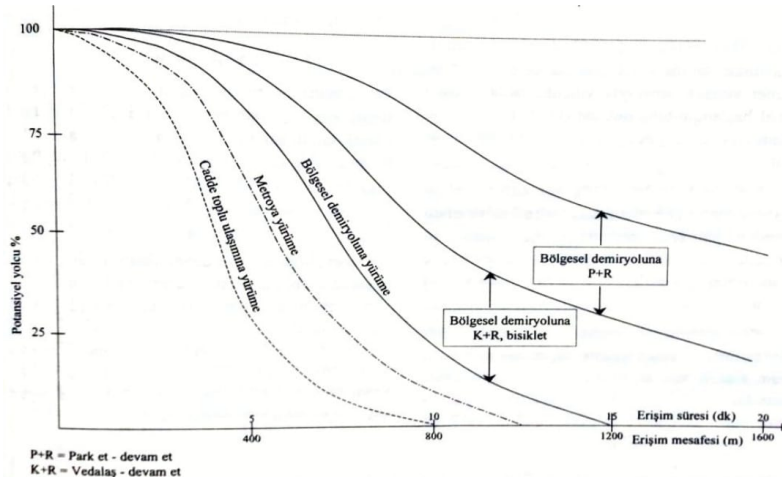
A. Tramvay Durağı Hizmet Performansı Değerlendirme Kriterleri

Potansiyel yolcuların ulaşım hizmeti ile ilk kez karşılaştığı alan olan durakların verilen ulaşım hizmetinin cazip hale getirilmesinde etkisi bulunmaktadır. Hattın planlanması aşamasında durak konumlandırması, sisteme erişim, yol tasarımı gibi kriterler göz önünde bulundurulsa da durakların hizmet kalitesi değişiklikler gösterebilmektedir [2, 5]. Bundan dolayı durakların hizmet performansının incelenmesinde durak hizmet alanına, durak güvenilirliğine, durak erişim güvenliğine ve durak konforuna yönelik değerlendirme kriterleri bu çalışmanın konusunu oluşturmaktadır.

1) Durak Hizmet Alanı: Hizmet alanı kavramı, tramvay durak performansının değerlendirmesinde önemli bir etkidir. Potansiyel kullanıcıların ulaşım sistemine erişimi ile doğrudan ilgilidir ve kullanıcının durağın konumlandırıldığı noktaya olan mesafesi ile belirlenmektedir. Durağın hizmet alanı da potansiyel kullanıcıların konumu ile ilgilidir. Tramvay sistemlerinin yolcuları duraklara genellikle yürüme yoluyla ulaştıklarından, durağa yakın olan kullanıcıların ulaşım sistemini kullanma olasılıkları nispeten daha yüksektir. Raylı toplu ulaşım sistemlerinde durak ile potansiyel kullanıcı arasındaki mesafe arttığında durağın hizmet düzeyinin azaldığı yapılan çalışmalarda gözlemlenmiştir [14]. Durağa olan mesafeye göre kullanıcı çekme oranı, farklı tür raylı toplu taşıma sistemlerinde de farklılık göstermektedir. Tramvay duraklarının potansiyel yolcu çekme düzeyi 200 metre yarıçaplı alanda en yüksek düzeye erişirken, 400 metreden sonra büyük oranda bir düşüş görülmektedir (Şekil 1). Hizmet alanı ölçütü ile durak çevresinde bulunan nüfustan sistemi kullanabileceği düşünülen potansiyel kullanıcı sayısı belirlenmektedir. Her durağın hizmet alanı incelemesi yapılarak hattın tahmini kullanıcı sayısı bulunabilmektedir [14].

Hizmet alanı incelemesinde durak merkez olarak kabul edilir ve durak çevresindeki bölgenin nüfusu, alan içerisinde bulunan konut sayısı, tramvay hattının bulunduğu bölgede sıklıkla gözlemlenen bina kat, daire sayısı ve inceleme yapılan şehirdeki haneye düşen ortalama kişi sayısı ile hesaplanabilmektedir. Potansiyel kullanıcı hesaplaması için Şekil 1’de verilen grafiğe bağlı alınarak, 100 metre yarıçaplı dairesel alanda durağın yolcu çekme oranı %95, 200 metrede %85, 300 metrede %50 ve 400 metrede %25 kabul edilmiştir. İlgili oranların ilgili çap içindeki nüfus ile çarpımı ile potansiyel yolcu sayısı genel anlamda hesaplanabilmektedir.

$$\text{Potansiyel yolcu miktarı} = \text{Alan nüfusu} \times \text{Durağın yolcu çekme oranı}$$



ŞEKİL 1

POTANSİYEL YOLCU ÇEKME ORANI GRAFIĞI [14]

2) *Durak Güvenilirliği*: Güvenilirlik, sefer tarifesinde belirlenen sabit sapmadan daha az süre içinde gerçekleşen toplu taşıma aracı varışlarının yüzdesi olarak tanımlanabilir [14]. Tramvay duraklarında hareket zamanının güvenilirliğinin incelenmesinde taşıtın duraktan kalkış anının zaman çizelgesine uyumuna dikkat edilmektedir. Dolayısıyla, güvenilirliğin yüksek olması o hattın başarılı bir biçimde işlediğinin bir göstergesidir. Güvenilirlik düzeyinin yüksek olması kullanıcı açısından da cazip bir durumdur [12]. Tramvay hatlarında ve durakların bulunduğu noktalarda diğer karayolu taşıtlarının bulunabilmesi nedeniyle duraklardaki güvenilirlik düzeyinin yüksek olmasında durak ve hat çevresindeki trafiğin düzgün bir şekilde kontrol edilmesinin de etkisi bulunmaktadır.

Tramvay durak güvenilirliği tramvayın duraklardaki zaman çizelgesinden sapma süresine bağlıdır ve sapma süresi de tramvayın herhangi bir duraktaki planlanan kalkış saati ile gerçekleşen kalkış saati arasındaki fark ile hesaplanmaktadır. Hesaplama için, tramvayın her bir duraktan kalkış zamanlarının kaydedilmesi gerekmektedir. Kayıt işleminin ilk aşamasında, öncelikle ölçüm yapılan ilk durakta tramvayın zamanında kalkış yaptığı varsayılmalı ve ölçüm için referans alınan saatin, tramvayın kalkış saatine göre kalibrasyonu yapılmalıdır. Veri toplama için belli bir hafta boyunca her gün hattın yoğun olduğu gözlemlenen sabah ve akşam zaman dilimlerinde taşıtın hat boyunca duraklardan kalkış zamanları kaydedilmelidir. Bu noktada, ölçüm yapılan seferde özel olarak sapmaların etkisini azaltabilmek için arka arkaya sürdürülen seferler boyunca veri toplanması önerilir. Kaydedilen hareket zamanları ile ilan edilen hareket zaman çizelgesi arasındaki farkların tespit edilmesi ile birlikte, bir tramvayın seferini sürdürdüğü hattı boyunca duraklardaki hareket zamanı sapmaları gün, zaman dilimi (sabah-akşam), sürücü ve sefer sayılarından bağımsız olarak elde edilmiş olur. Bir tramvayın, bir duraktan planlanan vakitten önce kalktığını ifade eden negatif sapma değerlerini de dikkate alabilmek adına, durağın hareket zamanı güvenilirlik değeri olarak, sapma değerlerinin standart sapmasının kullanılması tercih edilmelidir. Tablo I'de örnek durak güvenilirlik değerleri verilmiştir.

TABLO I

GÜVENİLİRLİK HESAPLAMA ÖRNEĞİ

Duraklar / Günler	1. Durak			2. Durak			3. Durak		
	Planlanan kalkış saati	Gerçekleşen kalkış saati	Sapma	Planlanan kalkış saati	Gerçekleşen kalkış saati	Sapma	Planlanan kalkış saati	Gerçekleşen kalkış saati	Sapma
Pazartesi	11:43:00	11:43:00	00:00:00	11:47:00	11:46:42	00:00:18	11:50:00	11:49:08	00:00:52
Salı	11:25:00	11:26:20	00:01:20	11:29:00	11:29:37	00:00:37	11:32:00	11:31:29	00:00:31
Çarşamba	10:49:00	10:48:38	00:00:22	10:53:00	10:51:54	00:01:06	10:56:00	10:53:58	00:02:02

International Engineering and Technology Management Summit 2022– ETMS2022
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Perşembe	10:49:00	10:50:38	00:01:38	10:53:00	10:54:23	00:01:23	10:56:00	10:56:46	00:00:46
Cuma	10:31:00	10:31:59	00:00:59	10:35:00	10:35:37	00:00:37	10:38:00	10:38:13	00:00:13
Cumartesi	10:49:00	10:48:24	00:00:36	10:53:00	10:52:23	00:00:37	10:56:00	10:54:28	00:01:32
Pazar	10:49:00	10:49:32	00:00:32	10:53:00	10:53:27	00:00:27	10:56:00	10:55:28	00:00:32
Standart Sapma			00:00:34	Standart Sapma		00:00:23	Standart Sapma		00:00:38

3) *Durak Konforu*: Taşıta erişim sağlamak için beklerken yolcunun mevsimsel dış etkilere karşı korunması ve fiziksel engeli bulunan kullanıcıların durağa erişim kolaylığı, ayaktaki yolcu sayısının alandaki yoğunluğu gibi etmenler konforu etkilemektedir [15]. Durak konforu incelemesi yapılırken, durakta kullanılabilecek olan oturma ve ayakta durma alanlarına ve yolcuların ayakta durulabilecek alandaki yoğunluğuna bakılmaktadır. Durak konforu, aracın durağa geliş anından, taşıta binme anına kadar olan bekleme süresince kullanıcının duraktaki konforunun incelenmesi ile değerlendirilebilir.

Durak konfor ölçütü, durağa erişim ve korunma gibi koşulları hat boyunca aynı olan tramvay duraklarında, metrekareye düşen ayakta yolcu sayısı ile incelenebilir. Bazı duraklar bölgenin kullanıcı yoğunluğundan dolayı oldukça kalabalık olabilmektedir. Konforun nicel olarak hesaplanabilmesi için tramvayın ilgili durağa geldiğinde duraktaki ortalama ayakta bulunan yolcu sayısı ile durağın ayakta durulabilen alan yüzölçümü kullanılabilir. Durakta ayakta bekleyen yolcu sayılarının belirlenmesi için, hareket zamanı güvenilirliği değerlendirmesinde kullanılan ölçüme benzer olarak yapılan çoklu ölçümlerden yararlanılmalıdır. Her durakta, taşıtı bekleyen yolcu sayılarının ortalaması alınarak o durağın ortalama yolcu sayısı bulunmaktadır. Ortalama olarak elde edilen bu sayı durakta ayakta durulabilecek alana bölünerek duraktaki genel yolcu yoğunluğu hesaplanır ve bu değer durak konforu olarak kabul edilir. Durak konforuna ait örnek hesaplama Tablo II’de verilmiştir.

TABLO II

DURAK KONFORU HESAPLAMA ÖRNEĞİ

Duraklar / Günler		Pazartesi	Salı	Çarşamba	Perşembe	Cuma	Cumartesi	Pazar	Ortalama	Alan (m ²)	Yoğunluk
n. Durak	1. tur	7	8	13	9	10	9	11	10,071	50	0,201
	2. tur	10	15	9	12	8	7	13			

4) *Durak Erişim Güvenliği*: Durak çevresindeki yolcuların kaza riskinin azaltılmasına ve durağa erişimlerinin kolaylaştırılmasına yönelik yaya geçidi ve sinyalizasyon gibi trafik elemanlarının kullanılması ile durak erişim güvenliği sağlanmaktadır. Ancak, trafik elemanları kullanılsa bile hattın yapılmasından önceki şehir yol düzeninden kaynaklanan kesişim alanları gibi bölgeler yolcunun durağa erişim güvenliğinde sorunlar oluşturabilmektedir [3, 15]. Yol yapısından kaynaklanabilecek sorunlar dışında, diğer özel taşıtların trafik kurallarına uymaması gibi durumlar da durak erişim güvenliğinde sorunlara neden olabilmektedir.

Durak erişim güvenliğinin incelenmesi için her durak çevresinde bulunan trafik elemanları, karayolu kesişim bölgeleri ve olumsuz sonuçlara neden olabilecek trafik kuralları ihlalleri gözlemlenerek kaydedilir. Durağın yolun ortasında veya kenarında olması, durak çevresinde yaya yolu, devamlı veya sadece tramvay taşıtı durağa yaklaştığında çalışan sinyalizasyon sistemi, ara sokaklar ile kesişim alanları ve kavşaklar, hat ve durak alanının yaya ve tramvay sistemi dışında kullanıma kapatılmış olması ve trafik ihlalinin yaşanması gibi unsurlar durak güvenliğini etkilemektedir. Sayılan bu unsurlara bağlı olarak, Tablo III’de verilmiş olan likert ölçeğinden yararlanılmış ve uzmanların, durakların erişim güvenliği değerlendirmesi yapmaları sağlanmıştır.

TABLO III
DURAK ERİŞİM GÜVENLİK ÖLÇEĞİ

Seviye	Güvenlik seviyesi
1	Çok riskli
2	Riskli
3	Az riskli
4	Biraz riskli
5	Orta (ne riskli ne de güvenli)
6	Biraz güvenli
7	Az güvenli
8	Orta güvenli
9	Çok güvenli

B. Tramvay Durağı Hizmet Performansının Değerlendirilmesine Yönelik Metodoloji

Ulaştırma sistemlerinde karar verme ihtiyacı, diğer tüm alanlarda olduğu gibi, yeni alternatiflerin değerlendirilmesi, var olan seçeneklerle ilgili sorunların belirlenmesi ya da seçeneklerle ilişkili iyileştirilmeler yapılması gereksinimiyle ortaya çıkmaktadır. Ulaştırma sistemlerinin değerlendirilmesinin doğası gereği olan çok nitelikli yapısı, uzlaşık çözüm konseptine dayanan ve alternatiflerin kıyaslanmasını sağlayan çok kriterli karar verme yaklaşımlarına uygunluk göstermektedir. Tüm çok kriterli karar verme problemleri birden fazla kriterle ilişkilendirilir. Kriterler aynı zamanda "hedefler" veya "nitelikler" olarak da adlandırılır ve alternatiflerin görülebileceği farklı boyutları temsil eder [16]. Hizmet performansı kavramının da yukarıda belirtildiği üzere duraklar arası kıyaslamalarının yapılabilmesi için çok kriterli bir yapı altında değerlendirilebileceği açıktır. Dolayısıyla durakların hizmet performanslarına yönelik yapılacak incelemelerin çok kriterli bir karar verme problemi olarak ele alınabilmesi mümkündür.

Çok kriterli karar verme problemleri ile sayısal analizler aracılığıyla ham veriden anlamlı bilgiler elde edebilmek amaçlanır. Farklı kriterler altında değerlendirilecek durak alternatiflerinin çoklu kriterler altında aldıkları değerlerinden oluşan karar matrislerinin belirlenmesi, ilgili karar verme probleminin en önemli aşamasıdır. Bu noktada, sayısı birkaç taneden yüzlerce ye kadar çoğalabilecek alternatiflerin ilgili kriterler altındaki değerlendirmeleri için objektif ya da sübjektif yaklaşımlardan yararlanılır. Çalışma kapsamında sunulduğu gibi, durak hizmet alanı, durak hareket zamanı güvenilirliği ve durak alan konforu kriterlerinin değerlendirilmesinde matematiksel hesaplamalardan yararlanmak mümkündür. Fakat durak erişim güvenliği kriteri, her durağın diğer taşıtlarla birlikte paylaştığı trafikle ilişkili karmaşık risk unsurlarının ele alınmasını gerektirir. Bu noktada, uzman yargılarından yararlanılması tek veri kaynağı olarak kabul edilebilir. Çünkü veri eksikliği sebebiyle, riskle ilişkili durumlar üzerine herhangi bir girişimde bulunmadan karar almaktansa, uzman yargılarıyla yapılan değerlendirmeler eşliğinde karar vermek kabul edilebilir bir yaklaşımdır [17]. Bu durumda tek bir karar verici ya da grup karar verme yöntemleri aracılığıyla, ikili karşılaştırmalar matrislerinden [18] faydalanılabileceği gibi, Tablo III'deki gibi bir likert ölçeğinden ya da bulanık mantık yaklaşımlarından [19] yararlanılması da mümkündür.

Durakların hizmet performansına yönelik yapılacak değerlendirmelerde ele alınan kriterlerin her birinin eşit öneme sahip olduğu kabul edilebileceği gibi, yine uzman görüşleri aracılığıyla önem ağırlıklarının belirlenmesi de sağlanabilir. Bu noktada yine ikili karşılaştırma matrislerinden [18] yararlanılabilir.

Tramvay duraklarının hizmet performansının farklı kriterler altında değerlendirilebilmesi için, ilgili duraklar (A_i), belirlenmiş kriterler (C_j), kriterlerin ağırlık değerleri (W_j) ve durakların her bir kriter altındaki değerleri (x_{ij}) tespit edilerek Şekil 2'deki gibi bir karar matrisine dönüştürülür.

Durak Alternatifleri	C₁	C₂	C₃	...	C_j
A₁	x ₁₁	x ₁₂	x ₁₃	...	x _{1j}
A₂	x ₂₁	x ₂₂	x ₂₃	...	x _{2j}
A₃	x ₃₁	x ₃₂	x ₃₃	...	x _{3j}
⋮	⋮	⋮	⋮	⋮	⋮
A_i	x _{i1}	x _{i2}	x _{i3}	...	x _{ij}
W	W₁	W₂	W₃	...	W_j

ŞEKİL 2

HİZMET PERFORMANS DEĞERLENDİRMESİ İÇİN KARAR MATRİSİ ÖRNEĞİ

Çok kriterli karar verme problemlerinin çözümü için literatürde kullanılan çeşitli yöntemler vardır. Ağırlıklı toplam modeli olarak bilenen SAW (Simple Additive Weighting) yöntemi en eski ve muhtemelen en çok kullanılan karar verme yöntemi olup, ağırlıklı çarpım modeli olarak bilenen WPM (Weighted Product Model) yöntemi ise ağırlıklı toplam modelinin modifikasyonu olarak kabul edilir [16]. Thomas L. Saaty tarafından 1980 yılında [20] geliştirilen AHP (Analitik Hiyerarşi Proses), Yoon ve Hwang tarafından 1981 yılında [21] geliştirilen TOPSIS (Technique for Order Preferences by Similarity to an Ideal Solution), Benayoun vd. tarafından 1966 yılında [22] geliştirilen ELECTRE (Elimination and Choice Translating Reality) metodları da literatürde araştırmacılar tarafından sıklıkla tercih edilirler. Hangi metod kullanılrsa kullanılsın, problemin etkin bir şekilde çözümlenebilmesinde en önemli nokta, problemin amacının ve hiyerarşik tanımının doğru yapılması ile karar matrisini oluşturan parametrelerin doğru belirlenmesidir.

Bu çalışmada sunulan durak değerlendirme kriterlerine yönelik yapılabilecek analizler aracılığıyla elde edilecek karar matrisleri, çok kriterli karar verme yöntemleri ile değerlendirilerek, durakların çoklu kriterler altındaki genel performans sıralamalarına ulaşılabilecektir. Böylelikle durakların hem farklı kriterler altında hem de genel performans sıralamalarına bakılarak iyileştirme önerileri sunulması mümkün olabilecektir.

III. SONUÇ VE ÖNERİLER

Şehirlerdeki nüfus yoğunluğunun artması, insanların toplu ulaşım sistemlerine olan talebini doğrudan etkilemektedir. Artan bu talep ile birlikte, çevreye ve insan yaşamına daha duyarlı ulaşım sistemlerinin tercih edilmesi giderek yaygınlaşmaktadır. Kent içi raylı ulaşım sistemleri, iş gücüne olan yüksek katkısı, güvenli ve güvenilir oluşu, çevre ile uyumu, konforu ve yüksek hizmet düzeyi ile bu talebi karşılayan toplu ulaşım sistemleridir. Tramvaylar ise, diğer toplu ulaşım modları ile entegrasyonu sayesinde, özellikle gelişmekte olan şehirlerde iş gücüne olan yüksek katkısı ile toplu ulaşım talebini yerine getirmektedir. Tramvay hatlarının ve duraklarının şehirlerdeki konumunun planlaması özel önem taşımaktadır.

Bu çalışmada, tramvay duraklarının hizmet performansının belirlenmesi için kullanılan durak hizmet alanı, durak güvenilirliği, durağa erişim güvenliği ve durak bekleme konforu ölçütleri incelenmiş ve bu ölçütlerin sayısallaştırılması amaçlanmıştır. Ayrıca, çeşitli karar verme yöntemlerinin bu ölçütlerin değerlendirilmesinde kullanılabileceği sunulmuştur.

Durak hizmet alanı kavramı ile durakların potansiyel kullanıcı sayısı belirlenmiştir. Durakların potansiyel kullanıcılara olan uzaklıkları doğrudan hizmet kalitesini etkilemektedir. Durakların, potansiyel kullanıcıların yüksek olduğu noktalarda hizmet vermesi tramvay hattının verimini arttıracak ve sistem cazip hale gelecektir. Optimum kullanıcı sayısına ulaşan hatların diğer tüm ölçütler (hattaki yeterli araç sayısı, hat güvenliği, güvenilirlik vb.) sabit kaldığında düşük işletme maliyetleri ile işletilebileceği düşünülmektedir.

Güvenilirlik, hatta hareket eden araçların zaman çizelgesinde verilen kalkış ve varış zamanlarına uyumu ile ölçümlenmektedir. Dolayısıyla, duraklardaki ve hattaki bekleme süreleri güvenilirlik seviyesini değiştirmektedir. Duraktaki zaman çizelgesinden sapma değeri ne kadar az ise güvenilirlik o kadar yüksektir. Güvenilirlik düzeyi yüksek sistemlerin potansiyel yolcular tarafından tercih edilme oranı kademeli olarak artacaktır. Sistemi kullanan yolcuların zamanında varışlarının yüzdesi güvenilirlik ölçütü ile yükselmektedir.

Yolcunun durağa erişimini negatif veya pozitif olarak etkileyen unsurların varlığı durakların verimini etkilemektedir. Kaza riskinin düşük ve güvenliği tehlikeye düşüren unsurların bulunmadığı durak tasarımları şehrin ve hattın ihtiyaçlarına göre tercih edilmelidir. Durakların çevresini, hattan bağımsız çalışan trafik ışıkları, yaya yolları, ihlallere karşı güvenlik kameraları, güvenlik elemanları vb. uygulamalar ile güvenli hale getirmek gereklidir. En üst seviyede güvenlik elde edilmesi amacıyla durakları

yayalaştırılmış bölgelere yerleştirmek durak erişim güvenliğini yükseltecek bir başka uygulama olarak düşünülebilir.

Durak konforu, duraklarda bekleyen potansiyel kullanıcıların bekleme alanı, oturma grubu, engelli erişimi gibi unsurlarından etkilenmektedir. Durak alanı, potansiyel kullanıcıların ihtiyacını karşılayacak ölçüde ve minimum kriterler gözetilerek oluşturulmalıdır.

Sonuç olarak, tramvay durakları hizmet performansının durakların konforuna, güvenilirliğine, güvenliğine ve durakların hizmet alanına bağlı olduğu görülmektedir. Bu ölçütlerin sayısal verilere dönüştürülerek, tramvay duraklarının hizmet performanslarının geliştirilebilmesine yönelik karar verme metodolojisi sunulmuştur. Durakların potansiyel kullanıcı sayısı, zaman çizelgesine uyumu, durak erişim güvenliği ve durak konforu üzerinde incelemeler yapılmalı ve durakların hizmet performansı, uzman yargıları kullanılarak çok kriterli karar verme yaklaşımı ile değerlendirilmelidir. Kurum ve işletmelerin hizmet performanslarını geliştirmeye yönelik zaman, personel ve ekonomik açıdan sınırlı kaynaklarının bulunması nedeniyle, performans artırma uygulamaları için doğru karar verme stratejilerine ihtiyaç duyulmaktadır. Önerilen yaklaşım metodolojisinin, durakların ilgili niteliklere yönelik değerlendirmeler yapılarak, hat hizmet performanslarının iyileştirilmesi konusunda bir altyapı çalışması olarak kabul edilmesi hedeflenmiş, sonuçlar ve öneriler paylaşılmıştır.

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Trust, Leadership, and National Culture in Engineering Endeavours

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Abstract— Trust has been investigated over several decades. Trust has been defined as a psychological state that implies the intention to accept vulnerability, based on positive expectations of the intentions or behaviours of another. Trust can be based on cognitions and/or based on affect. Cognition-based trust is based on rational decision-making; we choose who we are going to trust, in what way and in which circumstances. Competence and responsibility would be elements to be considered in establishing trustworthiness. When these elements are not present, trust may be withheld. Within organisations, cognition-based trust will depend upon past interactions, social similarity, and various contextual considerations. Evidence from the past about reciprocity and fairness and following through on commitments will be evidence used to establish this trust. Affect-based trust is based on emotion, and it is easier for trust to develop between people who are similar. Studies have looked at the impact of national culture on the ability to develop trusting relationships, often using models of national culture. Engineers working in multicultural workplaces will be impacted by differences in their ability to develop trust in followers. Engineering leadership will increasingly require soft skills to lead in a way that establishes trust. This paper will present literature around trust and national culture, and will pinpoint some best practices for engineers managing and leading in a multicultural workplace

Keywords—Trust, national culture, engineering leadership, values

I. INTRODUCTION

“Trust... tends to be somewhat like a combination of the weather and motherhood: it is widely talked about, and it is widely assumed to be good... When it comes to specifying just what it means in an organisational context, however, vagueness creeps in.” [1]. Questions that could be considered when trying to pin down the notion of trust might include the following: Are you a trusting kind of person? Would you trust your family as business partners? Does trust mean good intentions or good performance? Do you need to trust people to be able to do business with them? Is it okay to tell a white lie?

Trust is very important in relationships. As noted by Amy Cuddy, upon first meeting a person, we subconsciously ask ourselves: “Can I trust this person?” People value trust very highly and it is only after trust is established that we might consider getting to know someone further [2]. Trust is often associated with warmth, and a few small non-verbal gestures can help people to understand that you are pleased to be with them, and that they are being listened to. Warmth helps people to connect with and be trusted by others. As Cuddy says: “Without a foundation of trust, people in the organisation may comply outwardly with the leader’s wishes, but they’re much less likely to conform privately- to adopt the values culture and mission of the organisation in a sincere, lasting way.” [2]. Essentially trust is about confidence in the other person’s goodwill and integrity and your belief in their ability and credibility. Trust is much easier to maintain than establish; and it is very easy to destroy [3]. Trust is particularly relevant in today’s times of uncertainty [4].

Trust can occur between people, groups, organisations, and nations. Developing trust involves a willingness to take a risk. There must also be interdependence between the parties; and the greater the dependence, then the greater the likelihood of trust developing. Having trust has been shown to be associated with a range of positive outcomes. Trust promotes cooperative behaviour and adaptability, trust lowers the likelihood of conflict, and is useful in crisis management. When there is trust there is likely to be a greater exchange of relevant information and thus better problem-solving [5]. Within project management, it has been established that there is a strong correlation between stakeholder trust and project success, and that trust leads to strong working relationships and less conflict [6].

Trust is really only successful if it goes both ways [7]. When people have not worked together before, it takes time to build up trust. Trust is dynamic and over time trust can be expanded or reduced [8]. Trust is now emerging as a central theme in international strategy research. The greater frequency of global operations has highlighted multiculturalism and its challenges, and the building of trust among culturally diverse groups and people headlines trust as a major success factor in this context.

II. TRUST INVESTIGATIONS IN DIFFERENT DOMAINS: PSYCHOLOGY, SOCIOLOGY, AND SALES

Psychologists have investigated trust in terms of relationships between people (interpersonal trust). Rotter defined trust as: “An expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon.” [9]. Trust is also linked with individual differences; some people are more trusting than others. The tendency to trust and the tendency to be trustworthy are both linked to personality characteristics. Three components often associated with trust are benevolence or kindness, competence or ability, and honesty or integrity. The Big Five personality test is a well-known psychological instrument that measures openness, conscientiousness, extraversion, agreeableness, and neuroticism [10]. In this model, the trait of agreeableness is linked to both benevolence and honesty. The competence component of trust is related to another trait, that of conscientiousness. As these authors say: “Conscientious people are rational, informed, and generally think of themselves as being high in competence.” [10]. Another trait that could be related to trust is neuroticism: anxious people are likely to worry, and hostile people are likely to be bad-tempered: neither of these behaviours will be related to developing trusting relationships.

Sociologists tend to consider the environment where the relationships between people occur. Trust can be affected by many social and cultural factors. Without trust, it would be difficult to navigate comfortably through the day. A system of shared values is helpful for society to operate well and predictably. Trust will not mean the same thing to people holding different beliefs about benevolence, competence, or honesty. These three attributes are not always combined in one person: hence the prevalence of the white lie. Society needs there to be a certain level of trust, especially now when things are changing so fast. A trust deficit will impede smooth social functioning.

Trust has also been investigated in the field of sales; for example, Høgevold, et al. [11] who tested trust and commitment as factors in the sales exchange. Transactional marketing, which does not consider issues of trust and commitment, focus solely on making the sale and is not concerned about the customer’s liking and use for the product. Relationship marketing, on the other hand, takes a different and broader focus and is concerned with creating customer loyalty, interacting with them regularly, focusing on their needs and wants and therefore satisfying them in a more comprehensive way. This builds up brand loyalty and trust. Trust is integral to the idea of persuasion, as it is easier to influence or persuade someone who is trusting.

III. IS TRUST A BELIEF OR A FEELING?

McAllister [12] differentiated between two primary types of trust. In the case of cognitive-based trust, we choose who we are going to trust and under which circumstances. The choice to trust is based upon an evaluation of the other person’s characteristics, such as integrity, competence, reliability, and dependability. When these elements are not present, trust may be withheld. This is a rational evaluation based upon credible evidence concerning intentions and/or performance and might include reputation or certification where trustworthiness can be verified. Past interactions, for instance reciprocity and fairness and following through on commitments, can be observed and noted. Social and cultural similarity may also help the development of trust. Similarity makes it easier to create trusting working relationships. Within group dynamics, people who are perceived as outgroup members are less likely to be seen as trustworthy.

On the other hand, affective trust is emotion based and will be built when people express care and concern for each other within relationships [13]. A sense of mutual obligation develops. McAllister indicated that there might need to be some level of cognitive trust before affective trust could develop. Webber [14] expanded this definition to include the time dimension, indicating that we need to examine how trust develops at various points in time; and while there may be early trust based upon familiarity or reputation, this can develop into both cognitive and affective trust with time.

IV. TRUST AND CULTURE

The increasing prevalence of multicultural workforces and teams has led to research considering how national culture influences the development of trust. The idea that levels of trust differ across nations has been explored by several researchers. According to Brake [15]: “We think we perceive the world as it is. In fact, the world is mediated through our dominant assumptions, values, and beliefs. Our cultural prism determines how we understand and know ourselves and others in the world. Each of our cultural prisms is built out of a history of our group, our religions and other belief systems, economies, educational and legal systems, ascetics, language and to some extent our geography.”

Maintaining trust between people from different cultures is challenging due to differing beliefs and incompatible assumptions that can prevent positive interactions and collaboration [16]. Trust is interlinked with culture [17]. Scholars have investigated whether judgements about trust are made in the same way across cultures, or whether judgements vary depending on culture. The way in which we assess trust

involves deciding who to trust, taking account of the context, and looking for counter indicators for placing trusting another person [18]. Research indicates that trust judgements do in fact depend greatly upon culture.

But how do we assess and describe culture? There have been many large-scale studies of cultural values. Probably the best known model is that of Hofstede who refers to collective programming of the mind and way of viewing the world (Hofstede, 1984, Hofstede, 2001). He collected data across around 90 countries and identified several basic dimensions concerning cultural differences. His model contains six dimensions used to compare nations: power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. In this model, the two dimensions that most relate clearly to trust are individualism/collectivism and power distance, because these two factors stimulate trust [19]. Power distance (PD) is about the rules, behaviours and hierarchies that occur when people interact: in cultures which are high power distance, powerful people expect to be in charge and make decisions. Less powerful people accept this norm. In individualistic cultures, people are concerned about how decisions will affect them personally, while in collectivist cultures, people are more concerned about the impact of a decision on the group.

Fukuyama [20] proposed that trust should be viewed as a separate cultural dimension, and he differentiated national cultures as being low trust or high on trust, based on people's likelihood to trust strangers. This concept of generalised social trust (GST) is about willingness to trust others, even strangers, and expect that they will not deliberately harm us; this is a social norm learned from the environment, and this includes culture. High measures of GST at the national level, according to Fukuyama [20], are associated with lower levels of corruption, higher wealth, and greater development. GST is related to many positive outcomes including economic growth, good economic performance, reduction in crime, cooperation, and greater overall happiness and well-being [21]. This construct can be assessed by this question: "Generally speaking would you say that most people can be trusted: or that you can't be too careful in dealing with people?" Many authors have suggested that similarity in values fosters GST. According to Delhey and Newton [22], there were significant differences between nations in terms of GST in the 60 countries they tested. Developed western countries scored in the high to medium trust category. In this study, Australia recorded a GST index of 40/65, which is at the high level; Australian people are fairly trusting. Factors which load strongly in terms of a negative correlation with social trust include internal war, external war, income inequality and ethnic fractionalisation. Political corruption had a very high negative relationship with social trust in this study.

V. ENGINEERS IN MULTICULTURAL WORKPLACES

Engineers increasingly work in multicultural teams and workplaces. Bourn [23] describes engineering as one of the most global of professions. Global preparedness and intercultural understanding are priorities for skills development. Effective engineering in a global context will recognise the need to adapt to local contextualisation. Engineers from different countries may define problems in different ways and with different interpretations [24]. In multicultural engineering endeavours, project leaders need sufficient cultural awareness or sensitivity to be able to understand the behaviour of local people through a cultural lens. Engineers working in out of country assignments will need preparation and training to handle an unfamiliar environment and building trusting relationships, especially in countries where there is a different attitude towards risk and uncertainty and different levels of GST. Otherwise, it will be very easy for there to be misinterpretation and possibly mistrust. People from high PD countries may be less likely to give their opinions and less likely to challenge the manager. They might need encouragement to participate.

Cultural intelligence (CQ) is a person's competence to be able to function effectively in a cross-cultural context and is a kind of intelligence [25]. People with higher CQ are more likely to finish their assignments effectively, and less likely to leave early [26]. CQ is a major advantage for multinational corporations (MNCs). CQ it consists of cultural knowledge, cross-cultural skills, and cultural metacognition [27]. Cultural knowledge is general information about other cultures and how they differ from one's own. Cultural skills indicate an appreciation that there are differences in how we should adapt our behaviour to act appropriately. Cultural metacognition occurs when we consciously and deliberately monitor our knowledge and regulate our behaviour. Exhibit 1 below presents a comparison between the three countries of Australia, Pakistan and Finland on each of the six Hofstede dimensions.

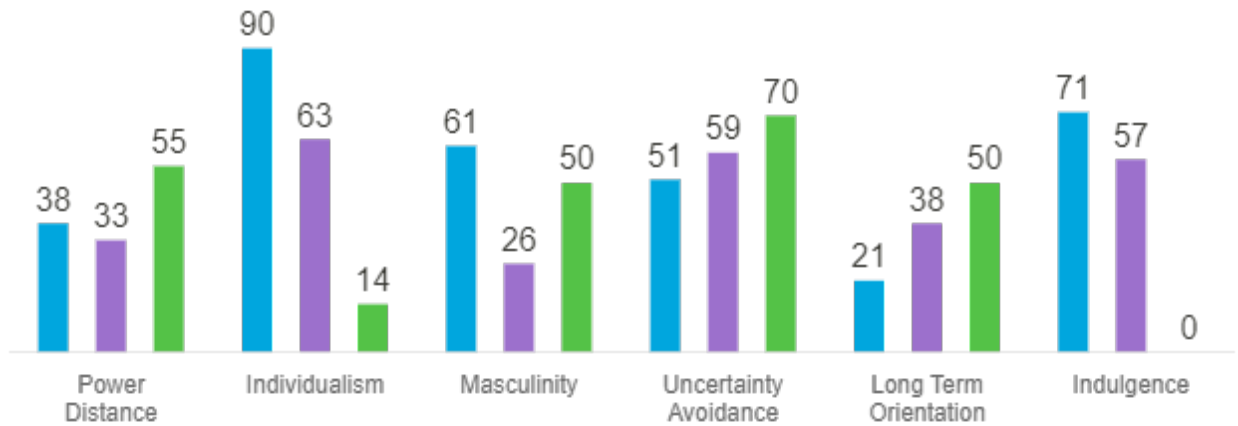


Figure 1. Hofstede comparison of Australia, Pakistan and Finland on the six dimensions (Pakistan is in Green, Finland is in purple, and Australia is in blue)

As might be expected there are large differences between Australia, Finland, and Pakistan on all six dimensions of the Hofstede model. In terms of trust, the focus is on individualism versus collectivism (Pakistan scores 14, Finland 63, and Australia 90) and power distance (Pakistan scores 55, Finland 33, and Australia 38). In terms of individualism, people from collectivist (or low individualism) countries prefer a tightly knit social framework and expect others to look after them in exchange for loyalty. On the other hand, in countries with high levels of individualism, there will be a preference for a looser knit social framework where people are only expected to take care of themselves and their families. In higher PD countries, autocratic leadership is more acceptable and even expected, whereas in low PD countries this approach would be unacceptable. Followers would be less able to express their different opinions in high PD countries, but speaking our mind would be normal in low PD countries such as Australia. This is an important cultural dimension [28], likely to influence a number of variables such as innovation, organisational citizenship, leadership practices and trust.

In considering the implications of these differences one might imagine that an Australian engineer going to manage a project in Pakistan will likely find very different attitudes towards trust. Workers in Pakistan, which is a high PD country, will not normally expect to have a close friendly relationship with the leader or to express their opinions openly, in contrast to expectations in Australia. In terms of the GST findings reported earlier, Pakistan is a very low trusting country, and it may be difficult for an Australian engineering manager to establish trust in a local workforce. Engineers from low PD countries like Australia might act in ways that are different from the norm when in high PD countries. Australian engineering managers working in Pakistan might find that workers are less forthcoming in giving their opinions. Ways to reduce this lack of feedback might include using leadership practices that support team working, collaboration and problem-solving, features that are so fundamental to engineering endeavours.

VI. THE CASE OF FINLAND

In considering Finland, we find a country at the halfway point between Australia and Pakistan, but there are many other differences, as I found when I came across a fascinating book series called “Culture Shock!”. This series presents helpful cultural information for travellers to various countries. The book on Finland suggest that Fins have some very specific traits that may make doing business with them interesting. The book points out that Fins are keen to keep their promises and expect others to keep theirs. They are extremely honest, and do business “on a handshake”, which is viewed as being as good as signing a contract. They are very comfortable with silence, and they don’t like to indulge in small talk. They speak directly and would like others to speak unless they have something useful to say. Extreme chattiness is viewed with suspicion or surprise, and may indicate untrustworthiness. Finnish people dislike noisy people and

strangers who smile at them in the street. This may seem a little bit rude to visitors. They themselves don't walk around smiling all the time. Fins don't usually complain, and they find it very difficult to handle a complaint. They pride themselves on the peace and harmony of their country and they don't like standing out in a crowd. They are calm, quiet introverts who leave people alone and respect their privacy. Foreigners are viewed with interest and welcomed warmly. Finnish people are very open to new ideas and are quick to adopt and improve any new concept or thing. Direct eye contact is viewed as an invasion of privacy. They answer questions with minimal information which may seem abrupt, especially when delivered without a smile. They do not boast or brag, and they hate it when people show off. There is a high focus on trust. Finnish people are hard-working, conscientious, and reliable, and like to make decisions efficiently. They expect others to get straight down to business. They rarely ask questions and don't show much emotion, so you they may be easily upset but this may not be apparent. They are quite frank, and they tell people when things are going wrong. In making business presentations, while Australians may like to inject enthusiasm and energy, a Finnish audience might be silent, but this is not indicating a lack of interest, rather a desire for facts and analysis so that they can go ahead and make a decision

The culture shock book related to Pakistan being unavailable, I asked a colleague in Karachi to present some issues for Australians doing business in Pakistan. He reported that things change quickly day to day, perhaps because of government policy changes, or strikes or delays (which are very common), and flexibility will be necessary. People in Pakistan do not expect to start meetings on time, so plan for meeting participants to arrive 30 minutes later than expected. Having some knowledge of the local language would help foreign managers to build up trust. Demonstrating genuine interest in learning about the Pakistani culture is also appreciated. Social networking opportunities occur during office hours, and especially at lunch time, prayer times and tea break times. Religion is a big part of daily life. Australian managers would do well show genuine interest in being sensitive to religious matters (or alternatively avoiding any discussion about religion). Australians are inclined to use humour as a useful social lubricant, but humorous comments about religion or cultural practices in Pakistan will not be well-received. Pakistan is a high context socially connected environment, and it is beneficial to understand the complexities of local social networks when doing business. However, forgiveness is an important part of religion and culture; if Pakistani people can see that an outsider is making a genuine effort to understand them, then innocent mistakes will be pardoned. Pakistani is known for its hospitality all around the world, said my contact there.

VII. IMPLICATIONS FOR ENGINEERING MANAGERS: SOME IDEAS FROM THE DOMAIN OF SALES

A social psychologist called Robert Cialdini [29] has studied persuasion techniques based upon his experiences in a sales marketing course. He describes six keys of how to influence people. He says he immersed himself in the world of the compliance professionals: the marketing gurus. His six basic categories may provide some clues about how to influence people and thereby create trust. His six principles are as follows: reciprocity (people like to return a favour and they want to say yes to someone who has done something for them); commitment (people want to be consistent with what they have said they will do); social proof (we like to follow the lead of similar others); authority (we follow the lead of experts and authorities); liking (we say yes to people we know and like); scarcity (we are attracted by an opportunity that is scarce).

In terms of creating trust, reciprocity would seem to be a useful strategy. If you do favours for people, they are likely to return the favour later, and this can create a relationship of trust. This works even between people who don't like each other much: the free sample has a long and effective history. Another key that could be very useful in the context of engineering managers working in another country is liking. It is no surprise that we more often say yes to people we know and like. We are also much more likely to trust people whom we see is similar. Similarity is one of the top factors in persuasion. The similarity could be in a range of different areas; opinions, personality type, background, family lifestyle. So drawing out the similarities between people can help with creating trust. Most people are very responsive to flattery, even if they recognise it as such. Authority can be effective if based upon acceptable evidence and credibility. If you can get people to publicly praise a project or initiative, they will likely continue to behave in accord with that publicly stated belief, having made a public commitment. If you can get important people to exhibit the style of behaviour that is important in a project, others will likely follow.

VIII. CONCLUSIONS

Trust is a powerful force in interpersonal relationships and is becoming a hot topic in global business studies. "Trust is critical to the success of global business teams because it encourages cooperation and it minimises unproductive conflict." [30]. When trust is not present, people may not reveal their true beliefs and diversity can become a liability. Working to increase trust levels can make international collaboration

much easier and more productive. Low levels of trust or mistrust may result in conflict and a project will likely be less productive. This paper has considered the specific case of an Australian engineer leading and engineering management project in Pakistan or Finland. The various differences noted in that comparison have implications much more broadly. People working in a different country can help to develop trust by understanding and accommodating the cultural differences they meet. This includes understanding the non-verbal signals of trustworthiness. Cultural metacognition means being conscious of our behaviour and its impact in a different society. In the end, creating and building on trust is about sensitivity to others and their differing worldviews, considered in the light of much commonality regarding a desire for successful outcomes.

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Türkiye'nin İlk Metaverse Girişimcilik Maratonu Katılımcıları Üzerine Bir Araştırma

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Özet— Evren ötesi bir düzeni temsil eden farklı alanlar ve deneyimler arasında kolayca hareket edebilmeyi mümkün kılan Metaverse teknolojisi internetin geleceği olarak düşünülmektedir. 21. Yüzyıl dünyasında hızla gelişen teknolojiyi takip etmek, adapte olmak ve katkı sunmak önem taşımaktadır. Bu hususta özellikle yeni nesil gençler metaverse'ün şekillenmesinde rol oynamaktadır. Gençleri bu kaçınılmaz geleceğe hazırlamak ve metaverse farkındalığı oluşturmak adına Türkiye'de ilk kez Süleyman Demirel Üniversitesi Girişimcilik Uygulama ve Araştırma Merkezi (SDÜ GİMER) ile GamFed Türkiye Uluslararası Oyunlaştırma Federasyonu iş birliğiyle “Metaverse Türkiye Girişimcilik Maratonu” gerçekleştirilmiştir. Bu çalışmada katılımcıların metaverse farkındalığı, 21. Yüzyıl yetkinlikleri ile girişimcilik düzeyleri arasındaki ilişkiler tespit edilmeye çalışılmıştır. Gelecekte yapılacak araştırmalar için özgünlüğü bağlamında literatüre katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler— Metaverse, Girişimcilik, 21. YY. Becerileri, Üniversite Öğrencileri

I. GİRİŞ

Son yıllarda teknolojiye yaşanan gelişmeler ile hemen hemen hayatın her alanında dijital dönüşümün yaşandığı ve yeni bir yaşam şeklinin temellerinin atıldığından bahsetmek mümkündür. Yeni nesil internet olarak tanımlanan metaverse'ün hayatımızın bir parçası olacağı öngörülmektedir. Özellikle dünyaya geldikleri andan itibaren dijital vatandaşlar olan Z kuşağı ve sonraki nesillerin deneyimlerini sürekli geliştirebilmeleri, çalışabilmeleri, sosyalleşebilmeleri, üretebilmeleri fiziksel ve dijital yaşamlarımızın kusursuz bir birleşimi olan metaverse ortamında mümkün hale gelecektir. Bu bağlamda gençlere ilham verecek metaverse farkındalığı oluşturmak adına Süleyman Demirel Üniversitesi Girişimcilik Uygulama ve Araştırma Merkezi (SDÜ GİMER) ile GamFed Türkiye Uluslararası Oyunlaştırma Federasyonu iş birliğiyle Türkiye'de İLK kez “Metaverse Türkiye Girişimcilik Maratonu” 9-15 Mayıs 2022 tarihleri arasında gerçekleştirilmiştir. Maratonda genç girişimciliği yükselen bir ivme gösteren “metaverse” özelinde inovatif ve teknoloji tabanlı yeni projelerin üretimi ile destekleyerek teşvik etmek amaçlanmıştır. Türkiye'deki çeşitli üniversitelerden Metaverse dünyasına ilgili ve girişimci ruha sahip ön lisans, lisans, yüksek lisans ve doktora öğrencilerinin katılımıyla gerçekleştirilmiştir. Alanında uzman kişilerce verilen online eğitimlerin ardından yüz yüze olarak katılımcılara bu alanda sahip olunan iş fikirlerinin 48 saatte ürüne dönüştürülmesine fırsat sunmak amacıyla teknik eğitimler ve alanında uzman kişilerce mentorluk sağlanmıştır. Yeni modern dijitalleşme sürecinin bir parçası olan metaverse farkındalığı yaratan bu maratonda genç yetenekler jüri oturumunda sektördeki uzman ve yatırımcılara sunum yapma fırsatı elde etmiş ve dereceye giren ekipler ödüllendirilmiştir. Bu çalışmada Türkiye'de ilk kez gerçekleştirilen “Metaverse Türkiye Girişimcilik Maratonu” katılımcılarının metaverse farkındalığı, 21. Yüzyıl yetkinlikleri ile girişimcilik düzeyleri arasındaki ilişkiler tespit edilmeye çalışılmıştır.

II. KAVRAMSAL ÇERÇEVE

A. Girişimci, Girişim, Girişimci Niyetler

Girişimci teriminin ilk tanımı Cantillon tarafından 1755'te “riski üstlenen ve herhangi bir karı meşru bir şekilde elde edebilen biri” olarak yapılmıştır [1]. Schumpeter'e (1951) göre ise girişimci, yeni hizmetler, ürünler veya teknolojiler sunan kişidir [2]. Low ve MacMillan ise [3] girişimciliği “yeni girişim yaratma” olarak tanımlarken, Pillis ve Reardon [4] girişimcilik niyetini “yeni bir iş kurma niyeti” olarak tanımlamaktadır. Girişimci ile ilgili kavramlar çok geniş olmakla birlikte sürekli güncellenmektedir. Girişimcilik niyeti de bu kavramlardan biri olmakla birlikte girişimci davranışın en iyi yordayıcısı olarak

görülmektedir. Niyetlilik, insan davranışını açıklamaya veya tahmin etmeye çalışan bilişsel psikolojiye dayanmaktadır. Davranışsal niyetin tutumlardan kaynaklandığı ve davranışın doğrudan bir belirleyicisi haline geldiği görülmektedir. Girişimci niyet, aile geçmişi, kişinin aile içindeki konumu, anne-baba mesleği, eğitim ve öğretim gibi dışsal değişkenler tarafından yönetilen yeni girişim yaratma eyleminin önemli bir belirleyicisidir [5]. Bireyin kariyer nedenini anlamak söz konusu olduğunda niyet anahtar bir kavramdır [6]. Bu, özellikle girişimci niyetin ana unsur olarak kabul edildiği yeni girişim başlatma kararını açıklamak için geçerlidir. Sosyal psikoloji literatüründe, niyetlerin, özellikle davranışın nadir olduğu, gözlemlenmesi zor veya öngörülemez zaman gecikmeleri içerdiği durumlarda, planlı bireysel davranışların güçlü bir yordayıcısı olduğu kanıtlanmıştır [7]. Girişimcilik, bu tür planlı ve kasıtlı davranışların tipik bir örneğidir [5,7]. Yeni bir iş kurma kararında niyetlerin çok uygun bir rol oynadığını savunan çok sayıda literatür vardır [8]. Bu modellerde kariyer niyeti, davranışın (bir işe başlamak gibi) hemen önceliği olarak görülmektedir. Niyetler de tutumlar tarafından belirlenirken özellikler, eğitim, demografi ve durumsal değişkenler gibi 'dışsal etkilere' etkilenir [9]. Öğrencilerin de girişimci niyetlerinin çeşitli faktörlerden etkilendiği mevcut ampirik çalışmalarda ortaya konmuştur. Bu çalışmalara göre yaratıcılık, öz yeterlilik, rol modelleri, özgüven, geçmiş girişimcilik deneyimi, girişimcilik kültürü, kişilik tipi, aile geçmişi veya desteği, ilişkisel ve eğitimsel destekler, cinsiyet, sosyal bağlam ve girişimcilik eğitiminin öğrencileri etkilediğini göstermektedir [10]. Ayrıca, son birkaç yılda küresel toplumdaki ve ekonomideki köklü dönüşümler nedeniyle üniversiteler, akademik yan ürünlere daha kolay bir başlangıç sağlamak için politikalarını [11], [12] ve eğitim müfredatlarını [13], [14] iş odaklı öğrencilerin veya öğretim üyelerinin paralel olarak şirket kurarken akademik yolculuklarını sürdürmelerini sağlamak amacıyla değiştirmektedir.

B. 21.YY Yetkinlikleri

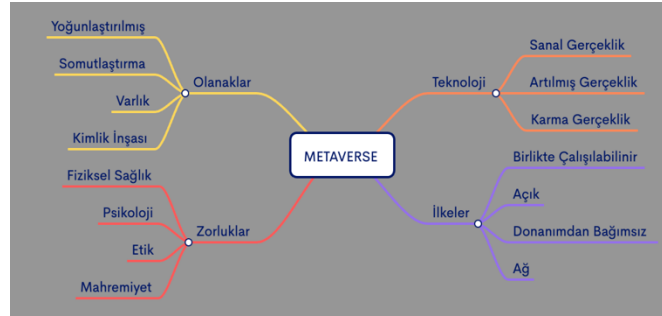
21. yüzyıl yeterlikleri terimi, 21. yüzyılda ihtiyaç duyulan yeteneklere göre eğitim veya öğrenme çıktılarına yönelik amaçların yeniden tanımlanması anlamına gelmekle birlikte [15], [16], tanımlı konusunda literatürde farklı görüşler vardır. Bu beceriler a) öğrenme ve yenilik becerileri, b) bilgi, medya ve teknoloji becerileri, c) yaşam ve kariyer becerileri ana başlıkları altında toplanmıştır. Kuzey Merkez Bölgesel Eğitim Laboratuvarı ve Metiri Grubu (NCREL) bu becerileri dijital okuryazarlık, yaratıcı düşünme, etkili iletişim ve yüksek verimlilik olarak tanımlamaktadır. NRC (Amerikan Ulusal Araştırma Konseyi) tarafından belirlenen bu yetkinlikler ise bilişsel beceriler, kişilerarası beceriler ve içsel becerilerdir [17].

21. yüzyıl becerilerini düzenlemeye yönelik Ekonomik İş Birliği ve Kalkınma Teşkilatı (OECD) yaklaşımı ise bilişsel becerilere, kişilerarası becerilere, kişilerarası becerilere ve teknik becerilere odaklanır [18]; Bilişsel beceriler, diğerleri arasında, rutin olmayan problem çözme, eleştirel düşünme ve sistem düşünmeyi içerir. İçsel beceriler ise öz-yönetim, zaman yönetimi, öz-gelişim, öz-düzenleme, uyarlanabilirlik ve yönetici işlevle bir grup üst bilişsel beceriyi içermektedir. Kişilerarası beceriler ise karmaşık iletişim, iş birliği, takım çalışması, kültürel duyarlılık ve çeşitlilikle başa çıkma gibi sosyal becerilerden oluşur. Son olarak teknik beceriler, öncelikle araştırma ve bilgi akıcılığı becerilerinin yanı sıra girişimcilik becerileri ve finansal okuryazarlığa odaklanır [19]. Soland, Hamilton ve Stecher [20] de OECD çerçevesinin üç bileşeniyle benzer bir model kullanmakla birlikte teknik becerileri dışarıda bırakmaktadır. Modelleri bilişsel yeterlilikler (akademik ustalık, eleştirel düşünme ve yaratıcılık); kişilerarası yetkinlikler (iletişim ve iş birliği, liderlik ve küresel farkındalık); ve kişisel yetkinlikler (gelişen zihniyet, öğrenmeyi öğrenme, içsel motivasyon ve cesaret) olarak sınıflandırılmıştır.

21. yüzyıl bağlamı, bilgi ve iletişim teknolojisi okuryazarlığının ötesinde yeni bir dizi yeterlilik gerektirir. Kamuoyunda, akademik çevrelerde ve özel okullarda ismi sıkça anılsa da 21. yüzyıl becerileri kavramı net bir bakış açısı yoktur. Eğitimciler, politikacılar, işverenler, eğitim dernekleri ve yüksek öğretim kurumları, yatay beceriler olarak da adlandırılan 21. yüzyıl becerilerine farklı açılardan bakmaktadır. 21. yüzyıl becerileri, Endüstri 4.0 ve 21. Yüzyıl Becerileri, Makine Öğrenimi ve Robotlar, Dijital Vatandaşlık, Eğitim/Pedagoji 4.0 ile ele alınmaktadır. Öğrencilerin gelecekteki yeniliklerle başa çıkmak ve yeni iş ve teknolojilere uyum sağlamak için 21. yüzyıl becerilerine sahip olmaları beklenmektedir. Yaşamın her aşamasında gerekli görülen bu beceriler, öğrenme ve yenilik becerileri, bilgi, medya ve iletişim teknolojileri, yaşam ve kariyer becerileri olarak gruplandırılmıştır. Ayrıca bu beceriler bilişseldir (eleştirel düşünme, problem çözme, yaratıcılık, öğrenmeyi öğrenme); kişilerarası beceriler (iletişim, iş birliği, sosyal ve kültürel beceriler) ve içseldir (öz yönetim, öz düzenleme, zaman yönetimi, kişisel gelişim, yaşam boyu öğrenme, uyum sağlama, üretkenlik, esneklik ve girişimcilik) [21].

C. Metaverse

Metaverse "meta" (aşmayı ima eden) ön ekinin "evren" kelimesiyle birleşimi, fiziksel dünyayla bağlantılı varsayımsal bir sentetik ortamı tanımlar. 'Metaverse' kelimesi ilk olarak 1992'de Neal Stephenson tarafından yazılan Snow Crash adlı bir spekülatif kurgu parçasında ortaya çıkmıştır [22]. Stephenson bu romanda metaverse'i, kullanıcıların dijital avatarlar aracılığıyla etkileşimde bulunduğu fiziksel dünyaya paralel olarak devasa bir sanal ortam olarak tanımlar. Bu ilk ortaya çıkışından bu yana, bilgisayar tarafından üretilen bir evren olarak meta-verim, yaşam günlüğü [23], sanallıktaki kolektif uzay [24], somutlaştırılmış internet/uzaysal İnternet [25], amirror dünyası [26], simülasyon ve iş birliği mekânı [27] gibi çok çeşitli kavramlar aracılığıyla tanımlanmıştır. Başka bir ifadeyle Metaverse, fiziksel gerçekliği dijital sanallıkla birleştiren sürekli ve kalıcı çok kullanıcı bir ortam olan gerçeklik sonrası evrendir. Sanal ortamlar, dijital nesnelere ve sanal gerçeklik (VR) ve artırılmış gerçeklik (AR) gibi insanlarla çok-duyulu etkileşimleri mümkün kılan teknolojilerin yakınsamasına dayanır. Bu nedenle, Metaverse, kalıcı çok kullanıcı platformlarında birbirine bağlı bir sosyal, ağa bağlı sürükleyici ortamlar ağıdır. Dijital yapay nesnelere gerçek zamanlı ve dinamik etkileşimlerde kusursuz, somutlaştırılmış kullanıcı iletişimi sağlar. İlk versiyonu avatarların aralarında ışınlanabildiği bir sanal dünyalar ağıken, Metaverse'in güncel hali çok oyunculu çevrimiçi video oyunları, açık oyun dünyaları ve AR ortak çalışma alanlarıyla uyumlu sosyal, sürükleyici VR platformları içermektedir. Kapsamı Şekil I'de gösterilmektedir [28].



Şekil I. Metaverse Teknolojileri, İlkeleri, Olanakları ve Zorlukları

Kaynak : *Mystakidis, Stylianos. 2022. "Metaverse" Encyclopedia 2, no. 1: 486-497.*

III. ARAŞTIRMA

Türkiye’de ilk kez Süleyman Demirel Üniversitesi’nde gerçekleşen Metaverse Girişimcilik Maratonuna katılan 50 katılımcı spesifik örneklem olarak belirlenmiştir. Bazı anketlerde tutarsız cevaplar tespit edildiğinden 41 anket değerlendirilmiştir. Araştırmanın kısıtı Türkiye’de ilk Metaverse Girişimcilik maratonuna katılan katılımcılarla sınırlıdır. Araştırmada veri toplama aracı olarak anket yöntemi kullanılmıştır. Bu araştırmada veri toplama aracı olarak kullanılan anket 4 bölümden oluşmaktadır. İlk bölümünde demografik sorulara yer verilmiştir. 2. bölümünde Çevik ve Şentürk tarafından geliştirilmiş 41 maddelik 21 yy. Becerileri Ölçeği kullanılmıştır. Bilgi ve teknoloji okuryazarlığı becerileri, eleştirel düşünme ve problem çözme becerileri, girişimcilik ve inovasyon, sosyal sorumluluk ve liderlik becerileri olmak üzere 5 alt boyuttan oluşmaktadır [29]. 3. bölümde, Yılmaz ve Sünbül tarafından geliştirilmiş 36 maddelik tek boyutlu Girişimcilik Ölçeği kullanılmıştır [30]. 4. bölümde, Süleymanoğulları vd. tarafından geliştirilmiş 15 maddelik Metaverse ölçeği kullanılmıştır. Teknoloji, dijitalleşme, sosyal ve yaşam biçimi olmak üzere 4 alt boyuttan oluşmaktadır. Bu ölçekler 5’li likert niteliğindedir. Ankete cevap verenlerin ifadelerine katılma düzeyi “tamamen katılıyorum” “1”, “kesinlikle katılmıyorum” ise “5” puan aralığında ölçeklendirilmiştir [31].

Anket formları aracılığıyla elde edilen veriler SPSS 16.0 (Statistical Package for the Social Sciences) programı ile analiz edilmiştir. Yapılan analizler güvenilirlik analizi, frekans analizi ve bağımsız örneklem t testi şeklindedir. Aşağıda bulunan alt başlıklarda yapılan analizler ve elde edilen bulgular detaylı bir şekilde açıklanmaktadır.

TABLO I

GÜVENİLİRLİK ANALİZLERİ

Ölçekler	Cronbach's Alpha	Soru Sayısı
21. yy. Becerileri Ölçeği	0.928	41
Girişimcilik Ölçeği	0.916	36
Metaverse Ölçeği	0,860	15

21.yy. becerileri ölçeğinin ifadelerinin güvenilirlik katsayısı 0.928 olarak $0.90 \leq \alpha \leq 1.00$ arasında yüksek derecede güvenilir, girişimcilik ölçeğinin güvenilirlik katsayısı 0.916 olarak $0.90 \leq \alpha \leq 1.00$ yüksek derece de güvenilir ve metaverse ölçeğinin güvenilirlik katsayısı da 0.860 olarak $0.60 \leq \alpha \leq 0.90$ arasında oldukça güvenilir olarak bulunmuştur [32]. Ayrıca, veriler normallik testlerine tabi tutulmuşlardır. Bu nedenle boyutların çarpıklık ve basıklık değerleri incelenmiştir. Skewness ve Kurtosis değerleri [-1.5, +1.5] aralığında olduğundan verilerin normal dağılıma sahip olduğu tespit edilmiştir [33]. Katılımcıların demografik özelliklerine (yaş, cinsiyet), eğitim düzeylerine, çalışma durumlarına ve çalışma sürelerine göre dağılımları incelenmiştir. Buna göre katılımcıların (%92,7)’si 18-25 yaş aralığındadır. 14’ü kadın (%34,1) ve 27’si erkek (%65,9)’dir. Çoğunluğu (%92,7) lisans mezunudur. Çalışan öğrenci sayısı 13 (%31,7) ve çalışmayan öğrenciler ise 28 (68,3)’dir. Çalışma sürelerine bakıldığında ise, 1 yıldan az sürede çalışan sayısı 34 (%82,9) çoğunluğu oluşturmaktadır. 21. yy. Becerileri ölçeğinin, $4,26 \pm 0,41$ ortalama ile en yüksek katılıma sahip ölçek olduğu tespit edilmiştir. Aynı zamanda Metaverse ölçeğinin $3,97 \pm 0,54$ ortalama ile en düşük katılıma sahip olan ifade olduğu tespit edilmiştir. Buna göre, katılımcıların 21 yy. Becerileri ve Girişimcilik ölçeklerine karşı olumlu algısı varken, Metaverse ölçeğine daha az olumlu algısı söz konusudur.

A. Demografik Özelliklerin Türkiye'nin İlk Metaverse Girişimcilik Maratonu Katılımcıları Üzerine Fark Analizi

Türkiye'nin İlk Metaverse Girişimcilik Maratonu Katılımcılarının demografik özelliklerini karşılaştırmak amacı ile bağımsız örneklem t-testi analizleri yapılmıştır. Cinsiyet için 21 yy. ölçeğine yönelik bağımsız örneklem için t testi sonuçları, Sig. 0,216, t değeri 0,811 olarak bulunmuştur. T değeri 0,05'den büyük olduğu için kadın ve erkek arasında 21 yy. boyutunda fark yoktur. Çalışma durumu için 21. yy. boyutuna yönelik bağımsız örneklem için t testi Sig. 0,661, t değeri 1,563 çalışan ve çalışmayan arasında fark yoktur. Girişimcilik alanındaki deneyim için 21 yy boyutuna yönelik bağımsız örneklem için t testi Sig. 0,354, t değeri 1,067 girişimcilik deneyimi olan ile olmayan arasında fark yoktur. Cinsiyet için Girişimcilik boyutuna yönelik bağımsız örneklem için t testi Sig. 0,485, t değeri 0,319 kadın ve erkek arasında fark yoktur. Çalışma durumu için Girişimcilik boyutuna yönelik bağımsız örneklem için t testi Sig. 0,109, t değeri -0,096 çalışan ve çalışmayan arasında fark yoktur. Girişimcilik alanındaki deneyim için Girişimcilik boyutuna yönelik bağımsız örneklem için t testi Sig. 0,111, t değeri 2,232 girişimcilik deneyimi olan ile olmayan arasında fark yoktur. Cinsiyet için Metaverse boyutuna yönelik bağımsız örneklem için t testi Sig. 0,200, t değeri 1,268 kadın ve erkek arasında fark yoktur. Çalışma durumu için Metaverse boyutuna yönelik bağımsız örneklem için t testi Sig. 0,376, t değeri -1,752 çalışan ve çalışmayan arasında fark yoktur. Girişimcilik alanındaki deneyim için Metaverse boyutuna yönelik bağımsız örneklem için t testi Sig. 0,473, t değeri 0,929 girişimcilik deneyimi olan ile olmayan arasında fark yoktur.

B. 21.YY. Becerileri, Girişimcilik ve Metaverse Arasındaki İlişki

Tablo 2.'de Pearson kolerasyonuna ilişkin sonuçlar yer almaktadır. Bu analizde belirlenen hipotezler doğrultusunda kolerasyonlar incelenmiştir.

TABLO II
KATILIMCILARIN GÖRÜŞLERİNE İLİŞKİN KORELASYON ANALİZİ SONUÇLARI

N=41	21. Yüzyıl Becerileri	Girişimcilik	Metaverse Farkındalığı	Kariyer Bilinci	Eleştirel Düşünme	Sosyal Sorumluluk	İnovasyon	Okuryazarlık	Teknoloji Eğitimi	Dijitalleşme	Sosyal	Yaşam Biçimi
21. Yüzyıl Becerileri	1											
Girişimcilik	0,550 **	1										
Metaverse Farkındalığı	0,054	0,427 **	1									
Kariyer Bilinci	0,711 **	0,299	0,079	1								
Eleştirel Düşünme	0,652 **	0,172	- 0,102	0,386 *	1							

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Sosyal Sorumluluk	0,721 **	0,429 **	- 0,001	0,402 **	0,334 *	1						
İnovasyon	0,732 **	0,680 **	0,110	0,491 **	0,240	0,566 **	1					
Okuryazarlık	0,906 **	0,462 **	0,087	0,614 **	0,443 **	0,602 **	0,544 **	1				
Teknoloji Eğilimi	0,070	0,385 *	0,890 **	0,124	- 0,044	0,032	0,120	0,057	1			
Dijitalleşme	- 0,060	0,256	0,670 **	- 0,021	- 0,278	- 0,014	0,092	0,005	0,464 **	1		
Sosyal Sorumluluk	0,093	0,319 *	0,760 **	- 0,031	- 0,079	0,001	0,130	0,183	0,483 **	,540*	1	
Yaşam Biçimi	0,017	0,336 *	0,751 **	0,075	- 0,030	- 0,062	- 0,013	0,045	0,489 **	0,380 *	0,593 **	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

TABLO III
HIPOTEZLERİN DURUMU

Hipotezler	Durumu
H1: Katılımcıların Metaverse farkındalığı ve girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H1a: Katılımcıların teknoloji eğilimi ile girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H1b: Katılımcıların dijitalleşme ve girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Ret
H1c: Katılımcıların sosyal ve girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H1d: Katılımcıların yaşam biçimi ve girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H2: Katılımcıların 21.yy becerileri ile girişimcilik düzeyi arasında anlamlı ilişki vardır.	Kabul
H2a: Katılımcıların bilgi ve teknoloji okuryazarlığı becerileri ile girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H2b: Katılımcıların eleştirel düşünme ve problem çözme becerileri ile girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Ret
H2c: Katılımcıların girişimcilik ve inovasyon becerileri ile girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H2d: Katılımcıların sosyal sorumluluk ve liderlik becerileri ile girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Kabul
H2e: Katılımcıların kariyer bilinci ve girişimcilik düzeyi arasında anlamlı bir ilişki vardır.	Ret
H3: Katılımcıların 21.yy becerileri ile metaverse farkındalığı arasında anlamlı ilişki vardır.	Ret
H3a: Katılımcıların bilgi ve okuryazarlığı beceriler ve teknoloji eğilimi arasında anlamlı bir ilişki vardır.	Ret
H3b: Katılımcıların bilgi ve okuryazarlığı beceriler ile dijitalleşme arasında anlamlı bir ilişki vardır.	Ret
H3c: Katılımcıların bilgi ve okuryazarlığı beceriler ile sosyal arasında anlamlı bir ilişki vardır.	Ret
H3d: Katılımcıların bilgi ve okuryazarlığı beceriler ve yaşam biçimi arasında anlamlı bir ilişki vardır.	Ret
H3e: Katılımcıların eleştirel düşünme ve problem çözme becerileri ile teknoloji eğilimi arasında anlamlı bir ilişki vardır.	Ret
H3f: Katılımcıların eleştirel düşünme ve problem çözme becerileri ile dijitalleşme arasında anlamlı bir ilişki vardır.	Ret
H3g: Katılımcıların eleştirel düşünme ve problem çözme becerileri ile sosyal arasında anlamlı bir ilişki vardır.	Ret
H3h: Katılımcıların eleştirel düşünme ve problem çözme becerileri ile yaşam biçimi arasında anlamlı bir ilişki vardır.	Ret
H3i: Katılımcıların girişimcilik ve inovasyon becerileri ile teknoloji eğilimi arasında anlamlı bir ilişki vardır.	Kabul
H3j: Katılımcıların girişimcilik ve inovasyon becerileri ile dijitalleşme arasında anlamlı bir ilişki vardır.	Ret
H3j: Katılımcıların girişimcilik ve inovasyon becerileri ile sosyal arasında anlamlı bir ilişki vardır.	Kabul
H3k: Katılımcıların girişimcilik ve inovasyon becerileri ile yaşam biçimi arasında anlamlı bir ilişki vardır.	Kabul
H3l: Katılımcıların sosyal sorumluluk ve liderlik becerileri ile teknoloji eğilimi arasında anlamlı bir ilişki vardır.	Ret
H3m: Katılımcıların sosyal sorumluluk ve liderlik becerileri ile dijitalleşme arasında anlamlı bir ilişki vardır.	Ret
H3n: Katılımcıların sosyal sorumluluk ve liderlik becerileri ile sosyal arasında anlamlı bir ilişki vardır.	Ret
H3o: Katılımcıların sosyal sorumluluk ve liderlik becerileri ile yaşam biçimi arasında anlamlı bir ilişki vardır.	Ret

H3ö: Katılımcıların kariyer bilinci ile teknoloji arasında anlamlı bir ilişki vardır.	Ret
H3p: Katılımcıların kariyer bilinci ile dijitalleşme arasında anlamlı bir ilişki vardır.	Ret
H3r: Katılımcıların kariyer bilinci ile sosyal arasında anlamlı bir ilişki vardır.	Ret
H3s: Katılımcıların kariyer bilinci ile yaşam biçimi arasında anlamlı bir ilişki vardır.	Ret

IV. SONUÇ

Dünya dijital teknolojiler üzerine kurulu yeni bir döneme doğru yol almaktadır. Bu süreçte hızla gelişen teknolojiyi takip etmek, uyum sağlamak ve destek vermek önem taşımaktadır. Web 3.0 ile Metaverse hayatımızda yer edinmeye başlamıştır. Metaverse kişilerin birbirleriyle bağlantılı dünyalar arasında sorunsuz bir şekilde sonsuz geçişler yapabildiği ve aynı zamanda sosyalleşerek iş birliği sağlayabildiği sürükleyici XR deneyimlerinin de yer aldığı birbirine bağlı dijital alanlar kümesi olarak tanımlanmaktadır. Metaverse deneyimleri ile satın alma, çalışma, bağlantı kurma, sosyalleşme, oynama gibi imkanlar sunulmaktadır. Bunlarla birlikte küresel ekonomiye potansiyel katkısı olacaktır. Bu bağlamda özellikle gençlerin metaverse'ün şekillenmesinde rol oynayacağı düşünüldüğünde, gençlerin metaverse farkındalığını geliştirmek adına Türkiye'de ilk kez Süleyman Demirel Üniversitesi Girişimcilik Uygulama ve Araştırma Merkezi (SDÜ GİMER) ile GamFed Türkiye Uluslararası Oyunlaştırma Federasyonu iş birliğiyle "Metaverse Türkiye Girişimcilik Maratonu" gerçekleştirilmiştir. Bu çalışmada katılımcılarının metaverse farkındalığı, 21. Yüzyıl yetkinlikleri ile girişimcilik düzeyleri arasındaki ilişkiler tespit edilmeye çalışılmıştır. Bulgular ışığında; katılımcıların Metaverse farkındalığı ve girişimcilik düzeyi arasında; teknoloji eğilimi ile girişimcilik düzeyi; sosyal ve girişimcilik düzeyi; yaşam biçimi ve girişimcilik düzeyi; 21.yy becerileri ile girişimcilik düzeyi; bilgi ve teknoloji okuryazarlığı becerileri ile girişimcilik düzeyi; girişimcilik ve inovasyon becerileri ile girişimcilik düzeyi; sosyal sorumluluk ve liderlik becerileri ile girişimcilik düzeyi; girişimcilik ve inovasyon becerileri ile teknoloji eğilimi; girişimcilik ve inovasyon becerileri ile sosyal; girişimcilik ve inovasyon becerileri ile yaşam biçimi arasında anlamlı bir ilişki bulunmuştur. Araştırmanın kısıtı Türkiye'de ilk Metaverse Girişimcilik maratonuna katılan katılımcılarla sınırlıdır. Gelecekte yapılacak araştırmalar için örneklem sayısı artırılarak bu çalışmanın ışık tutacağı düşünülmektedir.

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Uzaktan Çalışma Ortamlarında İş Tatminini Etkileyen Faktörler

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Özet — Uzaktan çalışma, mobil çalışma, ev ofis, dışarıda çalışma ve esnek işyeri olarak da adlandırılan çalışma şekli, son yıllardaki gelişmeler, özellikle de salgın ortamı ile birlikte bir çok firma için popüler hatta zorunlu hale gelmiştir. Bu çalışma yaklaşımında geleneksel çalışma ortamına göre değişen birçok kavram bulunmaktadır. Bu değişim çalışanların işe bakışını ve tatminini dolayısıyla çalışma performansını etkilemektedir. Bu çalışmanın amacı çalışanların performanslarını hatta iş değiştirme gibi kararlarını etkileyen iş tatmininin uzaktan çalışma ortamlarında ne gibi faktörlerden etkilendiğini ortaya koymak ve firmaların gerekli önlemleri almasında yol gösterecek bir çerçeve oluşturmaktır. Çalışmada uzaktan çalışma ortamlarında yönetici desteği, finansal ve teknik destek, çalışma ortamı, temel motivasyon temaları ele alınmış ve katılımcılara bu temaları detaylandıran sorular sorulmuştur. Katılımcılara göre ilgili temalardaki cevaplar çeşitli olsa da ortaya çıkan genel olgu çalışanların desteklenerek bir güven ilişkisinin kurulmasının gerekliliğidir.

Anahtar Kelimeler — Uzaktan Çalışma, Covid-19, Olgubilim, İş Tatmini, Motivasyon

I. GİRİŞ

Uzaktan çalışma (Remote Working), mobil çalışma, ev ofis, dışarıda çalışma ve esnek işyeri olarak da adlandırılan çalışanların şirket içindeki iş yerlerine gidip gelmediği bir çalışma şeklidir. Son yıllardaki gelişmeler özellikle de salgın ortamı ile birlikte uzaktan çalışma birçok firma için popüler hatta zorunlu hale gelmiştir.

Esasen bu yüzyılın başlarına biraz bakıldığında uzaktan çalışma çekici bir kavram olarak karşımıza çıkmaktadır. Firmaların özellikle de bilgi işlem ve telekomünikasyon sektöründeki firmaların uzaktan çalışma imkanlarını işe alımda bir avantaj, çalışanlar için de bir bağlılık faktörü olarak kullandığı da görülmektedir. Burada belli çalışanlar için tercih edilebilir olan ve avantajları çok olan bir çalışma yönteminin tüm çalışanlar için aynı anlama geldiğini söylemek pek de mümkün olmamaktadır [1].

Yapılan araştırmalarda uzaktan çalışmanın firmalar ve çalışanlar açısından birçok avantajı olduğunu ortaya konulmuştur. Özellikle de iş ve özel yaşam dengesi açısından bir avantaj gibi gösterildiği olmuştur [2], [3]. Genel olarak, uzaktan çalışma ve iş tatmini arasındaki ilişki, uzaktan çalışmanın çalışanlara işlerini nasıl başardıkları konusunda daha fazla esneklik ve daha fazla özerklik sağladığı ve bu da çalışanın işinin ve kendi kişisel (yaşam ve aile) taleplerini karşılamasını sağladığı varsayımından kaynaklanmaktadır [4]. Fakat esasen uzaktan çalışmanın iş ve özel yaşam dengesini iyileştirdiği çok da net olarak söylenemez. Örneğin yerinde çalışmada veya yerinde ziyaret ile yapılabilecek toplantı sayısı kısıtlı iken, uzaktan çalışmada çok daha fazla ve yorucu toplantılar yapıldığını görülmektedir. Aynı şekilde bir işin tamamlanması için çalışanlar iş ve özel yaşam saatlerinin iç içe girmesinden de şikayetçi olmaktadır. Bu noktada iş tatmininin nasıl etkilendiği de merak konusu olmaktadır. Küçük çocukların varlığı, yardıma ihtiyacı olanların varlığı, cinsiyete bağlı faktörler de ayrıca ele alınmalıdır [5].

Temel yaklaşımlara bakıldığında uzaktan çalışma ortamlarında iş tatminini etkileyen faktörler, organizasyonel faktörler, bireysel çalışma tarzı, iş karakteristiği, çalışma (ev) ortamı şeklinde ele alınabilmektedir. Özellikle organizasyonel faktörlerin detaylandırılarak ele alınması gereklidir. Yönetim kültürü, teknik destek, yöneticiye güven, finansal destek gibi konular önem kazanmaktadır. İş karakteristiğinin uzaktan çalışmaya uygun olup olmaması hem etkin çıktı üretmeyi dolayısı ile iş tatminini etkileyecektir. Bireysel çalışma tarzı özellikle kendi kendine motivasyon ve iş-özel yaşam dengesini kurma gibi konuları açıklamaktadır. Çalışılan ortamının düzeni literatürde en az dikkat edilen kavramdır, ancak

ortamda konsantrasyonu etkileyen, çalışmayı kesen faktörlerin olması da önemli bir konu olabilmektedir [6].

Bu çalışmanın amacı çalışanların performanslarını hatta iş değiştirme gibi kararlarını etkileyen iş tatmininin uzaktan çalışma ortamlarında ne gibi faktörlerden etkilendiğini ortaya koymak ve firmaların gerekli önlemleri almasında yol gösterecek bir çerçeve oluşturmaktır.

II. ARAŞTIRMANIN ÖNEMİ VE KATKISI

Literatür araştırması sırasında uzaktan çalışma ile ilgili yayınların genellikle yurt dışı kaynaklı olduğu görülmüştür. Ülke içindeki durumu araştıran kaynak sayısı kısıtlı kalmaktadır.

Yerli işletmeler açısından bakıldığında, uzaktan çalışma çok yaygın bir çalışma sistemi olarak kullanılmamaktaydı. Ülkemizde salgın şartları ile pek çok firma uzaktan çalışma modeline geçiş yapmak zorunda kalmıştır. Bazı firmalar tamamen uzaktan çalışmaya geçerken, bazı firmalar ise karma yöntemleri seçmiştir. Bu dönem esasen ülkemiz için de yeni bir çalışma sisteminin başlangıcı olmuştur.

Günümüz şartlarında pek çok işletmede çalışma ortamının yapılan işe çok uygun olmadığı ve işe yoğunlaşmayı etkilediği, gizlilik konusunda zorluklar yaşandığı bilinmektedir. Çalışanlar evden çalışma ile aslında kendileri için daha uygun bir ortama erişmişlerdir ancak ülkemizde ev ortamında çalışma dünyadaki gibi yerleşmiş bir kültür değildir. Bu açıdan evden çalışma düzenine alışmak ülkemiz çalışanları açısından kolay olmamıştır.

Ev ortamındaki bölücü faktörlerin fazla olması, iş-yaşam dengesinin ayarlanması, firmaların teknik olarak çalışanlara sağladığı destek, yöneticilerin uzaktan çalışma modeline adaptasyonu ve ekiplerine verdiği destek gibi birçok konu firmaların değerlendirmek ve sürdürülebilir politikaları belirlemek zorunda olduğu kavramlardır. Uzaktan çalışma modelinin rutin bir uygulama olarak devam ettirilmesi bir maliyet avantajı oluşturabilir. Fakat bunun yanı sıra insanların bir arada olduğundaki iletişimleri ve sosyal paylaşımları, şirket kültürüne ve başarısına katkıları uzaktan çalışma ortamlarında azalacaktır ve bunun da iş tatminine etkisi söz konusu olacaktır.

Tüm bu sayılan faktörlerin ele alınarak incelenmesi önemlidir. Bu çalışma ülkemizde uzaktan çalışma modelini uygulayan firmalar açısından belli bir kapsamda da olsa ele alacak ve farklı dinamikleri olan yerli işletmelerde çalışanların uzaktan çalışma modelindeki iş tatmininin etkileyen faktörlerini incelemektedir.

II. LİTERATÜR ARAŞTIRMASI

Uzaktan çalışmayı ve iş tatmini ilişkisini inceleyen çalışmalara bakıldığında bu konuyu geleneksel çalışma ortamı ile karşılaştırmalı ele alan veya sadece uzaktan çalışma ortamı faktörlerine değerlendiren çalışmalar mevcuttur.

Genel teorik bir yaklaşım olarak uzaktan çalışma ve iş tatmini arasındaki ilişki ele alındığında bu ilişkiye aracılık eden birtakım değişkenlerin olduğu da söylenebilir. Schall [7] araştırmasında, uzaktan çalışma ve iş tatmini arasındaki ilişkiye aracılık eden iş-özel yaşam çatışması, algılanan özerklik ve iletişim sıklığı değişkenlerini ele almıştır. Uzaktan çalışma ve iş tatmini arasında doğrusal bir ilişkiden ziyade zaman göre değişken bir ilişki olduğu ve başlangıçta pozitif eğilimde olan ve sonradan gittikçe azalan bir iş tatmini olduğundan söz edilmiştir. İletişim sıklığı az olan ortamlarda bu tatminin daha hızlı azaldığı gözlemlenmektedir. Özerklik yani kendi çalışma alanında daha serbest davranabilme açısından bakıldığında ise uzaktan çalışmanın iş tatminini artırdığı gözlemlenmiştir. Araştırmada aynı zamanda, İş-Özel Yaşam dengesi açısından bakıldığında ise uzaktan çalışmanın iş tatminini artırdığı gözlemlenmiştir.

Hem firmalar hem de çalışanlar düzeyinde uzaktan çalışmanın artı ve eksileri sürekli tartışılacak gibi görünmektedir. Bellmann ve Hübler [5], çalışmalarında uzaktan çalışma ortamının iş tatmini ve iş ve özel yaşam dengesine olan etkisini araştırmışlardır. Bu araştırmaya göre ortaya konan, firmaların, iş-özel yaşam dengesizliklerine katkıda bulunan işe bağlı faktörleri azaltmaları gerektiğidir. Örneğin, görevlerin çalışanlar tarafından öngörülen zaman çerçevesi içinde iş yüküne yol açmadan yerine getirilebilmesi için zamanlamayı çok sıkı yapmamalıdır. Daha fazla iş tatmini, iş motivasyonunu arttırmakta ve daha yüksek performansı getirmektedir.

İş tatmini ve çalışan verimliliği konusunda da çalışmalar mevcuttur. Pemble [8] tez çalışmasında, karma yöntemli bir araştırma yaparak, uzaktan çalışanların en yüksek üretkenliğiyle ilişkili faktörleri

açıklamak ve ilişkiler hakkındaki algıları keşfetmeye çalışmıştır. Öncelikle nicel analizde, iş motivasyonu ve üretkenlik arasında istatistiksel olarak anlamlı bir ilişki ortaya konmuştur, ancak yöneticilerin liderlik tarzının bu etki dışında kaldığı gözlemlenmiştir. Bu analizde ilk aşamada İş tatmini analizin dışında tutulmuştur, ancak nitel çalışma ile keşfedildiği gibi, düşük bir iş tatmini oranı muhtemelen daha düşük üretkenlik ile sonuçlanmaktadır; bununla birlikte, yüksek bir iş tatmini oranı mutlaka artan üretkenliğe yol açmamaktadır.

Lassiter [9] çalışmasında uzaktan çalışan ve yerinde çalışanlar açısından iş tatmini, sorumluluk, özveri kavramlarını farklı jenerasyonlar bazında ele almıştır. Araştırmada X ve Y kuşağının Baby Boomers kuşağına göre uzaktan çalışma ortamından daha çok memnun olduğu ortaya konmuştur.

Dönüşümsel liderlik açısından bakıldığında ise karşımıza daha farklı sonuçlar çıkabilmektedir. Dönüşümsel liderlik, vizyonu paylaşan, öğrenmeyi teşvik eden, güvene dayalı ilişki kuran, ilham verici bir liderlik tarzıdır. Buna rağmen uzaktan çalışma ortamlarında farklı etkilerle karşılaşmak mümkün olmaktadır. Jones ve Schöning [10], çalışmalarında dönüşümsel liderliğin uzaktan çalışma ortamlarında psikolojik açıdan emniyetli bir ortam sunabildiğini buna karşın iş tatmini üzerinde negatif etkileri olduğunu ortaya koymuşlardır. Özellikle çalışanların uzaktan çalışma günleri arttıkça bu etkinin daha negatif olduğu belirtilmiştir. İşletmelerin çalışanlarının durumuna göre kendi hibrit modellerini kurmaları gerekmektedir.

Ülkemizde az sayıda da olsa uzaktan çalışma ortamlarına yönelik araştırmalar mevcuttur. Arıkboğa, Doğan, Akdöl ve İrengün [11], tarafından hazırlanan betimleyici raporda salgın sırasında evden çalışma ile ilgili durumun ortaya konması ve salgın öncesi durumla kıyaslanarak bundan sonraki iş yaşamında yapılabilecek düzenlemeler için bir katkı sağlanması hedeflenmiştir. Raporda uzaktan çalışma ortam faktörleri, firmanın sağladığı destekler, teknik araç gereçler, iş-özel yaşam zaman dengesi, çalışma yoğunluğu, yönetici faktörleri, gibi birçok kavram ele alınarak iş tatmini ve çalışan bağlılığı incelenmeye çalışılmıştır. İşletmeleri sadece olumlu unsurlara odaklanmayıp olumsuz unsurları da ele alıp, uzun vadede uzaktan çalışmanın sürdürülebilirliği için stratejilerin belirlenmesi gerektiği ortaya konmuştur.

IV. ARAŞTIRMANIN YÖNTEMİ

Araştırma yöntemi olarak nitel bir araştırma yöntemi olan olgubilim (fenomenoloji) kullanılmıştır. Olgubilimde araştırma yapılan olgu ve olaylar kendi bağlamında ele alınarak insanların onlara yükledikleri anlamların yorumlanması hedeflenir [12]. Olgubilim yaklaşımına göre tek bir gerçeklik yoktur. Gerçeklik kişisel algılamalara dayanır ve zamanla değişebilir. Ne bildiğimiz içinde bulunduğumuz durum, çevre ve şartlara göre değişiklik gösterir [13].

Olgubilim (fenomenoloji) Kant tarafından 1794 yılında tanımlanmıştır. Esasen Filozof Edmunt Husserl'in öncülüğünde gelişmiştir [14]. "Phenomenography" kelimesi Yunan kökenlidir. Phainomenon (görünüş) ve graphein (tanım) kelimelerinin bir araya gelmesiyle oluşur.

Olgubilim araştırmasında "olgunun kendisi" araştırılmaktadır. Bu sebeple "görüntü ya da bilince sahip herhangi bir şey" araştırılabilir. Olgubilim araştırmasında bireylere herhangi bir müdahalede bulunulmamaktadır. Olduğu gibi kabul edilmekte, izlenmekte ve incelenmektedir [14]. Bu tür çalışmalarda uzun görüşmeler, hatta birden fazla oturum gerektiren görüşmeler söz konusu olacağı için örneklemin sınırlı kalması doğaldır. Olgubilim araştırmasında daha fazla bireyle görüşmek olguyla ilgili daha fazla bilgi elde etmek anlamına gelmemektedir.

A. Araştırma Grubu

Araştırma grubunu Türkiye'de uzaktan çalışmayı uygulayan Yazılım, Finans, Hukuk gibi farklı sektörlerden 10 firma çalışanı oluşturmaktadır. Araştırma grubundaki katılımcıların iş deneyimleri de farklılık göstermektedir. Bu yöntem ile belli bir sektör veya çalışan grubu ile verilerin standartlaşmasının önüne geçilmeye çalışılmıştır. Araştırma grubunda yer alan katılımcıların özellikleri aşağıdaki tabloda verilmiştir.

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TABLO XXI
ARAŞTIRMA GRUBU KATILIMCI ÖZELLİKLERİ

No	Sektör	İş Deneyimi	Görev Tanımı
Katılımcı-1	Yazılım	10-15 yıl	Proje Yöneticisi
Katılımcı-2	Hukuk	15-20 yıl	Hukuk Danışmanı
Katılımcı-3	Telekomünikasyon	20-25 yıl	Uygulama Destek Uzmanı
Katılımcı-4	Finans	20-25 yıl	Destek Ekip Yöneticisi
Katılımcı-5	Yazılım	10-15 yıl	Yazılım Takım Yöneticisi
Katılımcı-6	Yazılım	5-10 yıl	Yazılım Uzmanı
Katılımcı-7	Yazılım	1-5 yıl	Yazılım Uzmanı
Katılımcı-8	Telekomünikasyon	10-15 yıl	Satış Yöneticisi
Katılımcı-9	Yazılım	15-20 yıl	Yazılım Takım Yöneticisi
Katılımcı-10	Eğitim	5-10 yıl	Eğitim Danışmanlığı

B. Veri Toplama Aracı

Veri toplama aracı olarak 8 sorudan oluşan yarı yapılandırılmış mülakat formu kullanılmıştır. Bazı katılımcılar ile birebir görüşmeler yapılarak cevaplar alınmış, bazı katılımcılardan ise e-posta vb. yöntemlerle cevaplar alınmıştır. Katılımcıların araştırmaya gönüllü olarak katkı vermesi sağlanmış ve verilen cevapların sadece bilimsel amaçla kullanılacağı, herhangi bir ismin yer almayacağı belirtilmiştir. Araştırma sorularını hazırlarken soruların kolay anlaşılmasına ve yanıltıcı veya yönlendirici içerikte olmamasına dikkat edilmiştir.

C. Araştırma Soruları

Araştırma soruları cevabı merak edilen ana sorunsalı detaylandıran sorulardır. Temel olarak alınan araştırma soruları ile bunları detaylandıran ve mülakatta kullanılan sorular aşağıdaki tabloda verilmektedir.

TABLO XXIII
ARAŞTIRMA VE MÜLAKAT SORULARI

1	Uzaktan çalışmada yönetici desteği ne derece önemlidir?	1.1	Uzaktan çalışma modelinde yöneticinizden beklentileriniz nelerdir?
		1.2	Yöneticinizin hangi yaklaşımları sizi mutsuz eder?
2	Uzaktan çalışmada Finansal ve Teknik konular ne derece iş tatminini etkiler?	2.1	Uzaktan çalışma modelinde finansal destek beklentiniz var mı? Firmanızın hangi konularda size destek sağlamasını beklersiniz?
		2.2	Teknik altyapı olarak olmazsa olmaz sistemler nelerdir? Teknik destek konusunda firmanızdan ne gibi yaklaşımlar beklemektesiniz?
3	Çalışma ortamının uzaktan çalışmaya ne gibi etkileri vardır?	3.1	Uzaktan çalışmada iş-yaşam dengesini ayarlama konusunda en çok zorlandığımız durum nedir?
		3.2	Uzaktan çalışma ortamınızı verimli bir hale getirebiliyor musunuz? Sizi bölen faktörleri yönetmek konusunda zorlanıyor musunuz?
4	Uzaktan çalışmada temel motivasyonu ne sağlar, beklentileriniz nelerdir?	4.1	Uzaktan çalışmada sizi en çok motive eden ne olur?
		4.2	Firmanızdan uzaktan çalışma modeli ile ilgili farklı beklentileriniz nelerdir?

D. Verilerin Analizi

Olgubilim çalışmalarında veri analizi yaşanmış tecrübeleri ve anlamları ortaya çıkarmayı hedeflemektedir. Bu sebepten yapılan içerik analizinde verilerin kavramlara dönüştürülmesi ve olguyla tanımlayabilecek temalara ulaşma çabası vardır. Temalar ortaya çıkartılıp, örüntüler çerçevesinde bulgular açıklanır [15].

Araştırmada uzaktan çalışmadaki iş tatmini etkilerini tespit etmek üzere literatüre dayalı olarak araştırma sorularına ulaşılmıştır. Bu sorulardan biraz daha detaylı açık uçlu mülakat soruları oluşturulmuştur. Sorulara katılımcıların verdiği cevaplar araştırma bulguları kısmında aktarılmıştır. Bu cevapların incelenmesi ile kodlar oluşturulmuş bu kodlardan da belli temalara ulaşılmıştır. Bu kodlar ve temalar ışığında uzaktan çalışmada iş tatminini etkileyen olgular açıklanmaya çalışılmıştır.

V. BULGULAR VE YORUM

A. Uzaktan çalışmada yönetici desteği ne derece önemlidir?

Katılımcıların verdiği cevaplara bakıldığında en yüksek çoğunlukta ortaya çıkan kod Güvene Dayalı Yönetim, Sürekli Denetimden Kaçınma olarak görünmektedir. Katılımcılar yüksek oranda denetim ve emredici bir yaklaşım yerine güven ortamında çıktılara odaklanmayı tercih etmektedir. Bununla beraber iletişimin sağlıklı olarak yönetilmesinin de önemi ortaya çıkmaktadır. Bu iki konunun aslında birçok cevapta ilişkili olduğu görülmektedir. Çalışma ortamının rahat olduğu düşünülüp fazla mesai beklentisinin olduğu ve bunun rahatsız edici olduğu cevaplardan anlaşılmaktadır.

TABLO XXIII

“UZAKTAN ÇALIŞMADA YÖNETİCİ DESTEĞİ NE DERECE ÖNEMLİDİR?” SORUSUNA AIT ANALİZLER

Temalar	Kodlar	Gösterge
Yönetici Yaklaşımı	İletişimin iyi yönetilmesi ve Periyodik İletişimlerin Kurulması	K1, K3, K6, K9
	Güvene Dayalı Yönetim, Sürekli Denetimden Kaçınma	K1, K3, K4, K5, K7, K8, K9
	Fazla Mesai Beklentisinin Olmaması	K3, K4, K5

B. Uzaktan çalışmada Finansal ve Teknik konular ne derece iş tatminini etkiler?

Katılımcıların vermiş olduğu cevaplar incelendiğinde tüm katılımcıların ortak bir yaklaşıma işaret ettiği görülüyor. Uzak çalışmada mutlaka ek finansal desteğin olması beklenmektedir. Özellikle uzaktan çalışmanın çevrimiçi olduğu göz önüne alınırsa şirket kaynaklarına sorunsuz erişimin önemi burada yine katılımcılar tarafından vurgulanmıştır. Aynı şekilde diğer bir kavram olarak da teknik sorunlara hızlı müdahale beklentisi karşımıza çıkmaktadır. Az sayıda katılımcı tarafından da olsa ergonomik çalışma imkanlarının desteklenmesi beklentisi de görülmektedir.

TABLO XXIV

“UZAKTAN ÇALIŞMADA FİNANSAL VE TEKNİK KONULAR NE DERECE İŞ TATMINİNİ ETKİLER?” SORUSUNA AIT ANALİZLER.

Temalar	Kodlar	Gösterge
Finansal ve Teknik Destek	Yemek ve Fatura Yardımlarının Olması	K1, K2, K3, K4, K5, K6, K7, K8, K9, K10
	Şirket Kaynaklarına sorunsuz Bağlantı	K1, K2, K4, K6, K10
	Sorunlara Hızlı Müdahale	K1, K3, K6, K7, K9
	Ergonomik Çalışma Desteği	K7, K10

C. Çalışma ortamının uzaktan çalışmaya ne gibi etkileri vardır?

Çalışma ortamına yönelik soruların cevaplarına bakıldığında katılımcıların çoğu iş ve özel yaşam dengesi kurmakta zorlandığı görülmektedir. Özellikle çalışma ortamındaki konsantrasyon dağıtıcı faktörler herkes için aynı olmasa bile iş ve özel yaşam dengesini kurmak için çoğu katılımcının desteğe ihtiyacı olduğu ortaya çıkmaktadır.

TABLO V

“ÇALIŞMA ORTAMININ UZAKTAN ÇALIŞMAYA NE GİBİ ETKİLERİ VARDIR?” SORUSUNA AIT ANALİZLER

Temalar	Kodlar	Gösterge
Çalışma Ortamı Uygunluğu	Daha İzole Çalışma Ortamı Beklentisi	K2, K4, K8, K9
	İş-Yaşam Dengesi İçin Yönlendirme	K2, K3, K4, K6, K8, K9, K10

D. Uzaktan çalışmada temel motivasyonu ne sağlar, beklentileriniz nelerdir?

Genel motivasyon ile ilgili cevaplara bakıldığında en belirgin konunun uzaktan çalışmanın sürekliliği olduğu görülmektedir. Katılımcıların büyük çoğunluğu geçici olarak belirlenmiş çalışma modelinin tamamen kalıcı veya hibrit şekilde devam etmesini beklemektedir. Bununla bağlantılı olarak - özellikle kalabalık şehirlerde- yolda ve trafikte harcanan sürelerin insanların kendisine kalması büyük motivasyon kaynaklarından biridir. Uzaktan çalışmanın devam etmesi durumunda da sürekli iletişim ortamının sağlanması, sosyal organizasyonlar, gerektiğinde bir araya gelebilme imkanlarının da sağlanması beklentisi ifade edilmektedir.

TABLO VI

“UZAKTAN ÇALIŞMADA TEMEL MOTİVASYONU NE SAĞLAR, BEKLENTİLERİNİZ NELERDİR?” SORUSU İÇİN ANALİZLER

Temalar	Kodlar	Gösterge
Genel Motivasyon Kaynakları	Ekip Üyeleri ile sürekli iletişim ve organizasyonlar	K1, K6, K9
	Yolda ve Trafikteki sürelerin kazanımı	K2, K3, K4, K7, K9
	Uzaktan Çalışmanın Sürekli Olması	K1, K2, K3, K4, K5, K6, K7, K10

VI. TARTIŞMA, SONUÇ VE ÖNERİLER

Çalışanların ofis dışında farklı ortamlarda, yoğunlukla da ev ortamında çalıştığı uzaktan çalışma, son yıllarda yaşanan salgın nedeniyle de birçok firma için kaçınılmaz olmuştur. Bu çalışma yaklaşımında geleneksel çalışma ortamına göre değişen birçok kavram bulunmaktadır. Bu değişim çalışanların iş bakışını ve tatminini dolayısıyla çalışma performansını etkilemektedir. Bu araştırmada uzak çalışmanın iş tatminine etkilerini anlamak amacıyla, literatür taramasından edinilen bilgiler ışığında oluşturulan araştırma ve mülakat soruları ile katılımcılardan görüş ve öneriler alınmıştır.

Öncelikle katılımcıların verdiği cevaplara baktığımızda yöneticilerin uzaktan çalışma sürecinde önemli bir rol oynadığını anlaşılmaktadır. Buradaki Yönetici desteği teması altında, İletişimin iyi yönetilmesi ve Periyodik İletişimlerin Kurulması, Güvene Dayalı Yönetim, Sürekli Denetimden Kaçınma, Fazla Mesai Beklentisinin Olmaması kodlarına ulaşılmıştır. Buradan çıkan en önemli sonuç ise esasen karşılıklı güven ortamını kuran bir yöneticinin varlığıdır.

Finansal ve teknik destek temasına baktığımızda Yemek ve Fatura Yardımlarının Olması, Şirket Kaynaklarına Sorunsuz Bağlantı, Sorunlara Hızlı Müdahale, Ergonomik Çalışma Desteği kodlarına ulaşılmıştır. Tüm katılımcıların ortak görüşü ve en önemli sonuç finansal desteğin mutlaka sağlanması olarak karşımıza çıkmaktadır.

Ulaşılan Çalışma Ortamı Uygulduğu teması ele alındığında Daha İzole Çalışma Ortamı Beklentisi, İş-Yaşam Dengesi İçin Yönlendirme kodlarına ulaşılmaktadır. Çalışanların çalışma ortamının gerektiği zamanlarda farklılaştırılarak izole çalışma alanları oluşturmak bunun yansısı iş ve özel yaşam dengelerini doğru kurduklarından emin olmak önemli konular olarak karşımıza çıkmaktadır.

Katılımcılara ayrıca uzaktan çalışmada onları neyin motive ettiği sorulmuş buradan ulaşılan Genel Motivasyon Kaynakları teması ile Ekip Üyeleri ile sürekli iletişim ve organizasyonlar, Yolda ve Trafikteki sürelerin kazanımı, Uzaktan Çalışmanın Sürekli Olması kodlarına ulaşılmıştır. Buradaki katılımcı cevaplarında en dikkat çeken nokta ise neredeyse tüm katılımcıların uzaktan çalışmanın devam etmesini beklediğidir.

Bu çalışmada farklı tecrübe ve farklı sektörlerden çalışanlar birlikte aynı grup içinde değerlendirilmiştir. Belli sektörlerle veya belli tecrübe gruplarına ayrı ayrı odaklanarak uzaktan çalışmanın iş tatminine etkilerine bakılabilir ve bu çalışmanın farklı versiyonları oluşturulabilir. Bunun da firmalar bazında veya çalışan grupları bazında özel uygulamalar geliştirmeye olanak sağlayacağı düşünülmektedir.

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Yaratıcılığın Inovasyona Etkisinin Değerlendirilmesi: Steve Jobs Örneği

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Abstract—Yaratıcılık kavramı son zamanlarda gündemde en çok tartışılan konulardan biridir. Eğitimciler yaratıcılığı tanımaya, psikologlar ölçmeye, şirketler ise satın almaya çalışmaktadır. Endüstri perspektifinden bakıldığında, yaratıcılık yeniliğin hammaddesi olarak en büyük itici güçlerinden biri haline gelmiştir. Bu araştırmada daha önceleri doğuştan geldiğine inanılan bireysel yaratıcılığın nasıl geliştirilebileceği, yeniliğe etkisi ve şirketlerdeki bireysel yaratıcılığın inovasyona nasıl dönüştürüldüğü araştırılmıştır. Bu araştırmada Apple Inc.'in kurucu CEO olarak görev yapmış Steve Jobs'un yaratıcılık özellikleri araştırılmış ve kurum kültüründeki örgütsel yaratıcılığa olan etkisini, n incelenmesi sonucunda bireysel yaratıcılığın yenilikle ilişkisi açıklanmıştır.

Keywords— Yaratıcılık, Inovasyon, Steve Jobs, Apple

I. GİRİŞ

Yaratıcılık ilk zamanlardan bu yana insanların hayatında yer tutmuştur. Yaratıcılığın tanımı çok geniş olup, bu gün dahi tarif edilmesi hala zor bir kavramdır. Her birey, başlangıçtan ileri seviyeye kadar değişen bilim, ekonomi, müzik vb. gibi çeşitli konularda yaratıcı becerilere sahip olabilir. Yıllar geçtikçe, "yaratıcılık" kelimesinin tanımı birkaç kez değiştiğini söylemek mümkündür. Zamanda geriye doğru bakarsak, bu terimin ilk tanımlarında ilahilikle ilişkilendirildiğini görebiliriz. Plato, şairlerin ilahi olarak ilham aldığını da öne sürmüştür, yalnızca seçkin bir azınlığın yaratıcılığa erişiminin var olduğunu savunmuştur [1]. Tarihsel olarak, en büyük düşünürlerden bazılarının bu konuda aktardıklarına bakılırsa Platon (İon), ilhamın bir tür delilik olduğunu söylerken, Kant yaratıcılığı hayal gücüyle ilişkilendirir; her iki görüşün de Romantizm üzerinde ve sonuç olarak ortak yaratıcılık nosyonları üzerinde önemli bir etkisi olmuştur [2]. Kant, sanatta yaratıcı olmak için yaratıcılığın doğuştan geldiğini ve öğretilemez olduğunu, sanatsal üretim süreçlerinin hem sanatçı hem de izleyici için anlatılamaz olduğunu iddia etmiştir [3]. Ancak 19. yüzyılın ikinci yarısına geldiğimizde, Almanya'dan gelen ve insanın beş duyusundan aldığı tüm bilgileri düzenleyip şekillendirenin zihin olduğunu doğrulayan Gestalt adlı yeni bir kavram ortaya çıktı. Parçaları yeniden düzenlemek yerine bütüne yeni bir bakış açısı kazandırdığımızda yaratıcılığa ulaşılacağını öne sürdü[4]. Günümüzde ise bireysel yaratıcılığa farklı bir bakış açıları da mevcuttur. Yaratıcılık anlayışımıza yakın bir çok tanım olmasına rağmen, bu kavramla ilişkilendirebileceğimiz tek bir tanım yoktur. Çünkü yaratıcılık, en karmaşık insan davranışları arasındadır. Çok çeşitli eğitimsel, sosyal ve evrimsel deneyimlerden etkileniyor gibi görünmekte ve kendini çeşitli alanlarda farklı şekillerde göstermektedir [5].

Yirminci yüzyılda psikologlar IQ (Intelligence Quotient) ve yaratıcılığın bağlantılı olduğuna inanıyorlardı: yüksek bir IQ, yüksek düzeyde yaratıcılığı gösterirken, daha düşük bir IQ, daha az yaratıcılık anlamına geldiği düşünülüyordu. Guilford ise durumun böyle olmadığını gösterdi. Guilford, "Akıl Yapısı" olarak adlandırılan psikolojik modelinde, bu modelin parçası olarak iki ayrı düşünme türü tanımladı: iraksak düşünme ve yakınsak düşünme [6]. Iraksak düşünme, yaratıcı düşüncelerle veya açık uçlu sorulara benzersiz, çoklu ve çok sayıda yanıt elde etmek için belleğe erişme yeteneği ile ilişkili olan düşünme türüdür. Yakınsak düşünme, genellikle IQ testleriyle ilişkilendirilen her soru için "tek doğru cevap" bulmak anlamına gelir [7]. Yaratıcılığın her ne kadar doğuştan geldiğini düşünenler olsa da sonradan öğrenilip gelişebileceği artık ortak fikirdir. Yaratıcılık kavramı ile yanlış bilinen bazı kavramlar da açıklığa kavuşturmak faydalı olacaktır. Bunlar:

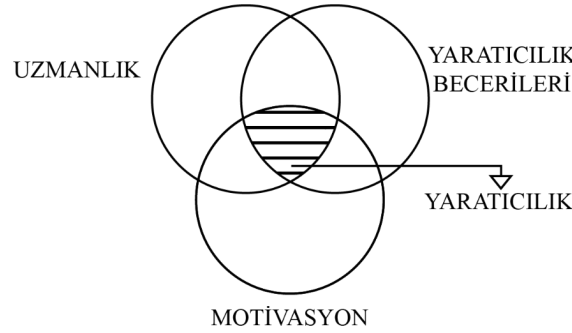
- Yaratıcılık, lider kullanıcılara veya yenilikçilere bağlıdır.
- Yaratıcılık kontrol edilemez.
- Yaratıcılık rastgeledir.
- Yaratıcı iş yenilikçileri dışarıdan gelir.

- Yaratıcı iş yenilikçileri geleneksel değildir.
- Yaratıcılık doğuştan gelir.

En kabul görmüş tanım olarak yaratıcılık; bir alanda yeni ve yararlı fikirlerin üretilmesi olarak tanımlanır [8]. Örgütsel boyutu da göz önüne alınarak yapılan başka bir tanımında ise yaratıcılık, birlikte çalışan bir birey veya küçük bir grup birey tarafından yeni ve faydalı fikirlerin üretilmesidir [9]. Standart tanımda iki parçada incelenmektedir. Yaratıcılık için hem orjinallik hem de verimlilik gerekir. Orjinallik bazen farklılıkla ile de açıklanır. Orjinallik yoksa yaratıcılık yoktur. Orjinallik çok önemli bir faktör olmasına rağmen yine de tek başına yeterli değildir. Bazı fikir ve ürünler her ne kadar yaratıcı olsa da faydasız olabilirler. Orjinallik elzem olsa da etkili veya uygun olduğu takdirde önem kazanır [10]. Yaratma kavramından bakarsak yaratıcılık daha önce aralarında ilişki kurulmamış nesnelere arasında ilişki kurarak onları anlamlı ve orjinal bir biçimde etkinleştirme olarak tanımlamak mümkündür. Yaratıcılık, kimsenin yapmadığı bağlantılar kurarken çevremizdeki herkesin gördüğü şeyleri görme eylemidir. Yaratıcılık bilinenin bilinmeyenine doğru ilerlemektedir. Çoğu araştırmacı, sonucun iki kriteri karşılması halinde yaratıcı olduğu konusunda hemfikirdir. Sonuç olarak, yeni olmalı ve alana daha önce orada olmayan bir şey katmalıdır. İkincisi, bir amaca hizmet etmelidir. [11] verdiği örneğe bakalım; mavi bir ketçap şişesi daha önce piyasaya çıkmamış olabilir, ancak bu anlamlı değildir, çünkü neden biri mavi ketçap şişesi istesin ki? Ama bunun yerine ketçap şişesi ters şekilde dökmeye hazır şekilde olsaydı, o zaman anlam kazanır.

Bireysel yaratıcılığı oluşturan, üç bileşenin var olduğu düşünülmektedir [9] Bunlar; bilgiye hakimiyet olan uzmanlık, yaratıcı düşünce ve görevin motivasyonu olarak açıklanmaktadır. Bireyde yaratıcılığın var olması için gerekli olan bileşenler Şekil 1’te olarak sıralanmaktadır.

Şekil 1: Amabile’ye Göre Yaratıcılık Bileşenleri Kaynak: [9]



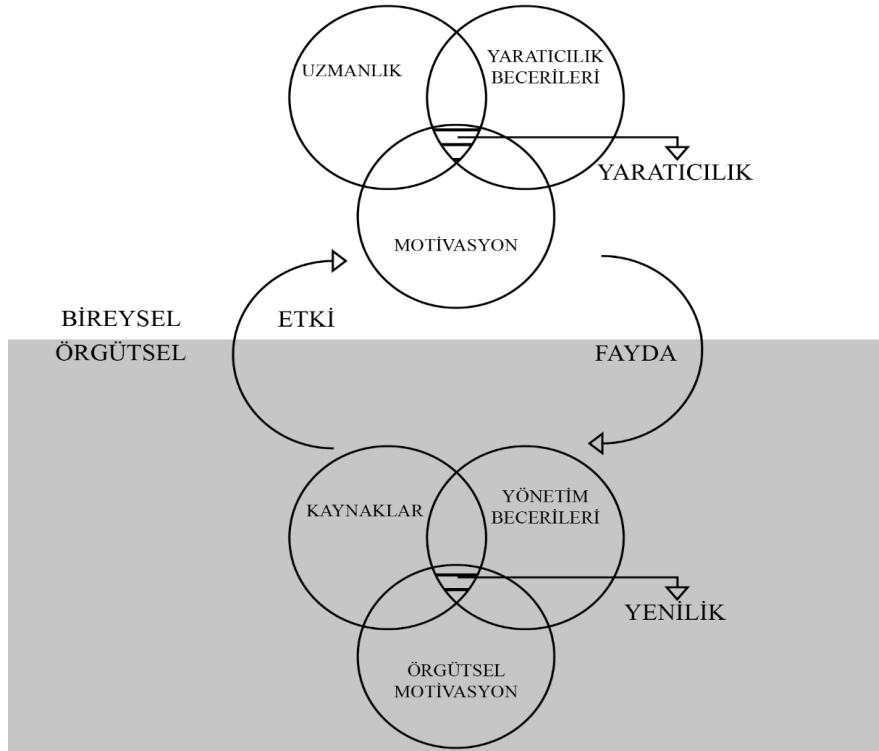
[12]’e göre bu üç faktör yaratıcılığı belirler ve kendi içinde motive olmuş bir birey, yaratıcılığı tam olarak destekleyen bir ortamda çalıştığında motivasyonun en yüksek olduğunu belirtmektedir. Ampirik araştırmalar, çalışanların içsel olarak motive olduklarında daha yaratıcı performans sergilediklerini de göstermektedir [13].

[14] yenilik ve yaratıcılık arasındaki yakın ilişkiyi iki gruba ayrılan örgütsel yaratıcılığın bileşen teorisiyle göstermiştir: birinci grup bireysel/takım yaratıcılığı ve ikinci grup örgütsel yaratıcılığı etkileyen çalışma ortamıdır. Her biri kendi bileşenlerine sahip olan, bireysel yaratıcılıkla ilgili faktörler ve yenilik ile ilgili faktörler olmak üzere iki kategoriyi göstermiştir. Bu, bir yanda onun kişilik özellikleri ve çalışma tarzları olduğu, diğer yanda ise çalışma ortamını ve mevcut kaynakları bulduğumuz anlamına gelir. Son olarak, yaratıcılık ve yeniliğin karşılıklı olarak sergileyebileceğini de görülmektedir. Yani, daha yenilikçi organizasyonların da bireysel yaratıcılığı etkilediği söylenebilir.

Karmaşık örgütsel sistemlerde yaratıcılığın kapsamlı bir şekilde anlaşılması için yaratıcı kişilerin bileşenleri, yaratıcı süreçler, yaratıcı durumlar ve yaratıcı ürünleri ele almak gereklidir. Şekil 2, kişiler, süreçler, durumlar ve yenilik arasındaki önemli bağlantıları kavramsallaştırmanın bir yolunu göstermektedir. Yeniliğe erişmek için, bu araştırmanın ilk bölümünde özetlenen bireysel düzeydeki uzmanlık, yaratıcılık becerileri ve motivasyonun yanı sıra grup ve organizasyonel düzeylerde de farklı değişkenlerle ilişkilendirilebileceğini görülmektedir. Bu bireysel özellikler, hem grup hem de organizasyon düzeyinde örgüt içi süreçler ve çevresel etkiler ile etkileşime girer. Bireysel yaratıcılıkta daha önce etkisi olmayan şirkete bağlılık, büyüklük, liderlik ve çeşitlilik gibi grup özellikleri, bireysel yaratıcılığın örgüt içerisinde yeniliğe dönüşmesini doğrudan etkilediği görülmektedir. Önemli örgütsel özellikler arasında

kültürel etkiler, kaynaklar, örgütsel misyon ve strateji, ödül politikaları ve liderlik özellikleri yer almaktadır [16]. Grup ve organizasyonel özelliklerin bu karmaşık mozaığı içinden doğan bireysel yaratıcılık ile grup davranışlarının doğru birleşimi yaratıcı ortamı yaratır. Bu şekilde bileşenlerin çoğu, bireylerin ve grupların yaratıcı başarısını artırma veya sınırlama yetenekleri açısından araştırılabilir [9]. Etkileşimli bir bakış açısından, örgütsel yaratıcı süreç, hem örgütsel davranışlardan hem de yaratıcı bireylerden oluşur. Yaratıcı iklim ortamı, yaratıcı birey üzerindeki sosyal ve çevresel etkilerin toplamı olarak görünmektedir. Organizasyondaki yaratıcı süreç, yaratıcı ürün yeni fikirler, ürünler, hizmetler, prosedürler veya süreçler bu dinamiklerden geçerek sonuçlanmaktadır.

Şekil 2 Amabile ve Pratt'a Göre Yaratıcılığı ve Yeniliği Etkileyen Bileşenler ve Birbiriyle Etkileşimi
Kaynak: [15]



II. UYGULAMA

Yaratıcılığın tanımında bahsedildiği üzere psikoloji, eğitim, eğitim psikolojisi, felsefe, işletme, pazarlama, insan kaynakları yönetimi, sanat, girişimcilik ve daha birçok açıdan araştırılmış ve yazılmıştır. Yıllar geçtikçe ve hayal edilebilecek her açıdan yaratıcılık hakkında sayısal olarak oldukça yüksek miktarda yazılı materyal üretilmektedir. Yaratıcılık konusu çeşitli araştırmacılar tarafından çok çeşitli yönlerden incelendiği için çok çeşitli sonuçlar ortaya çıkmıştır. Bazıları için süreç önemliyken bazıları için de sonuç önemlidir. Psikoloji ve felsefede yaratıcılık bireysel olarak incelenirken, işletme ve insan kaynakları yönetiminde ise örgütsel düzeyde ele alınmıştır. Çalışmalar yaratıcı birey ve bu bireyin yaratıcı olmasını sağlayan özellikleri konusunda yoğunlaşsa da zamanla yaratıcılığın içinde buldukları sosyal çevre ile de ilgili olduğu araştırmalarca tespit edilmiştir. Yenilik için önemli bir faktör olan bireysel yaratıcılığın örgüt içinde kümülatif olarak nasıl ele alındığı ve yönetildiği literatürde karmaşık, geniş, yeterince anlaşılmamış ve yetersiz tanımlanmış bir araştırma alanıdır. Yenilik hakkında her ne kadar işletme literatürü araştırma yapsa da yaratıcılığın yenilikteki etkisi ve bireysel yaratıcılıktan nasıl sistemsel bir örgütsel yaratıcılık elde edilir ve bu sistem nasıl yönetilir soruları halen açık kalmış olduğu görülmektedir.

Harvard Business Review (2010) tarafından yayınlanan araştırmada dünyanın bir numaralı en iyi performans gösteren CEO'su seçilen Steve Jobs bu tezde örnek olay olarak araştırılmıştır. Yaptığı yeniliklerle kurduğu her firmada yaratıcılığı ile ön plana çıkan Jobs şirketlerini de yine inovatif hale getirmeyi başarmıştır. Bu başarılar kişilik özellikleriyle ve ortaya koyduğu vizyon sonucunda yaratıcı çevik, yaratıcı ve hızlı cevap verebilen şirket kültürü ile açıklanabilir.

III. ARAŞTIRMA SORULARININ TANIMLANMASI

Araştırma esnasında araştırma sürecini daha belirgin kılmak adına kapalı uçlu sorular tercih edilmiştir. Bu çalışmada başlıca 3 soru başlığına yanıt aranmıştır:

Soru 1: Steve Jobs bir birey olarak yaratıcı mıdır?

Soru 2: Apple Inc. yenilikçi bir firma mıdır?

Soru 3: Steve Jobs'ın bireysel yaratıcılığı, Apple Inc. şirketinin yenilikçi olmasını etkilemiş midir?

IV. ARAŞTIRMANIN KISITLARI

Yaratıcılık kavramı ile ilgili bir çok tanım bulunmaktadır, bunun yanında yaratıcılığın ölçülmesine yönelik bir uzlaşıya varılamamıştır. Literatürde ağırlıklı olarak psikoloji ile ilgili yaratıcılık ölçümleri bulunmaktadır. Yaratıcılık konusu psikoloji içinde ölçülebilir olmakla birlikte, yaratıcılığın yeniliğe dönüşmesini ölçen bir kaynak bulunmamaktadır. Örnek olay olarak seçilen Steve Jobs'ın hayatta olmaması, hayatta iken iletişim halinde olan bir yakını ile yüz yüze görüşme yapılamaması gibi kısıtlardan dolayı ikincil kaynaklardan doküman incelemesi yapılmıştır. Bu da ulaşılan bilgilerin doğruluk ve güvenilirlik açısından kolayca doğrulanabilir olmasını zorlaştırmıştır. Ancak Steve Jobs'a dair kendi hayattayken ve kendisinin rıza ve kontrolüyle Walter Isaacson (2011) tarafından kaleme alınan biyografisi başlıca kaynak olarak kullanılmıştır. Kullanılan diğer kitap, makale ve kaynaklarda araştırmacıların etkisi de ayrıca bir sınırlılık olarak nitelendirilebilir.

V. ARAŞTIRMANIN METODU VE GÜVENİLİRLİĞİ

Bireysel yaratıcılığının örgütsel yaratıcılığa nasıl etki ettiği aynı şekilde örgütsel yaratıcılığın bireysel yaratıcılık ile beraber yapılan yeniliklere nasıl etki ettiğini nitel araştırma yöntemi ile açıklanmıştır. Veri toplama aracı olarak başlıca biyografiler ve makaleler daha sonrasında basın haberleri raporlar ve web sayfaları incelenerek örnek olay için literatür taraması yapılmıştır. Doküman incelemesi veri toplama aracı olarak kullanılmıştır. Veri analizi, nitel araştırmanın en zor ve en önemli yönüdür. Kodlama, metinsel verileri düzenlemek ve anlamlandırmak için analiz sırasında atılan önemli adımlardan biridir (Basit, 2010). Sıklıkla araştırma kısıtı olarak görülebilen sadece nitel araştırma yöntemi kullanılması konusunda güvenilirliği artırmak adına bu çalışmada da kodlama yapılmıştır. Yüzde 70 üzerinde olan kodlamada güvenilirlik unsuru sağlanmış olarak düşünülmektedir (İlgar ve İlgar, 2014). Bu çalışmada, yaratıcılık ve tasarım alanında bir, yönetim organizasyon alanında uzman bir olmak üzere 2 farklı akademisyenden tarafından kodlamanın doğrulanması istenerek güvenilirlik artırılmıştır. Yaratıcılık ve tasarım uzmanı ile yapılan kodlama doğrulanması güvenilirlik yüzdesi %92 çıkmıştır. Birinci kodlamada, bireysel yaratıcılık özelliklerinden 'renkli ve çeşitli hayata sahip olma' ile 'orijinal' birbirinin yerine kodlanmıştır. Yapılan diğer doğrulamada ise kodlamaların güvenilirlik yüzdesi %100 olarak hesaplanmıştır.

VI. SONUÇ VE ÖNERİLER

Teknolojinin ve müşteri taleplerinin sürekli ve hızlı değiştiği piyasalarda şirketlerin hızlı ve çevik olması gerektiği aşikardır. Bu değişkenlere ancak yenilik yapılarak ayak uydurmak mümkün olduğu bilinen bir gerçektir. Yeniliğin başlangıç noktası olan yaratıcılığın şirketler tarafından ön planda tutulması gerektiği vurgulanmıştır. Bu çalışmada yaratıcılığın yeniliğe etkisi ve yaratıcılığın nasıl yönetilmesi gerektiğine dair bulgular paylaşılmıştır. Birey düzeyinde yaratıcılık birçok firma tarafından kullanılan, kabul görmüş tekniklerle geliştirilebilmektedir. Araştırmada farklı düzeylerde yaratıcılık ele alınmış ve bileşenleri açıklanmıştır. Yaratıcılık bireysel olarak başlayarak örgütsel yaratıcılık içerisinde yönetilmesi gereken bir kavram olduğu ortaya konulmuştur. Örgütsel iklimin bireysel yaratıcılığa olan etkileri bulunmaktadır ve aynı şekilde bireysel yaratıcılık da bu iklime fayda sağlamaktadır. Gerçekleştirilen örnek olay araştırmasıyla da bireysel yaratıcılığın Apple şirketi yönetiminin ve kültürünün yeniliği nasıl teşvik ettiği, örgütsel yaratıcılığın şirket içinde nasıl yönetildiği incelenmiştir. Araştırma neticesinde, Apple şirketinin, ilham verici, arzu edilen ürünleri yaratmak için ileri görüşlü fikirleri organik örgüt yapısıyla yenilikçi ürünlere dönüştüren çeşitli örnekler yer verilmiştir. Apple'ın, kişisel yaratıcılığın ve mükemmeliyetçiliğinin önemini vurgulayan şirket kültürü tarafından desteklenen yeterli özgürlük ve özerklik sağlayarak yeniliği teşvik ettiği görülmüştür. Ayrıca, organik yapısı, Apple'ın verimli ve başarılı Ar-Ge faaliyetlerini olumlu yönde etkilemiştir. Örgüt kültürü, bir kuruluşun kurucuları ve üst düzey yöneticileri tarafından sağlanan stratejik liderlik tarafından oluşturulduğundan, Apple'ın kurucularından biri olarak CEO Steve Jobs'un şirketin kültürünü tasarlamak ve geliştirmek için en uygun kişi olduğu açıkça ortaya çıkmaktadır. Yaratıcılık ve yenilik arasındaki ilişki irdelenmiş ve çalışmada örnek olay olarak Steve Jobs'ın yenilikçi ürünler için yaratıcı fikirler bulma ve aynı zamanda farklı kavramlar arasında yeni bağlantılar görme

kabiliyetleriyle yaratıcı olduğu ortaya konulmuştur. Steve Jobs'ın ortaya koyduğu bireysel yaratıcılık, yaratıcılığı destekleyen şirket kültürü, tasarım odaklılık, Apple şirketi için birçok devrim niteliğindeki yeniliğin yolunu açmış olduğu gözlemlenmiştir. Steve Jobs kovulduğu şirkete 1997 yılında tekrar döndükten sonra yenilediği performans, Apple şirketinin mali bilançosunu, hisse senetlerini, müşteri sadakatini ve yenilik primini yükseltmiştir. Üstelik bu başarısını ve yaklaşımını Next ve Pixar firmalarında da göstererek yaratıcılıktaki ve yenilikteki düşkünlüğünü bir kez daha kanıtlamıştır (Iliev, Lindinger ve Poettler, 2004). Apple şirketinde Steve Jobs yönetiminde iki defa bulunmuştur ve yaratıcılığa verdiği değer sayesinde her iki defada da yenilikçi ürünler ortaya çıkarmayı başarmıştır. Bireysel yeniliklerinin yanında şirket kültürünün önemli bir parçası hale gelmesi için organizasyon yapısını düzenlemiş olduğu görülmüştür. Yeniliği sadece üründe değil birçok alanda aramış ve yaratıcı fikirlerini yenilikçi fikirlere dönüştürmeyi başarmıştır. Zaman zaman kişisel özelliklerinin zararlı sonuçları ile karşılaşılrsa da bireysel özellikleri yaratıcı birey özellikleri ile yüksek ölçüde örtüşmektedir. Son olarak Steve Jobs'ın bireysel yaratıcı özellikleri listelenmiş, bu özelliklerin Apple içerisinde etki ettiği olaylar tablo halinde sunulmuştur. Aslında Steve Jobs, güçlü teknoloji takıntısı, yaratıcı ve yenilikçi kabiliyetleri, coşku, kararlılık ve girişimcilik özellikleriyle karizmatik bir lider olarak tanımlanabilir.

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ABSTRACTS

An Agile Approach to Project Leadership: Complexities and KSA Perspective

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Abstract. The paper explores, through a review of literature, the complexities associated with the increasing need of taking an *agile approach to leadership* in managing projects. The paper aims to explore the Knowledge, Skills, and Abilities (KSA) required by project leaders to adopt an agile approach to leading their project teams. Project leadership in itself is complex given the wide range of activities it involves. In addition, agile is increasingly becoming a need in leadership style, let alone to be used as a methodology to manage projects. The goal is to explore a modern approach to leadership formation when applying agile methodology from the point of view of leading project teams. A systematic literature review has been conducted of literature available from the last five years (2017-2022) to capture the complexities associated with agile leadership. Alongside the complexities, the knowledge, skills, and attributes required by a project leader implementing an agile approach to their leadership style have been studied. As a result, an effort to create a development approach to agile leadership has been derived based on KSA for existing project leaders who might be willing to adopt this new leadership style. The results of this research will aid project leaders to gain a strong understanding of the changing landscape and provide an avenue to better support, guide, and coach their project teams with agility. The results will also inform future leadership preparation courses, in order to train new and upcoming leaders in the field of project management.

Keywords: project leadership, project management, agile, knowledge, skills, attributes, project leader

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Considering Privacy in Systems Thinking Assessment

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Abstract. Systems thinking is a skill that enables people to see an entire picture. People who possess systems thinking capabilities can conceptually perceive and understand a complete system and its performance, without understanding each of the details. This capability also includes synergizing many components in the system, being able to foresee the implications of changes in the system and propose solutions for a wide variety of situations [1]. Systems thinking supports decision-making at all strategic and operational levels of an organization. Managers and engineers with systems thinking capabilities can work on and manage projects efficiently because their comprehensive perception enables them to handle all components of the project, their effects and interactions. Therefore, systems thinking is a valuable skill often required of employees who are candidates for promotion to managerial or leadership positions in the business arena. Accordingly, systems thinking assessment is a significant factor for decision-makers to evaluate candidates for managerial roles.

Systems thinking skills can be assessed using a questionnaire that is a prevalent, accepted solution in this field, and which has been validated by previous research. However, some of the questions could potentially violate the respondent's privacy, which might bias their responses. This issue is becoming increasingly significant as privacy awareness grows in today's digital world. Therefore, this study tackles the issue, and offers a formal methodology to optimize the assessment questionnaire by modifying its design to accommodate the privacy factor and its effects [2]. By applying smart filtering, we detect "harmful" questions, this way increasing the assessment accuracy. In an empirical study, we tested the methodology (n=142) and demonstrate how systems thinking evaluation could be improved. This research makes a significant contribution to improving the process for assessing systems thinking skills specifically and could, with some modifications, be applied to assessment processes in other fields in which privacy is also a factor.

Keywords: systems thinking, privacy, skills assessment.

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Data Analytics for Quality Products in an Industrial IoT Environment

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Abstract. Today, in many production lines, loss of time, loss of work and profit loss occur due to the defective production. In order to prevent these losses, manual methods were considered with the follow-up of the employees by using certain data visualization and statistical analysis applications. However, today, thanks to the internet of things, the data related to the operations/processes applied to the product, are collected at the time of the production. By utilizing the collected data, automated studies are carried out with advanced data analytics. In this study, we studied the real data of a wheel production line equipped with the internet of things technology. Our data was dirty and heavily correlated. We applied data preprocessing techniques and analyzed the clean data using different machine learning classifiers. Finally, we detected important process variables where the anomalies in their values cause defective products. Result of our work helped the subject manufacturing system to automatically detect defective products, to prevent future defects and to improve their product quality.

Keywords: Data Analytics, Classification, Defective Products, Machine Learning, Internet of Things.

Dijital Kültür ve Örgütsel Değişim

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Özet. Dijital kültür kavramı teknolojinin ve internet olanaklarının dış çevreyle etkileşim ve iletişim kurma kalıplarının yeniden şekillenmesini, farklı toplumlarda olsalar dahi insanları ve örgütlerin fonksiyonelliğini, davranış biçimlerini içine almaktadır. Dijitalleşme, bir örgüt açısından çalışanların ve örgütsel düşünmeyle, davranış tarzının değişimi ve örgütlerin stratejik hamleler yapması için yeni değerlerin üretilmesidir.

Dijitalizasyon teknik açıdan her alandaki analog verileri dijital forma dönüştürerek bilgisayarlar aracılığıyla bu bilgileri saklamak, işlemek ve kullanmak anlamındadır. Günümüzde örgüt mensuplarının hatta yöneticilerin en önemli yanığı da bu yeni sürecin, dijitalizasyonun büyük ölçüde işletmelerin bilgi işlem merkezi çalışanlarının sorumluluğunda olduğunu düşünmeleridir.

Dijitalizasyonun kritik noktası örgüt kültürünün dijital ortamda yenilikçiliğe açık, müşteri odaklı ve takım ruhunun olduğu dinamik ve esnek bir yapının varlığıyla ilgilidir. Bu kültürel karakteristiklerin oluşturacağı örgüt ikliminin de çalışanların karar süreçlerine katılabilmesi, belli bir otonomiye sahip ve örgütün güçlü aynı zamanda zengin iletişim kanalları olmasıdır. Bu süreç, çalışanların klasik yöntemlerle, sadece sezgi ve deneyimlerine dayanarak değil kurumun departmanları arasında toplanan verileri sağlıklı analiz ederek işletmenin vizyonu doğrultusunda hareket etmelerini gerektirmektedir.

Goran (2017) McKinsey'in bir raporunda örgütlerin teknolojik değişime uyum yaparak dijital kültürü gerçekleştirebilmek için yöneticilerin öncelikle 3 engeli (örgüt departmanları arasında iletişimin yetersizliği, risk alma endişesi ve müşterileri tam olarak tanımlayamamak) dikkate almalarının önemi üzerinde durmuştur. Buna göre örgüt kültürünün teknolojik değişime ve yeni örgütsel değerlerin çalışanlar arasında benimsenmemiş olmasının dijitalizasyonla ilgili tüm faktörlerin %33'ünü oluşturduğunu belirtmek uygun olacaktır. Teknolojik değişimi destekleyen, dijitalizasyonun örgüte adapte edilmesiyle kurum stratejilerinin çalışanlar tarafından anlaşılıp çağın gerektirdiği yenilikçi hamleleri belirlemeleri ve iş süreçlerini buna göre saptamalarını sağlayacak kültürel yapı, dijitalizasyonun merkezini oluşturmaktadır.

Bu aşamada da devreye yaratıcılık potansiyelleri yüksek, değişimi destekleyen, girişimci ruhlu çalışanların işe alınması ve mevcut çalışanların eğitilmesi de insan kaynakları departmanlarının sorumluluğu olacaktır. Esasen girişimci olarak tanımlanabilecek bireyin ilk olarak yaratıcılığı, yenilikçiliği benimsemiş olması önemli bir koşuldur. Bu bağlamda rekabetçi düşünce, yeni iş yaratmak için öncülük etmek ve kesinlikle risk alma cesaretini gösterebilmektir. Amabile (1988) örgüt çalışanlarının yaratıcılık motivasyonlarını incelediği çalışmasında 'yaptığın işi sev ya da sevdiğin işi yap' özdeyişiyle yaratıcılık olmaksızın, uygun çalışma atmosferi (iklimi) oluşturulmadan yenilikçiliğin de olamayacağını vurgulamıştır. Dijital değişim de Uysal'ın (2021) Warner ve Wager'e atıfla örgütsel davranışın ve çalışanların teknolojik gelişmeleri benimseyebilmesinin ve beceri kazanmasının ancak, bu koşullar örgüt üst yönetimleri tarafından sağlandığında mümkün olduğunu söylemektedir.

Büyük olasılıkla günümüzden daha çok belirsizliklerle dolu geleceğin iş dünyasına hazırlanmak için örgütsel değişimin gerekliliğini ve bunun için de dijital kültürün, dijitalizasyonun anlamının örgüt üst

yöneticileri tarafından ne ölçüde anlaşıldığı, çalışanların bu değişim sürecinde nasıl yönlendirilebileceği önemli bir inceleme konusu olmuştur.

Bu amaçla sanayi sektöründe faaliyet gösteren büyük ölçekli iki tedarikçi firma seçilerek öncelikle bu örgütlerin tepe yöneticileri ve departman müdürleriyle keşfedici (*explorative*) ve kalitatif bir araştırma yapılması planlanmıştır. Bu çalışmadan elde edilecek verilere göre aynı ya da benzer firma çalışanlarına dijital kültür, dijitalizasyon, örgüt değişimi, yaratıcılık ve yenilikçilik hakkında görüşlerini öğrenmeyi amaçlayan tanımlayıcı (*descriptive*) ve kantitatif bir araştırma yapılarak literatüre katkı yapılması beklenmektedir.

Anahtar Kelimeler: Dijital kültür, örgütsel değişim, yaratıcılık, girişimcilik

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Emerging and Future Applications of Contemporary Knowledge Representation: A Literature Review

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Abstract. The development of knowledge production and storage technologies has accelerated the need for more advanced ways to efficiently process knowledge, using reasoning methods that prevent ambiguities. The accurate and unambiguous representation and interpretation of knowledge for both people and machines requires a common language based on a well-defined concept of knowledge, a task which people have been attempting since well before the modern era. In the scope of this research, knowledge is defined as propositions that include judgments about the way the world is and works. Knowledge Representation is the field that studies the representational options that enable computational reasoning. This paper reviews the literature systematically on Knowledge Representation to understand the contemporary state of the field and further discuss the emerging KR methods and future of KR.

Keywords: Knowledge, Representation, Knowledge Representation, Emerging Technologies, Expert Knowledge.

Interconnection of Smart City, Smart People and Stem Skills of People

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Abstract. This study is focused to prove the close relation between Smart people component of the smart city concept and stem/steam capability of the people under the findings of an EU project implemented in 3 countries; Turkey, Hungary and Lithuania.

One of the most important paradigms to improve civic life is considered today as building of smart cities based on innovative industries. This fact requires, naturally, creative, high level skilled and proactive people profile for solving sophisticated challenges. That's why "smart people" pillar of the smart city concept reflects the most considerable aspect of the whole paradigm. It can be said, in this context, smarting a city can be accomplished by smart people not only smart technologies. It is not possible to say that a smart city technologically-capable for the future has also a sustainability capability for prosperity if the citizens are not smart. Smart people are the key triggers to unlock economic and social value in a smart city concept.

The main determinants of the smart people are interconnected with STEM and STEAM skills of the people to success the science, mathematics, and engineering, and those needed to use technology effectively. The main difference between STEM and STEAM is STEM explicitly focuses on scientific concepts. STEAM investigates the same concepts, but does this through inquiry and problem-based learning methods used in the creative process. While STEM clearly focuses on scientific concept, STEAM includes the same disciplines, but does this through inquiry and problem-based learning methods used in the creative process by including the arts – humanities, language arts, dance, drama, music, visual arts, and design.

Keywords: Stem, Steam, Smart City, Smart people

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Investigating Urban Rail Transit System with District Based Socio-economic Parameters

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Abstract. Railway projects are mega projects for a country that have a strong impact in terms of development and improvement of public transport services. In order to reduce the negative (traffic jams, damage to the environment, noise, accidents) effect of a dominating road transport, the local government pays a lot of attention to the railway transport development. By September 2021, Istanbul's modal share of public transport is %79 percentage by public bus, minibus, service bus, taxi and metrobus, %19 percentage by railways (Marmaray, Metro and light rail systems) and %2 sea transport by sea buses and ferries. Metro system is the best way to improve the quality of public transport in urban cities due to their large capacity, rapidity, time reliability. This paper aims to analyze the suitability of the existing railway projects. In the context of this study, socio-economic values, public transport statistics, building density values (values or data sets) are obtained for Istanbul region. To analyze these values (data sets/information), models are developed regarding the rail transit length and associated impact factors as a result of the regression modeling with the Istanbul district's database integrating with Geospatial Information System. The model results are examined and compared spatial distributions at each district. In summary; it is necessary to investigate the suitable urban rail transit lengths or scope over a concerned region in the planning stage in order to make optimal investment plans. This study analyzes the relationship between rail transport and socio economic variables in the Istanbul Metropolitan Area. This study's findings provide valuable insight to explore the regression method for estimating the relations for urban rail transit and urban socio-economic structure. In future studies, this study's findings can extend by checking the suitability on-going and planning projects.

Keywords—Urban rail transit, socio-economic factors, railway transportation, GIS, regression.

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Multiple Criteria Decision-Making for Subcontractor Selection Using Fuzzy Analytic Hierarchy Process and TOPSIS Methods

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Abstract— Nowadays, it is very easy to reach search engines, social media, and mass amount of data in seconds because of the development of information technology. However, it is not as easy as it seems to reach correct and accurate data. Therefore, evaluation and analysis of data has great importance, especially in the decision-making process. The main key to successful decisions, especially in the construction industry, is to reach the right data on time during the selection of the contractor and subcontractor to work with. In general, companies with strong references, that have been worked with in the past, are preferred and the risk of selecting contractors is high because the data presented over the internet is unreliable and difficult to verify even if trusted. It is also important to choose the right professional network services and their relevant data. Today, service providers have started to fill this gap to ensure that subcontractor data analysis is provided to the companies in the construction industry in accurate and on time manner. In this study, the decision-making process for the contractor selection problem in the construction sector has been improved. A decision-making committee consisting of 10 experts has been established. The selected experts are senior executives in the construction sector. To determine the importance of the criteria used in the evaluation of the potential contractors, fuzzy Analytic Hierarchy Process (AHP) and fuzzy TOPSIS methods are developed. The results of this study can be incorporated in the search engine of professional service providers to facilitates choosing the contractor in the construction sector while using the opportunities provided by the internet.

Keywords—Multi-Criteria Decision Making, Fuzzy AHP, Fuzzy TOPSIS, Subcontractor Selection, Construction Industry

Process Design of New Digital Payment Platform

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Abstract— This study enhances to magnify a recent digital payment platform in which is currently used by in various sectors in Türkiye. With this study, better way of running a platform with one product is underlined by focusing on the previous studies of platform structure and examining the current application of software technology is covered. As a sample, this unique platform in Türkiye is detailed by benefits of the platform, platform experience, and characteristics of the product with platform structure and main structure of the digital mobile payment application including integration processes, testing procedure, and the cases which affect the digital payment product.

Keywords— POS, mobile phone, multi-sided platforms, Near Field Communication (NFC), contactless payment, mobile payment, payment infrastructure, payment systems

Study of the Fatigue Behavior of Plate with a Central Crack Repaired with Composite Patches

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Abstract. This research is based on the study of the fatigue behavior of an aluminum alloy plate with a central crack. The plate is subjected to a tensile loading on its lower and upper parts. Several parameters were highlighted, such as the loading effect with a load ratio $R = 0$. The effects of the load ratio on both the repaired and not repaired plates, by two composite patches, which are boron /epoxy and graphite/epoxy, were investigated, as well as the effect of the plate material on plate life, comparing different materials.

Keywords: Fatigue, Patch, crack, Composite.

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The Method of Selecting Employees in the System of Visual Quality Control of Wood-Based Panels

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Abstract. The research is concentrated on showing the concept of a model for selecting employees for visual quality control (VQC), taking into account the relevance and difficulty of the process, set in the reality of a system, taking into account the specificity of the wood-based products industry. The literature research carried out within the research allowed to identify the key features of an ideal quality controller, to indicate the factors affecting the process of visual quality control, as well as aspects related to the difficulty and relevance of the process, conditioned by the characteristics of the object of visual inspection and its attributes. Thanks to the analyses carried out using Thurston's method for the results of the questionnaire surveys, it was obtained classified in terms of importance, desirable attributes and classified in terms of importance factors, crucial for the correct execution of the VQC process. The application of the TOPSIS method for the data obtained from the assessment of inspectors according to the form proposed, allowed confirming the method in terms of the classification of visual quality control workers, due to their approximation to the ideal - in terms of having the desired, indicated, classified qualities. The selection of an appropriate inspector for the tasks associated with work in the area of VQC is conditioned by the difficulty and significance of the process. The literature research provided knowledge about the factors conditioning the difficulty and relevance of VQC. In order to evaluate according to the indicated factors, a checklist was proposed. The application of the list will provide an answer to the question of whether a given VQC process is relevant and difficult. The last stage of the research was the analysis of the environment, the working conditions in which the VQC process is carried out. Also in this stage, the literature survey provided information on the factors that characterize the correct execution of the VQC process. In order to evaluate a given position, a checklist was proposed in the research and the importance of individual characteristics was indicated, which will facilitate the process of introducing corrective actions, if necessary.

The analyses and tools elaborated in this research is a method for selecting employees for VQC in the wood-based industries, in the system, which consists of a human being, a technical object and the environment together with the interactions between them.

Keywords: The employee selection, visual quality control system

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TOPSISsort ile Scrum Takımlarının Performans Sınıflandırması

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Özet— Rekabetçi ve değişen piyasa koşulları, firmaların çevik metodolojilerin önemini her gün daha fazla benimsemesine neden olmakta ve çevik yaklaşımlar hızla yaygınlaşmaktadır. Geleneksel yazılım geliştirme projelerinin yönetiminin yerini alan ve en çok kullanılan çevik metodolojilerinden biri scrum'dır. Geleneksel proje yönetiminden temel farklılığı, tekrarlayan (genellikle 2 hafta) sürelerle geliştirmeler yapılarak, değişimlere hızlı adaptasyon imkânı sunmasıdır.

Scrum takımının kendi kendisini yönetmesi beklenmekle birlikte, takım başarısını ve performansını ölçülemek amacıyla ortaya koyulmuş metrikler bulunmaktadır; takımın hızı ve kapasitesi, yeni ürün üretim oranı gibi. Bu metrikler, scrum takımının anlık başarı durumunu ortaya koyar ancak, potansiyelini yansıtmakta yetersiz kalabilir. Literatürde çevik olarak yürütülen yazılım projelerinin başarı ve başarısızlık senaryoları üzerinden pek çok çalışma yapıldığı görülmekte olup takım başarısı ile ilgili çalışmalar Scrum metrikleriyle yapılan ölçümlenmelerle sınırlı kalmıştır.

Çok Kriterli Karar Verme (ÇKKV) yoluyla sınıflandırma, alternatiflerin ($A = \{a_1, a_2, \dots, a_m\}$), ölçütlere göre değerlendirilerek (her alternatifin n . kritere göre performans değerlendirmelerini içeren $G = \{g_1, g_2, \dots, g_n\}$) önceden tanımlanmış sınıflara (C_1, C_2, \dots, C_k) atamasının yapılmasıdır. Sınıfların, değerlendirme öncesinde tanımlanmış ve çok tercih edilenden az edilene doğru sıralanmış olması gerekmektedir. Sınıflar sıralanmış olduğundan C_i tüm diğer sınıflara göre daha çok tercih edilen sınıfı ifade etmektedir ($h < j$ için C_h sınıfı C_j sınıfına göre daha tercih edilir konumdadır: $C_h > C_j$).

Bu çalışmada Scrum takımlarının performanslarının başarı önceliklendirmesinde ÇKKV temelli bir sınıflandırma yöntemi uygulaması yapılmaktadır. Literatürden ve uzman görüşlerinden hareketle, dört ana kriter (Organizasyonel, İnsan Kaynağı, Teknik ve Proje) altında toplamda 23 başarı ölçütü belirlenmiştir. Bu başarı ölçütlerinin önemlerinin belirlenmesinde dört Çevik Koç ile çalışılarak Analitik Hiyerarşi Süreci (AHS) yönteminden yararlanılmıştır. Scrum takımlarıyla yakın çalışmaları nedeniyle gözleme ve değerlendirme konusunda imkanları, ayrıca çevik metodolojiler hakkında uzmanlıkları nedeniyle çevik koçlar değerlendirici olarak seçilmiştir. AHS uygulaması sonucunda, Organizasyonel, İnsan Kaynağı, Teknik ve Proje ana kriterlerinin ağırlıkları sırasıyla 0.25, 0.64, 0.07 ve 0.05 olarak belirlenmiştir. Alt kriterlerin global skorlarına göre “Takım içerisinde güven seviyesi–0.21”, “Takım içerisinde güçlü iletişim ve iş birliği–0.15” ve “Agile leaders desteği–0.11” kriterleri, takımların başarılarını belirleyen en önemli faktörler olarak belirlenmiştir.

Scrum takımlarının performans sınıflandırmasının yapılmasında TOPSISsort yaklaşımından yararlanılmıştır. 22 scrum takımının incelendiği uygulamada üç performans sınıfı belirlenmiştir: yüksek, orta ve düşük performans. Üç çevik koç tarafından takımlar, 1-10 ölçeğinde puanlanarak

karar matrisi oluşturulmuştur. Kriterlerin önem ağırlıklarıyla birlikte TOPSISsort uygulaması gerçekleştirilmiştir. TOPSIS'in pozitif ve negatif ideale bağlı mesafesi ilkesinden hareketle çalışan yöntem, ek olarak bir sınıflandırma algoritmasına sahiptir. Sınıfların aralık şeklinde tanımlandığı bu versiyonda alternatiflerin puanları hangi sınıfın değerlendirme aralığına giriyorsa o sınıfa atanmaları yapılır. Değerlendirilen takımlardan 4 tanesi yüksek, 17 tanesi orta ve 1 tanesi de düşük performans sınıflarına dâhil olmuştur. Uzmanlarla yapılan son analizler neticesinde sınıflandırma bulgularının mantıklı ve tutarlı çıktığı değerlendirilmiştir.

Bu çalışmayla, scrum takımı performans sınıflandırması konusundaki literatür boşluğu doldurulmakta; ayrıca takımların genel performanslarının ölçülmesinde kullanılabilir yeni bir karar modeli önerisi getirilmektedir. Gelecek çalışmalarda bulanık mantığın farklı versiyonlarının uygulanması yoluyla uzman görüşlerindeki belirsizliğin daha iyi modellenmesine çalışılabilir.

Anahtar Kelimeler— Çevik Proje Yönetimi, Scrum, Sınıflandırma, AHP, TOPSISsort.

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User Experience Evaluation of an Online University Library via User Test and Heuristic Evaluation

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Abstract. Digital transformation in education made online libraries key research and study platforms for modern universities. The online libraries offer access to reference catalogues, online databases and other research resources to students and academicians. As for all digital systems, User Experience (UX) has gained utmost importance for effective and efficient use of online libraries, as well as for user satisfaction. The present study applied user tests and heuristic evaluation to evaluate UX of an online university library. The user tests were applied to 20 students and included three common tasks: finding an article on a specific topic, searching for a topic in a database, and finding administrative information within library procedures. Task completion rate and task completion time were used to measure effectiveness and efficiency respectively. Additionally, Computer System Usability Questionnaire (CSUQ) was applied to test participants for collecting user satisfaction data. CSUQ results showed that, on a 7-point scale, mean sub-factor values for System Usefulness, Information Quality and Interface Quality sub-factors were 3.48, 3.26, and 3.55 respectively. Linear regression analysis on CSUQ data showed that all CSUQ sub-factors have significant positive relationship with overall user satisfaction, and among them System Usefulness had the strongest relation (with R^2 value of 0.75). Heuristic evaluation was further applied on different interfaces of online library based on Nielsen heuristics, and several problems with different severity levels were identified, such as unclear icons and signs, language problems, repeated login requests. The study exemplified how to perform quantitative and qualitative UX evaluation in combination to pinpoint UX problems and to improve online libraries for higher user satisfaction.

Keywords: Online library, User Experience, user test, heuristic evaluation

Well-Being as an Effect of Shaping Parameters in Office Space

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Abstract. Human well-being, due to the complexity of the concept's construct, is extremely difficult to measure. The literature offers numerous approaches and attempts to model the measurement of human well-being in general, however, the measurement of employee well-being is poorly represented in the context of measuring well-being in life. Each employee perceives the environment in a subjective way, which most often does not coincide with the feelings of other people in the office space. Therefore, it is necessary to optimize the factors of the working environment, especially regarding small groups of employees staying in the office space. For many factors of the work environment, appropriate ergonomic standards indicate what level of parameters of this environment allows to maximize the level of well-being. These standards, however, are based on statistical research to meet the needs of the average worker in the population. In the case of an office with up to a dozen employees, these standards may generally not be optimal. The models of well-being at work described in the literature most often do not consider the possibility of a dynamic impact directly on the subjective needs of the employee. Therefore, it would be necessary to look for the possibility of managing and controlling selected physical parameters in the office space. Multi-criteria certification of office buildings focused on the well-being of employees provides a good basis for further research on the possibility of managing employee well-being by finding possible and expected changes in parameters in the office space. The set of desired and possible, from the point of view of the employer's management, variable parameters can be defined in a qualitative study based on experts' opinion. In next step, the scope of changes indicated by experts may be determined in quantitative research in the form of a survey conducted among office workers. The developed methodology of managing the well-being of small groups of employees by shaping parameters in the office space may be an important tool in acquiring and stabilizing human resources.

Keywords: Ergonomics, Well-being, well-being at work, employee well-being, office space.

Promoting Team Collaboration in Engineering Teams through Mixed Reality Technology

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Abstract— With technological advances, engineering projects become too complex to be completed by individuals; the success of the engineering project relies on the performance of the whole team. Effectively interacting and collaborating with team members is essential in improving team performance. Through more social interaction and networking, team members can enhance their engagement, positively affecting team performance (Nguyen et al., 2016; Thompson & Heng-Yu Ku, 2010). Given the recent global pandemic, its impact on engineering teams, and the increased utilization of technology, we now face an era in which we not only deal with globally diverse teams but also carry out tasks and projects in virtual environments. With the restriction of time and distance, a global team can hardly achieve face-to-face interaction with team members. Instead, virtual collaboration tools are needed to establish workplace interactions in the context of an increasingly becoming hybrid working environment (both virtual and in-person requirements of performing in an international collaborative team) (Serçe et al., 2011).

Mixed reality (MR) or augmented reality (AR) provides the user with an immersive experience through the blend of the virtual and real-world (Wu et al., 2013). MR technology brings together the real world and the digital assets creating a mixed or hybrid platform in which one can control the digital objects laid over an actual environment through hand gestures. These digital assets or objects are visualized through 3D models and provide genuine real-life-like experiences to users and collaborative opportunities in person and remotely via avatars. In addition, the synchronous connections in the MR platform provide team members with real-time performance support (Farrell, 2018).

In this session, we will introduce MR technology within the context of virtual engineering collaborative teams and showcase an MR simulation we developed to support virtual collaboration among global engineering teams. The simulation requires a minimum of three team members to work on engineering-related tasks in real time using technical knowledge, team skills, and collaborative abilities while virtually engaging in knowledge sharing, problem-solving, and decision-making (Crans et al., 2021). The session's goal is to provide a background related to MR technology in engineering and technology management settings and further discuss the potential issues and challenges in adopting this technology platform for enhancing the work of global engineering teams.

Keywords—Mixed Reality, Engineering Management, Collaborative Skills, Simulation, Virtual Teams

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