Research Article GU J Sci, Part A, 11(1): 245-263 (2024) 10.54287/gujsa.1424764

Gazi University
Journal of Science
PART A: ENGINEERING AND INNOVATION
http://dergipark.org.tr/gujsa

A Conceptual Model to Measure Digital Maturity Level in Electricity Distribution Companies

Ezgi AVCI[1*]

[1] *Applied Data Science Department, TED University, Ankara, Türkiye*

Keywords

Digital Maturity Assessment
Conceptual Model
Technology Adoption
Digital Transformation

Abstract

Digitalization, while being one of the primary objectives in today's business world, increases its significance with technological advancements. Recently, there has been a need for tools to determine the levels of digitalization within certain standards and metrics for companies seeking to understand and accelerate their digitalization process, and to determine how these companies should proceed to address their shortcomings. When specifically looking at electricity distribution companies, the technological advancements such as distributed production, storage, and electricity vehicles make the digitalization process not just a choice but a necessity to operate distribution systems reliably and effectively. This study proposes a conceptual model specifically for electricity distribution companies for the first time, by researching digital maturity models developed for other sectors in the literature.

Cite

Avcı, E. (2024). A Conceptual Model to Measure Digital Maturity Level in Electricity Distribution Companies. *GU J Sci, Part A, 11*(1), 245-263. doi:10.54287/gujsa.1424764

Author ID (ORCID Number)

0000-0002-9826-1027 Ezgi AVCI

Article Process

Submission Date 23.01.2024
Revision Date 05.02.2024
Accepted Date 14.02.2024
Published Date 25.03.2024

1. INTRODUCTION

The development of computer and software technologies and their increased mobile usage have transformed data storage and processing from a significant problem into a structure that can be used as meaningful wholes, influencing processes and creating autonomous decision support mechanisms. Tasks previously recorded in human brains and on paper are now being performed based on computers and networks, making them fast and easily accessible by many users at the same time (Bharadwaj et al., 2013). The widespread use of sensor and data storage technologies, as costs have decreased, has accelerated the processes of data acquisition, monitoring, analysis, and storage. Consequently, data is utilized more effectively, the efficiency of processes and decision support systems is increased, and the transition to autonomous processes is becoming more widespread (Westerman et al., 2011; Majchrzak et al., 2016; Kraus et al., 2021; Vial, 2021).

Digitalization can be defined as organizations integrating the technological advancements in information and data management into their structures, both infrastructurally and culturally. As such, digitalization remains a paramount objective in today's business world, increasingly gaining importance with each passing day and technological development (Dahlström et al., 2017; Zaoui & Souissi, 2021). It has been clearly observed that companies investing in digitalization in the industrial and service sectors have a competitive advantage in the market over those who do not prioritize digitalization (Matt et al., 2015; World Economic Forum, 2018).

Recently, there has arisen a need for tools that can determine at what levels companies stand in terms of digitalization, within certain standards and metrics, and how these companies should proceed to address their deficiencies (Karimi & Walter, 2015; Svahn et al., 2017; Feliciano-Cestero et al., 2023). Hence, concepts like digital maturity level or digital maturity index have emerged. The digital maturity level describes a company's

*Corresponding Author, e-mail: ezgi.avci@tedu.edu.tr

or institution's competencies and deficiencies in the area of digitalization, based on specific metrics, and various methods are employed to determine this level (Perera et al., 2023).

As the fundamental building blocks of digitalization, developments in information, communication, and sensor technologies have greatly facilitated the processes of data collection, transmission, and processing across nearly all sectors, especially distribution systems, making it much easier than in the past. Primarily, technology adaptation has accelerated the digitalization of existing analog/manual processes and the widespread implementation of IT-OT interactive systems such as telemetry (Agarwal et al., 2010).

When looking specifically at electricity distribution companies; unlike other sectors, technological advancements such as distributed production, storage, and electricity vehicles have made the digitalization process not just an option but a necessity for operating distribution systems in a reliable and effective manner (Leroi & Martynov, 2020). Furthermore, determining the level of digitalization in the electricity distribution sector in Türkiye will also be quite beneficial in terms of creating regulations that will affect financials.

The main question addressed by this research focuses on assessing the level of digitalization within companies, particularly in the context of electricity distribution companies. We investigate how digital maturity can be measured, the impact of digitalization on operational efficiency, and the competitive advantage it may provide. The hypothesis involves a positive correlation between a company's level of digitalization (digital maturity) and its operational effectiveness, efficiency, and competitive stance in the market.

The primary aim is to develop a specialized digital maturity model that is specifically tailored to the electricity distribution sector, enabling a thorough assessment of digital maturity levels within this field. This model seeks to bridge the identified gap in both academic and industry literature, where there is a noticeable lack of comprehensive frameworks for accurately gauging the digital advancement of electricity distribution companies. Furthermore, the research endeavors to facilitate benchmarking by providing a standardized framework that will allow these companies to measure their digital maturity against recognized industry best practices and standards. Collectively, the manuscript underscores the necessity of a robust, actionable, and sector-specific framework that is essential for electricity distribution companies to effectively evaluate and enhance their digital maturity, which is increasingly vital for their adaptation to the rapidly evolving digital landscape.

The structure of the paper is organized as follows: In Section 2 we conducted a thorough literature review of existing studies on digital maturity models, highlighting the gap in research regarding electricity distribution companies. In Section 3 we present the conceptual framework in which we discuss the theoretical underpinnings of digital maturity and its relevance to the electricity distribution sector. In Section 4 methodology is provided with a detailed explanation of how the digital maturity model was developed, including research design, data collection, and analysis methods. In Section 5 we present the proposed conceptual model, including its components, metrics, and the rationale behind its structure, Description of the methodology used to assess digital maturity within electricity distribution companies, including both self-assessment and expert evaluation processes. In Section 6 we discuss potential limitations and challenges of the proposed model and then provide suggestions for future research to refine and validate the model, as well as its application to other sectors or in different regulatory environments. In Section 7 we give a summary of the study's contributions to the field, the significance of the findings, and the potential impact on the electricity distribution sector.

2. DIGITAL MATURITY IN THE ELECTRICITY DISTRIBUTION SECTOR

The digital world has three main components: (1) Data: Digital information (2) Analytics: The use of data to produce useful information and insights (3) Connectivity: The transfer of data between people and devices via digital communication networks (IEA, 2017). Higher-level digital transformation is achieved through developments in these three areas; namely, the increase in data volume thanks to the decrease in sensor and data storage costs, rapid development in advanced analytics and scientific computing, and greater connectivity with faster and cheaper data transmission.

Digital maturity is a concept that demonstrates an institution or company's capability to effectively compete in an increasingly digital environment. Although the foundation of digital maturity is the integration of new technologies, this definition alone is insufficient. Digital maturity goes beyond simply applying new technology; it changes the company's strategy, workforce, culture, technology, and organizational structure to meet the digital expectations of customers, employees, and business partners. Therefore, digital maturity is a continuous adaptation process to a changing digital landscape. (Haryanti et al., 2023)

Digital Maturity Level (DML) measures an organization's flexibility in adapting to this process. DML is a concept that describes the competencies and deficiencies of a firm or institution in terms of digitalization based on certain metrics, and various methods are used to determine it. It turns out that digitalization is not only about technology but is a more comprehensive concept that includes factors such as data analysis, customer satisfaction, corporate culture, and employees' competencies (Schumacher et al., 2016). The perspective of company managers on the digitalization process, the company's future strategies, employees' competencies regarding digital integration, technological investments, and company culture are also factors that determine the company's level of digital maturity.

Digital technologies have been contributing to the development of energy systems for a long time. In fact, the energy sector is among the first sectors to adopt large-scale information technologies compared to other sectors. In the 1970s, electricity companies became digital pioneers by using information and communication technologies to facilitate the operation and management of electricity grids. Since the production and consumption of electricity must be balanced instantaneously, real-time monitoring and optimization at each production, consumption, and transportation (transmission, distribution) point have an efficiency-increasing effect. Today, electricity markets serve many customers spread over extensive geographic areas and are monitored and controlled instantaneously.

Investments in digital technologies by energy companies have increased rapidly in the last five years. The transformation processes experienced in this rapid development sometimes lead to the misconception that digitalization is merely the application of technology and the forgetfulness that digitalization actually means the integration of technology into innovative strategies, products, processes, and customer experiences to achieve growth and efficiency. Therefore, a significant part of the digitalization practices of distribution companies have remained only as the replacement of existing technologies, the transfer of analog/manual processes to digital platforms without changing the current ways of doing business, or the faster proliferation of operational technologies such as SCADA. However, the goal of becoming a digital company requires a major transformation both internally and externally. The future of the electricity distribution sector lies in adapting to digital technologies. Thus, an efficient, low-cost, sustainable, and flexible structure will be obtained. The digital transformation process in the electricity distribution sector requires new infrastructure and technology investments. Rapidly increasing electricity demand, transmission, and distribution losses, and unexpected grid outages appear as prominent challenges. In this process, in addition to technological infrastructure, training employees on the subject and investments in cybersecurity are of critical importance.

There are some steps that the electricity distribution sector must follow on the path to digital maturity. Analytical models are needed to determine the balance of the production portfolio. These models should aim for maximum economic benefit with minimum cost and CO2 emissions. Production and demand forecasts based on the power source should be made depending on the weather. Considering the technological trends in the sector, the necessity of automating devices with analytical models emerges. Information technology and operational processes are now intertwined. In parallel, smart meters and distributed production should be designed with smart grids. Equipment should be able to supply electricity quickly and flexibly. Problems and interruptions experienced by consumers should be quickly identified. Thefts can be detected with analytical models, and losses can be reduced with real-time line voltage optimization (Annunziata & Bell, 2015).

Efficient control of distributed production areas, such as rooftop solar power plants and electricity vehicles, which can be used on both the demand and production sides, is crucial. Thus, peak demand can be reduced. Energy consumption should become more transparent, and everyone should be able to compare their consumption accordingly. This can lead to progress in consumption habits in terms of energy efficiency. Electricity prices and tariffs can change according to consumption. Demand-side participation should be

initiated. Smart homes should be activated with remote control. Electricity sector companies may partner with technology companies. Equipment maintenance should be determined based on optimization results. Companies will now be those that communicate with customers and guide them regarding energy consumption. There should be a digital platform where people can share innovative ideas (Annunziata & Bell, 2015).

3. CONCEPTUAL FRAMEWORK

3.1. International Studies

Numerous studies have been conducted internationally to determine levels of digital maturity, and it is often seen that global consulting firms are leading these projects. The digital maturity model created by the collaboration of Google and Boston Consulting Group (BCG) classifies companies into four categories according to their maturity levels (Corr, 2022). The identified four classes, in ascending order of digitalization level, are: beginners, developing, effectively using digitalization, and companies that elevate digitalization to the highest level in a multi-resource manner. Companies at the highest level effectively use all data and can offer personalized solutions to customers and employees.

Deloitte has developed a digital maturity methodology applicable to all sectors (Deloitte, 2018). Deloitte's general digital maturity model is categorized under five main headings: customer, strategy, technology, operations, organization, and culture. Under these main headings, sub-headings have been identified for more detailed analysis. For example, under the customer category, there are sub-headings like customer experience, and under the technology category, there are data and analytics, with a total of 28 sub-headings identified. The digital maturity for each title has been measured separately. Finally, a guide is provided for actions to be taken for the measured digital maturity level.

The Forrester Digital Maturity Model 4.0 stands out with the company's continuous comparison with other firms (Gill & Van Boskirk, 2016). They define the digital maturity level on four different axes and run a scoring system out of 84 through surveys. These axes are culture, technology, organization, and insights. According to the results of the scores, they classify companies into four different groups. These are defined as skeptics, adopters, collaborators, and differentiators. The behaviors, strategies, and score ranges of companies with different maturity levels are given in Table 1.

Table 1. *Forrester digital maturity classification*

Maturity Segment	Characteristic Behavior	Strategy	Score Range
Differentiator	Consistently exhibiting excellence	Systematization of best practices	75 – 84
Collaborator	Cooperative but not using insights	Adopting advanced analytics applications	57 – 74
Adopter	Stuck in traditional practices	Focusing on current digitalization efforts	34 – 56
Skeptic	Rejecting digitalization	Reflect	0 – 33

McKinsey offers its measurements as a service without making them public. It presents the measurement results as Digital Quotient to companies. It offers 6 building blocks to being a digital company: strategy and operation, understanding customer decisions, process automation, organization, technology, data, and analytics (Catlin et al., 2015; Dahlström et al., 2017).

The Open Digital Maturity Model prepared under the leadership of Huawei aims to provide community users with the opportunity to measure the digital maturity levels of their companies themselves and aims to gain an advantage in terms of popularity because it does not charge for this (Open Roads Community, 2020). The greater the number of companies reached, the more valuable the results will be as it means a healthier comparison. The Open Digital Maturity Model calculates a digital maturity index by evaluating approximately 140 metrics in six different titles out of 10. Each metric's own weight is also calculated by the model owners. The titles of the metrics are as follows: strategic dynamism, customer focus, digital culture, innovation and lean delivery, big data and artificial intelligence, and finally technology leadership.

Price Waterhouse Coopers (PwC) addressed digitalization in distribution companies in its 2015 report (PwC, 2015). The report presents the results of surveys about digitalization conducted with managers in distribution companies. As the building blocks of digitalization; data and IT infrastructure, organization and governance, digital culture, and change management have come to the forefront. Especially abroad in the energy sector, since data-orientedness already exists, data analytics opportunities have been seen as opportunities that can be implemented more quickly, but new business models (smart homes, etc.) have been seen as concepts that can be implemented later. An increase in complexities in business models and data structures is definitely expected. Distribution companies still do not use an open data approach and do not plan to use it in the near future.

Under the leadership of the German National Academy of Science and Engineering (Acatech) and with contributions from many stakeholders, the Industry 4.0 Maturity Index study was conducted in the 2016-2017 period to help companies manage their digital transformations (Schuh et al., 2018). The methodology identifies four main categories (resources, information systems, organizational structure, and company culture) and five functional areas (development, production, logistics, services and marketing&sales) to help show at what levels digital maturity is in different areas. Each category receives a score between 1 and 6 according to the criteria determined.

The Growth Hub, supported by the European Regional Development Fund (ERDF), has developed the Digital Maturity Index methodology to help create a digitalization roadmap for small and medium-sized enterprises, especially to keep up with the rapidly growing digital economy (Growth Hub, 2019). Digital maturity is evaluated in six main categories; strategy and company culture, technology and cybersecurity, marketing, finance and operations, R&D and innovation, and sales.

CISCO and the International Data Corporation (IDC) have collaborated on a project to calculate the Digital Maturity Index for SMEs in 14 countries in Asia (CISCO, 2019). For this, a survey was prepared and a total of 1,340 SMEs from different sectors participated in the survey. The digital maturity index was developed based on the responses of these firms and benchmark analysis. The methodology identified four main categories; strategy and organization, process management, technology, human resources, and skills.

Deloitte Europe; Middle East and Africa (EMEA) has conducted a study to measure the Digital Maturity levels of companies in the finance sector. With a survey conducted on a total of 8274 banks, benchmark analysis was performed (Deloitte Digital, 2018). The study, which evaluates the finance sectors of countries according to digital maturity in four categories, placed Türkiye in the highest category.

A market research company, Forrester, has developed a digital maturity survey, which has been completed by over 350 finance sector companies through Akamai. Thus, Akamai offers services to companies to determine the level of digital maturity and identify the steps in this path (Akamai, 2018). When determining the digital maturity level, priority was given to the use of online channels, user experience, and cybersecurity issues specific to the finance sector. The assessment of the digital maturity index is made under 5 main headings; cybersecurity, strategy, digital experience, cloud solutions, and technology.

The UK government is measuring how digitized the health system is and how easily processes can be performed. This aims to eliminate long paperwork and procedures (NHS, 2019). The digital maturity level is determined using a self-assessment survey methodology, and three main headings have been identified for assessment. These are; the ease and prediction ability of planning digital services, the competencies needed for digital services to support the health service, and the infrastructure that enables the use of these competencies.

PwC has developed a digital maturity model for the energy sector (PwC, 2019). As a result of a survey conducted with a total of 509 companies, benchmark analysis and digital maturity level determination have been made. The assessment was carried out over three main topics: the ability to adapt new technologies such as artificial intelligence, digital twins, cloud, blockchain; the digital ecosystem, including digital platforms, partnerships, and revenue models; and digital culture, which includes customer experience, education, and innovation. In the methodology to determine the digital maturity level, companies are evaluated out of a total

of 100 points, with 40 points from new technology adaptation, 40 points from the digital ecosystem, and 20 points from digital culture.

When looking at private sector studies, it is observed that the models developed gain meaning and find a place in the industry when used by as many companies as possible. Therefore, these models are usually developed by consulting firms that can hold the results of competitor companies and are present in the market. Most of the studies have been conducted by global consulting firms such as BCG, McKinsey, Deloitte and PwC. The digital maturity level measurement methods developed by consulting firms have usually been applied to many companies and their results have been reported, thus more visible results have been obtained. However, consulting firms also tend to develop these models independently of the industry. For this reason, models developed specifically for the electricity sector are quite limited.

3.2. Studies from Türkiye

The Informatics Industry Association of Türkiye (TÜBİSAD) measures the digital transformation in Türkiye with a methodology involving other countries (TÜBİSAD, 2023). The results are examined in four components: ecosystem, proficiency, usage, and transformation. The digital index is divided into sub-units of component, dimension, and indicator; respectively. The arithmetic average of the indicators determines the dimension score, the arithmetic average of the dimensions determines the component score, and finally, the arithmetic average of the components determines the digital index score. For example, under the usage component, there is a dimension for business world usage, and under this dimension, there is an indicator for personnel training investment. In the digital index, which is evaluated over a total of 64 indicators and on a scale of 1-5, Türkiye scored 2.94, 3.06, 3.21, 3.12 in 2019-2022. This methodology is also applied by companies abroad and the results are regularly published.

Accenture, in collaboration with Vodafone, Boğaziçi University, the Turkish Informatics Foundation, and Middle East Technical University, measured the digitalization level of various sectors in Türkiye in 2016 according to its own methodology and published the results in a report (Accenture, 2017). Accenture assessed digitalization in three main categories and ten subcategories linked to these categories. These are; digital services (industry trends and company objectives), digitized company (products and solutions, services, interaction, sales functions, and service functions), and digital operational competence (operations and processes, resources and organization, and workflow). For the digitalization index study, Accenture conducted interviews with executives from 106 companies in Türkiye. According to the results of the digitalization index, the most digitally mature sector was finance with 81%, while the least advanced sector was construction with 40%. The energy sector also received a relatively low score of 48%.

Turkish Industry and Business Association (TUSİAD) has conducted a comprehensive research study with 108 technology user companies and 110 technology supplier companies (TÜSİAD, 2017). The competence levels of technology user companies have been evaluated in 23 application areas with 118 survey questions under the titles of operational improvement, performance management, employee participation, and fundamental components. According to the research results, while the majority of companies indicate that their knowledge and interest in digital transformation in the industry are high, the proportion of companies that think they are ready for transformation is relatively lower. It is seen that industrial companies in Türkiye are still at the stage of carrying out pilot projects in digital transformation application areas. It is observed that companies, especially their digitalization strategy and roadmap competencies, are low. It appears that the competence levels of companies do not vary according to sectors. However, large-scale companies (companies with annual revenues of more than 250 million TL) have higher digital transformation competence levels in the industry compared to small-scale companies (33/100). Companies state that the biggest obstacles in front of digital transformation are the high cost of investment and the uncertainty of the return on investment.

The studies on digital maturity within Turkish firms present a comparative analysis of the progression, impact, and measurement of digital transformation across different frameworks and empirical findings. Gürder (2022) delves into the levels of digital maturity among Turkish firms, highlighting the critical nature of risk management and adaptation in the digital age. The categorization of businesses into various levels of digital maturity, such as digital champions and digital novices, underscores the varying degrees of digital integration

and data utilization across industries. In contrast, Asiltürk (2021) approaches digital maturity from a theoretical standpoint, emphasizing the need for firms to tailor their digital transformation roadmaps to their specific contexts, acknowledging that digital transformation is a relatively new and complex concept for many.

Düzcan and Fidan (2023) further this comparative analysis by examining the relationship between digital maturity and innovation performance, particularly through the lenses of big data analytical capabilities and data-driven culture. Their findings reveal the direct impact of digital maturity on innovation but also show that the expected moderating effect of a data-driven culture may not be as significant as hypothesized. This suggests that while digital maturity is crucial, the pathway to innovation may not be linear or solely dependent on cultural factors.

Nuroğlu and Nuroğlu (2018) provide a comparative study that extends beyond the Turkish context by juxtaposing the digital transformation roadmaps of Turkey and Germany. This comparative lens reveals gaps in Turkey's approach, particularly in standardization and legal infrastructure, indicating that while Turkish companies are aware of the importance of digital transformation, they may be overemphasizing investment costs at the expense of addressing broader structural issues such as data security and technical infrastructure.

Collectively, these studies provide a multifaceted comparison of digital maturity in businesses. They suggest that while there is a general movement towards digitalization, the depth of integration and strategic approach vary significantly. This variance is influenced by a range of factors including but not limited to the level of understanding of digital transformation concepts, the ability to manage and foresee digital risks, the analytical capabilities to utilize big data effectively, and the broader infrastructural and cultural readiness to implement digital changes. The comparative nature of these studies offers a comprehensive understanding of where businesses stand in terms of digital maturity and what factors contribute to their success or failure in this digital evolution.

The categories determined in digital maturity index methodologies used in international and Turkish private sector applications are summarized in Table 2.

4. METHODOLOGY

The developed models for determining the Digital Maturity Level (DML) initially aimed only to measure the economic impact of technology usage on companies. However, as digitalization has been enriched with various other topics such as customer satisfaction, information security, and the ability to make instant decisions, there has been a need for more comprehensive and detailed models. In addition to measuring the current level of digital maturity, the models are also designed to help determine a roadmap for digitalization.

This section explains the basic digital maturity models developed for DML determination in literature. The two primary types of assessment methods used in evaluating digital maturity, organizational capabilities, or performance are self-assessment and expert assessment. These methods provide insight into where an organization currently stands in a particular area and identify opportunities for improvement.

Self-assessment is a reflective process where an organization evaluates its own performance, capabilities, or maturity level based on predefined criteria. This method is introspective and relies on internal stakeholders to provide their perceptions of how well the organization is doing. Organizations typically use surveys, checklists, or assessment tools that are filled out by employees, managers, or executives. These instruments are designed to capture information about various aspects of the organization's operations and strategies. Self-assessments are usually cost-effective since they don't require external consultants. They can be done relatively quickly and can engage a broad range of employees, fostering a sense of ownership over the results and subsequent action plans. The main challenge is the potential for bias. Respondents may overestimate capabilities due to a lack of objectivity or underreport issues due to fear of negative repercussions. The quality of the results depends heavily on the honesty and self-awareness of the participants. For example, a company might use a digital maturity model self-assessment tool to determine where it stands regarding digital transformation. Employees rate their company's performance across several areas, such as digital customer experience, analytics capability, and IT infrastructure. The aggregated results give an overview of perceived digital maturity.

Expert assessment involves external professionals or consultants evaluating an organization. These experts use their specialized knowledge and experience to provide an unbiased view of the organization's performance or maturity. Experts conduct audits, interviews, and observations to collect data. They might also review documentation and processes to evaluate how the organization compares to best practices or industry standards. An expert assessment is typically more objective and can provide a fresh perspective. Experts can benchmark the organization against others in the industry and offer insights that internal staff might miss. This method can be more expensive and time-consuming than self-assessment. There's also a risk that employees may not be as forthcoming with external assessors, which can affect the quality of the data collected. For example, a financial institution wanting to improve its cybersecurity posture may hire a team of IT security consultants to conduct an expert assessment. The consultants would evaluate the bank's cybersecurity measures against regulatory requirements and industry benchmarks to identify vulnerabilities and recommend improvements.

Both assessment methods can be used together to provide a comprehensive view of an organization's status. Self-assessment can help prepare for an expert assessment, and findings from an expert assessment can be used to refine self-assessment tools for ongoing monitoring. When used effectively, these assessment methods can significantly contribute to an organization's continuous improvement and readiness to adapt to new challenges.

For the purpose of determining DML, 10 academic studies have been selected based on prevalence and appropriateness criteria and are shown in Table 3.

From the 10 selected articles above, 3 studies (Schumacher et al., 2016; Canetta et al., 2018; Durek et al., 2018) are explained below as they form the basis for the conceptual model.

Academics at the Vienna University of Technology have argued that existing methodologies for determining the level of digital maturity are solely technology-focused and have aimed to develop these methodologies by also including company culture and organizational structure (Schumacher et al., 2016). The methodology, which also encompasses technological components like cloud technology, cybersecurity, and the Internet of Things (IoT), has identified a total of 9 main categories for evaluation. Under these 9 main categories, a total of 62 sub-dimensions have been determined. The 9 main categories and sample sub-dimensions are as follows:

- Product: Product system integration, customization of products for customers
- Customers: Use of customer data, digitalization of sales and services
- Operations: Distribution of responsibilities in processes, modeling, and simulation
- Technology: Modern information and communication technologies, machine-to-machine communication
- Strategy: Industry 4.0 roadmap, adaptation to new business models
- Leadership: Leaders' desire for digitalization, central coordination
- Corporate Management: Implementation of technological standards, determination of employee rights compatible with Industry 4.0
- Culture: Knowledge sharing, openness to collaboration with other companies
- Employees: Employees' aptitude for information and communication technologies, speed of adaptation to new technologies

For each of the 62 sub-dimensions, a question has been formulated, and the answers to each question are designed to be scored between 1 and 5. A score of 1 indicates no digital maturity, while a score of 5 indicates that digitalization is at the best possible level (Table 4). Thus, the methodology indicates one of the five levels of digital maturity for each category based on the responses to the self-assessment.

Table 2. *Categories Identified in Studies of Digital Maturity Level Measurements*

Institution	Categories
Deloitte	• Customer • Strategy • Technology • Operations • Organization • Culture
Forrester	• Culture • Technology • Organization • Insight
McKinsey	• Strategy and Innovation • Understanding Customer Decisions • Process Automation • Organization • Technology • Data and Analytics
Huawei	• Strategic Dynamism • Customer Focus • Digital Culture • Innovation and Lean Delivery • Big Data and Artificial Intelligence • Technology Leadership
Acatech	• Resources • Information Systems • Organizational Structure • Culture
European Regional Development Fund (ERDF)	• Strategy and Company Culture • Technology & Cybersecurity • Marketing • Finance & Operations • R&D & Innovation - Sales
CISCO	• Strategy and Organization • Process Management • Technology • Human Resources and Talent
Akamai	• Cybersecurity • Strategy • Digital experience • Cloud solutions • Technology
NHS (Health sector)	• Data literacy • Competencies • Technological Infrastructure
PWC (Energy sector)	• Ability to adapt New Technologies • Digital Ecosystem • Digital Culture
TÜBİSAD	• Ecosystem • Competence • Usage • Transformation
Accenture	• Strategy • Digital Services • Digital Operational Capabilities
BCG - TÜSİAD	• Strategy and Roadmap • Governance • Infrastructure • Data Security

Table 3. *Selected Academic Studies on Digital Maturity Index*

Study Name	Country	Publication Year	Sector	Methodology Type	Citation Count
Industry 4.0 Maturity Readiness and Maturity (Schumacher et al., 2016)	Austria	2016	Manufacturing / Industry	Self-Assessment	528
Digitalization Maturity Model for Manufacturing (Canetta et al., 2018)	Switzerland	2018	Manufacturing / Industry	Self-Assessment	28
Digital Maturity Level of Higher Education Institutions (Durek et al., 2018)	Croatia	2018	Education	Expert Assessment	10
Digital Readiness Assessment Maturity Model (DREAMY) (De Carolis et al., 2017)	Italy	2017	Manufacturing / Industry	Self-Assessment	80
The Maturity Model Industry SIMMI 4.0 (Leyh et al., 2016)	Germany	2017	Manufacturing / Industry	Expert Assessment	71
VTT Model of Digimaturity (Leino et al., 2017)	Finland	2017	All Sectors	Self-Assessment	4
Empirical Maturity Study (Berghaus & Back, 2016)	Switzerland	2016	All Sectors	Self-Assessment	64
Digital Maturity in Traditional Industries (Remane et al., 2017)	Germany	2017	Manufacturing / Industry	Self-Assessment	26
SME's Maturity Model Assessment (Hamidi et al., 2018)	Malaysia	2018	Small – Medium Enterprises	Self-Assessment	13
Digital Hospital Transformation– Maturity Assessment (Williams et al., 2019)	Australia	2019	Health |	Expert Assessment	4

Table 4. *Sample Question for Determining the Level of Digital Maturity*

Question	1	2	3	4	5
Do you use a roadmap for the planning required under digitalization and Industry 4.0?	X				

1: We do not use it at all 5: The plan has been completed and we fully act according to it

Not all questions contribute equally to digital maturity, therefore each question has been given a weight. A total of 23 researchers and experts have scored the importance of the questions between 1 and 4, and weights have been determined by averaging these scores. For example, while modern information and communication technologies have received a score of 3.5, the use of mobile devices has received a score of 3.2. Then, weighted averages have been calculated using the weights of the questions, the scores obtained from the answers, and the category to which the questions belong, and the level of digital maturity for each category has been determined. As a result, the digital maturity level that emerges is shown as a score between 1 and 5 across 9 categories (Figure 1), allowing a company to easily see which areas they excel in and which areas are lacking.

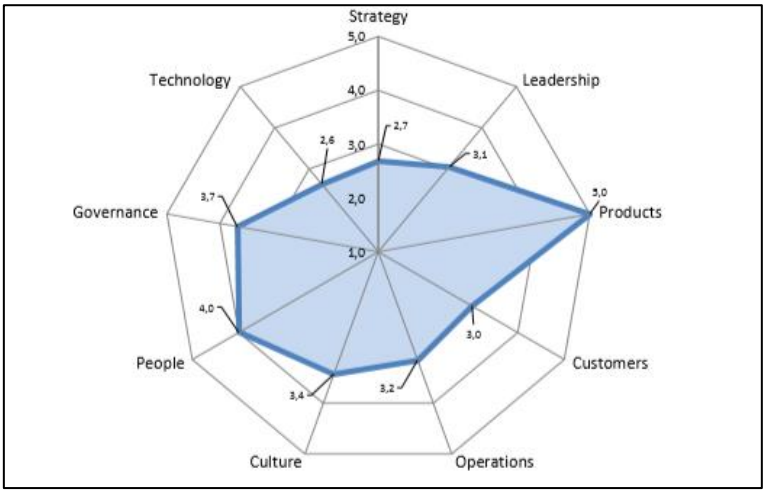

Figure 1. *Sample Digital Maturity Index Assessment Result for a Company*

In the second examined study, a digital maturity model has been developed for the manufacturing/industry sector (Canetta et al., 2018). The methodology in this study consists of three main steps: (i) conducting a survey

to determine the company's current state in the digitalization process and digitalization targets, (ii) conducting interviews with employees for process and operation analysis, and (iii) determining the steps to be taken in the digitalization process through discussions with employees. In the first step, the current level of digital maturity is generally measured, while the remaining steps involve determining more detailed steps for improvement and creating a roadmap. The evaluations measure how much technology has made processes efficient, how much digitalization will reduce the need for human labor, the level of information security, and how integrated technological systems are with devices. For the purpose of evaluations, a total of 36 questions have been determined under 5 main categories. The questions are designed to be inclusive and applicable for the entire industry sector. The 5 main categories and some of the key questions under these categories are as follows:

- Strategy: The company's production and sales strategy (R&D, order methods, stocking, etc.)
- Processes & Operations: Data collection, information security, device system integration, and collaborations
- Products & Services: Product tracking, product and service data management
- Technology: Implementation of new technologies, robust technological infrastructure
- Employees: Technological proficiency of employees and their adaptations to digitalization

It is emphasized that companies should have different digitalization roadmaps due to their distinct production and sales strategies. Accordingly, companies are classified based on the answers given in the strategy category. Different weights are assigned to each question according to this classification. Each question is scored as 0, 1, 2, 3 (none, low, medium, very good) based on the given answers. A digital maturity score between 0 and 3 is calculated for each category using a weighted average based on scores and weights. As a result, an example outcome as shown in Figure 2 is obtained.

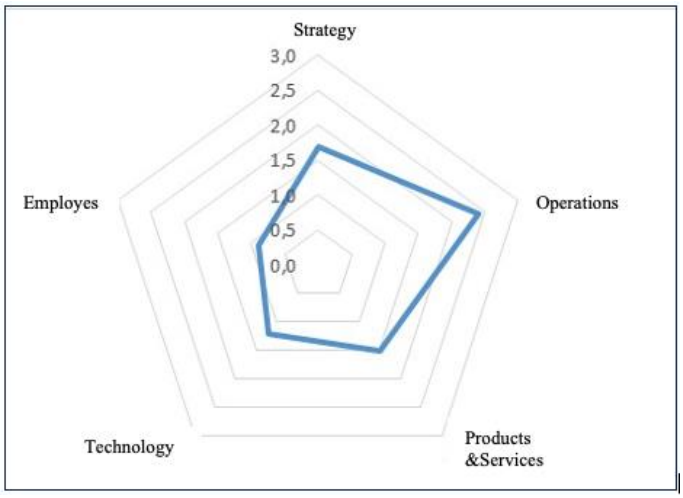

Figure 2. *An Example Digital Maturity Index Evaluation Result for a Company*

In the third and final study reviewed, academics at the University of Zagreb have conducted a methodology development study to measure the digital maturity level of schools in Croatia (Durek et al., 2018). The study evaluated 15 digital maturity index methods based on surveys and developed their methodology based on these evaluations. Initially, 7 main categories and 53 subheadings were identified by examining the 15 methods. Experts were asked to place these 53 headings into 7 main categories and also to rank them in order of importance. Consequently, the less important headings were eliminated, reducing the number from 53 to 43, which were then matched with the 7 main categories.

The determined 7 main categories and some associated headings are as follows:

- Leadership, Planning, and Management: Financial investments in technology use in teaching, public cooperation in technology integration
- Quality Control: Evaluation of teachers in lecture delivery, research, and other areas
- Scientific Research: Publications and research related to information and technology systems
- Technology Transfer and Community Services: Collaboration with stakeholders, increasing researchers' networks with technology assistance
- Teaching and Learning Processes: Digital competencies of teachers and students
- Information and Communication Technologies Culture: Training and incentivizing employees on digitalization
- Information and Communication Technologies Infrastructure: Network, technical support, and maintenance

Since the importance of the determined 43 elements is not the same, weights have been assigned using the analytical hierarchy method. This method compares all elements in pairs and defines categories such as equally important, slightly more important, and much more important. As a result, each element is assigned a weight between 0 and 1. Similarly, a weight assignment has been made for the determined 7 main categories. The evaluation elements were assessed by experts through discussions with relevant individuals in schools, and a score between 1 and 5 was given for each of the 43 elements, which was then multiplied by the weights to calculate the total score. In total, 5 different maturity levels have been determined for 151 schools.

5. CONCEPTUAL MODEL

After examining digital maturity index models used in academic literature, international and private sector studies in Türkiye, a conceptual model proposal has been developed for the Turkish electricity distribution sector. It has been observed that the studies show very similar characteristics but there was no study specifically for the electricity distribution sector. A model proposal to determine the digital maturity level specifically for the electricity distribution sector has been suggested.

In order to develop a robust set of survey questions for assessing digital maturity within the electricity distribution sector, a multi-faceted approach is employed. Initially, a literature review is conducted to thoroughly examine existing academic research, industry reports, and case studies. This review is crucial for identifying key factors and metrics previously used to measure digital maturity, ensuring that the survey is comprehensive and rooted in established theories and practices. Following this, consultations with industry experts, such as IT professionals, digital transformation consultants, and senior executives from electricity distribution companies, are undertaken to obtain practical insights into the sector's digitalization. These professionals can assess the survey's relevance and provide practical input that might not be immediately apparent from the literature.

Next, benchmarking is carried out to analyze digital maturity models from various industries and sectors, identifying those that could be adapted or serve as reference points for the electricity distribution sector. This involves customizing questions to address the specific challenges and opportunities present in the energy sector. Additionally, focus groups and interviews are organized with employees at different levels within electricity distribution companies. These discussions aim to capture their perceptions and experiences of digital transformation, with in-depth interviews offering nuanced insights that further refine the survey questions.

Finally, pilot testing is implemented. This stage involves creating an initial set of survey questions derived from the aforementioned methods and conducting a pilot survey to test them. Feedback gathered from this pilot phase is instrumental in fine-tuning the questions, ensuring clarity, lack of ambiguity, and effective measurement of the intended constructs. This comprehensive process is essential for crafting a survey that accurately gauges digital maturity in the electricity distribution sector.

To determine the digital maturity level in detail, different categories and subtopics have been identified. The aim here is to reduce complexity by dividing the assessment into as many independent small business units as possible. Also, this method will help to indicate which areas the companies are successful in and which areas they are lacking when the digital maturity level is determined. The identified categories and subtopics are shown in Figure 3.

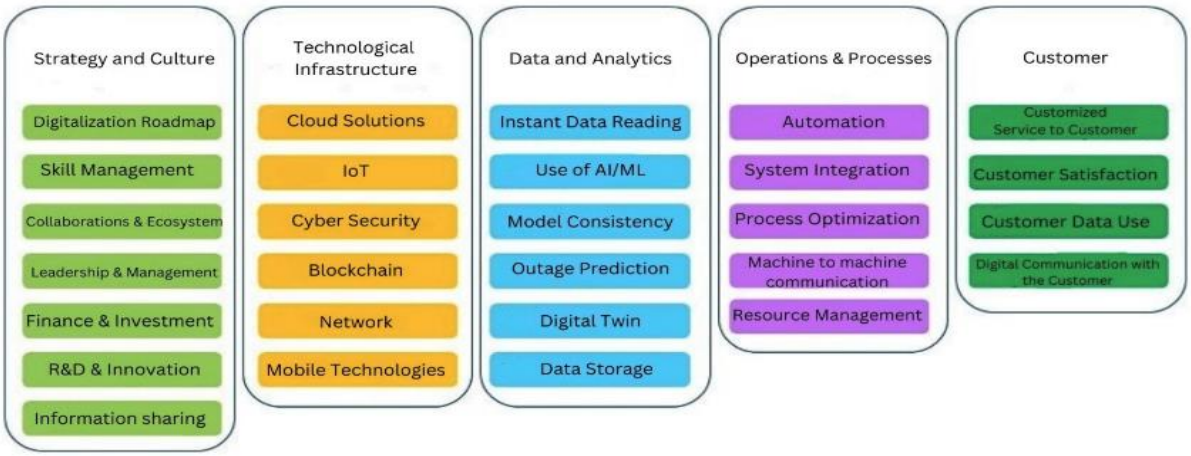

Figure 3. *Categories and Subtopics of the Digital Maturity Model*

For each subcategory, typically 3-4 survey questions are determined. These survey questions are designed to have multiple-choice answers only. Each option corresponds to a score between 0 and 100, predetermined. The questions have different weights due to their different contributions to digital maturity. These weights are determined by the average score given by subject matter experts rating the questions from 1 to 5. The final weight coefficient will be determined by rounding the result of the average score to the nearest decimal.

The proposed conceptual model for measuring the digital maturity level in electricity distribution companies is underpinned by a set of equations that systematically derive a Final Digital Maturity Index (FDMI).

Equation 1 is the FDMI which is a weighted average that gives you the overall digital maturity score for the company:

1. Each category of digital maturity within the company is given a score, which we call Digital Maturity Index (DMI_i) where i represents the category number (for example, 1 for 'Infrastructure', 2 for 'Skills', etc.).

2. Each of these category scores is multiplied by its importance to the company, represented by a weight coefficient W_i. If you think the 'Infrastructure' category is twice as important as 'Skills', you might give 'Infrastructure' a weight of 4 and 'Skills' a weight of 2.

3. You then add up all these weighted scores.

4. To get the average, you divide the total by the sum of all the weight coefficients. This ensures that the FDMI score is normalized and not skewed by the number of categories or the scale of their weights.

Equation 2 calculates the (DMI_i,) for each category. It is similar to Equation 1 but at a category level:

1. Within each category, every question about digital maturity is scored, Maturity Score (MS_s), with s representing the specific survey question.

2. Each question score is multiplied by its own weight (W_s), because some questions are more important than others.

3. These weighted question scores are added together.

4. The sum is then divided by the total weight of all questions in that category to get the average score for the category (DMI_i,).

Equation 3 defines how to calculate the weight coefficient (W_i) for each category:

1. It sums the weights of all the questions within a category (W_s).

2. Then it divides this sum by the number of questions (n_i) in that category to get an average weight for the category.

In summary:

- Equation 1 gives the big picture: the final digital maturity score for the whole company.
- Equation 2 zooms into each category, giving a score for that category based on the survey questions it contains.
- Equation 3 helps to understand the average importance given to each category based on the weights of the questions it includes.

Together, these equations provide a comprehensive mathematical model to assess and quantify the digital maturity of electricity distribution companies, allowing for comparisons across different categories and the company as a whole.

$$FDMI = \sum_{i=1}^{5} \frac{DMI_i * W_i}{\sum_i W_i} \quad (1)$$

$$DMI_i = \frac{\sum_{s \in i} MS_s * W_s}{\sum_{s \in i} W_s} \quad (2)$$

$$W_i = \frac{\sum_{s \in i} W_s}{n_i} \quad (3)$$

FDMI: *Final Digital Maturity Index*

DMI$_i$: *Digital Maturity Index for category i.*

MS$_s$: *Maturity score for question s (between 0 and 100)*

W$_s$: *Weight coefficient for question s (between 1 and 5)*

W$_i$: *Weight coefficient for category i (between 1 and 5)*

n$_i$: *Number of questions in category i*

Using these formulas, a digital maturity index score for each category is obtained between 0 and 100, and the average of these scores constitute the FDMI. Based on this index score, companies are labeled with one of five digital maturity level categories. Example question scoring is shown in Tables 5 and 6.

Table 5. *Example Question for Determining Digital Maturity Level*

Score	Digital Level
0-20 points	Unaware
21-40 points	Mediocre
41-60 points	Follower
61-80 points	Effective User
81-100 points	Leader

Table 6. *Example Question for Determining Digital Maturity Level*

Question Category	Strategy and Culture
Subcategory	Finance & Investment
Question	How much have you invested in the digitalization process in the last 5 years?
Question Weight (1-5)	3.8
Options and Scoring	• 0 - 250,000 TL (0 points) • 250,000 TL – 1 million TL (20 points) • 1 – 5 million TL (40 points) • 5-10 million TL (60 points) • 10-25 million TL (80 points) • Above 25 million TL (100 points)

6. LIMITATIONS AND FUTURE WORK

Potential limitations and challenges are: The electricity distribution sector is inherently complex, with a wide array of regulatory, technical, and operational factors. A model that aims to measure digital maturity must be sensitive to these complexities, which can vary widely between regions and companies. The model may struggle to account for all these nuances, leading to oversimplifications. Reliable data is the backbone of any maturity assessment. However, the availability and quality of data within electricity distribution companies can be a limiting factor. Some companies may not have the required data collection infrastructure in place or may have data that is incomplete or not up to date, which can skew the assessment results. Organizational culture and resistance to change can be significant barriers. The model's effectiveness is contingent on the company's willingness to accurately self-assess and implement recommended changes. A company that is resistant to acknowledging its digital shortcomings may not fully benefit from the model. The model suggests a hybrid approach of self-assessment and expert evaluation. However, finding experts with the requisite knowledge of both the digital and electricity distribution domains to perform these evaluations can be difficult. The electricity distribution sector is heavily regulated. Any model that seeks to measure and improve digital maturity must be aligned with regulatory requirements, which can be a moving target as regulations evolve. To address these limitations and challenges, the proposed model need to include mechanisms for regular updates to keep pace with technological changes, flexible metrics that can be customized for different company profiles, and a clear, actionable roadmap for companies to follow in addressing their digital maturity gaps.

Further research could focus on refining the digital maturity model based on feedback from initial implementations. Validation of the model through longitudinal studies across various companies could strengthen its reliability and predictive power. Customization for different market regulations through developing tailored versions of the model to account for different regulatory environments across countries or regions could improve the robustness of the model. This would involve studying the impact of regulations on digital maturity and incorporating these insights into the model. Future research could also focus on exploration of how the model interacts with and supports the adoption of smart grid technologies. Future studies moreover could measure the economic impact of increased digital maturity on electricity distribution companies, including cost savings, return on investment, and impact on revenue. Since digitalization increases cybersecurity risks, future work could develop methodologies for incorporating cybersecurity assessments into

the digital maturity model. Using machine learning and data mining techniques to predict the outcomes of digital maturity efforts could be another future work which help companies anticipate the benefits and challenges of their digitalization strategies.

7. CONCLUSION

In conclusion, this study has proposed a conceptual model for measuring the digital maturity level in electricity distribution companies, filling a critical gap in the existing literature. With the increasing importance of digitalization and technological advancements, the need for tools to assess and accelerate the digital transformation process in various sectors, including electricity distribution, has become imperative. The unique challenges and opportunities within the electricity distribution sector necessitate a tailored approach to digital maturity assessment.

The conceptual model presented here is grounded in an extensive review of digital maturity models across diverse sectors, with a specific focus on electricity distribution. Recognizing the multifaceted nature of digital maturity, the proposed model encompasses categories and subtopics crucial for a comprehensive evaluation. By adopting a hybrid approach that combines self-assessment surveys and expert evaluations, the model aims to provide a nuanced understanding of the digitalization landscape within electricity distribution companies.

The significance of digital maturity in the electricity distribution sector cannot be overstated, given the transformative impact of technology on grid management, energy efficiency, and customer engagement. The proposed model addresses key areas such as finance and investment, strategy and culture, and technological trends, aligning them with the specific needs of electricity distribution companies. Furthermore, the model incorporates a quantitative measure in the form of a Digital Maturity Index, allowing for a standardized and comparative assessment across companies. The index, derived through a systematic formula involving survey responses and expert weights, provides a numerical representation of digital maturity levels. This numerical scoring system enables companies to benchmark their progress and categorize themselves into distinct digital maturity levels, ranging from Unaware to Leader.

It is crucial to note that the success of the proposed model lies not only in its ability to evaluate the current digital maturity of electricity distribution companies but also in guiding them toward a strategic roadmap for future digitalization efforts. As the electricity distribution sector continues to evolve with advancements such as smart grids, distributed production, and electric vehicles, the proposed model can serve as a valuable tool for companies to stay competitive and resilient in an increasingly digital environment.

In summary, this study contributes to the literature by introducing a tailored conceptual model for assessing digital maturity in electricity distribution companies. The model provides a structured framework for companies to evaluate, strategize, and enhance their digitalization efforts, ultimately paving the way for a more efficient, sustainable, and technologically advanced electricity distribution sector.

CONFLICT OF INTEREST

The author declares no conflict of interest.

REFERENCES

Accenture. (2017). Accenture Türkiye dijitalleşme endeksi. (Technical Report).

Agarwal, R., Gao, G. (Gordon), DesRoches, C., & Jha, A. K. (2010). The digital transformation of healthcare: Current status and the road ahead. *Information Systems Research*, *21*(4), 796-809. https://doi.org/10.1287/isre.1100.0327

Akamai. (2018). Advancing digital maturity in financial services.

Annunziata, M., & Bell, G. (2015). Powering the future: Leading the digital transformation of the power industry. General Electric.

Asiltürk, A. (2021). İşletmelerde dijital dönüşüm yönetiminde nihai hedef: Dijital olgunluk. *Alanya Akademik Bakış*, *5*(2), 647-669. https://doi.org/10.29023/alanyaakademik.859300

Berghaus, S., Back, A. (2016). *Stages in digital business transformation: Results of an empirical maturity study*. In: Proceedings of the Mediterranean Conference on Information Systems (MCIS).

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, *37*, 471-482. https://doi.org/10.25300/MISQ/2013/37:2.3

Canetta, L., Barni, A., & Montini, E. (2018, June 17-20). *Development of a digitalization maturity model for the manufacturing sector*. In: Proceedings of the IEEE International Conference on Engineering, Technology and Innovation, Stuttgart, Germany. https://doi.org/10.1109/ICE.2018.8436292

Catlin, T., Scanlan, J., & Willmott, P. (2015). Raising your digital quotient. *McKinsey Quarterly*, *3*, 30-43.

Cisco. (2019). Cisco APAC SMB Digital maturity index. Cisco Systems.

Corr, J. (2022, April 6). *Unleashing the power of digital marketing: The digital maturity model explained*. Seer Interactive. URL: https://www.seerinteractive.com/insights/introduction-to-digital-maturity

Dahlström, P., Desmet, D., & Singer, M. (2017). The seven decisions that matter in a digital transformation: A CEO's guide to reinvention. *Digital/McKinsey: Insights*, *3*, 18-23.

De Carolis, A., Macchi, M., Negri, E., & Terzi, S. (2017, September 3-7). *A maturity model for assessing the digital readiness of manufacturing companies*. In: H. Lödding, R. Riedel, K-D. Thoben, G. von Cieminski, & D. Kiritsis (Eds.), Proceedings of the Advances in Production Management Systems. The Path to Intelligent, Collaborative and Sustainable Manufacturing (APMS 2017), (pp 13-20), Hamburg, Germany. https://doi.org/10.1007/978-3-319-66923-6_2

Deloitte. (2018). Digital maturity model achieving digital maturity to drive growth.

Deloitte Digital (2018). *EMEA digital banking maturity 2018: How to become a digital champion and why only few succeed?*.

Durek, V., Kadoic, N., & Redjep, N. B. (2018, May 21-25). *Assessing the digital maturity level of higher education institutions*. In: Proceedings of the 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), Opatija, Croatia. http://doi.org/10.23919/MIPRO.2018.8400126

Düzcan, A., & Fidan, Y. (2023). İşletmelerde dijital olgunluk düzeyinin yenilik performansı üzerindeki etkisinde büyük veri analitik yeteneğinin aracı ve veri odaklı kültürün düzenleyici rolü. *İstanbul Ticaret Üniversitesi Sosyal Bilimler Dergisi*, *22*(46), 356-389. https://doi.org/10.46928/iticusbe.1294014

Feliciano-Cestero, M. M., Ameen, N., Kotabe, M., Paul, J., & Signoret, M. (2023). Is digital transformation threatened? A systematic literature review of the factors influencing firms' digital transformation and internationalization. *Journal of Business Research*, *157*, 113546. https://doi.org/10.1016/j.jbusres.2022.113546

Gill, M., & VanBoskirk, S. (2016). The digital maturity model 4.0. Benchmarks: digital transformation playbook.

Growth Hub. (2019). Digital maturity index. Growth Hub. URL: https://www.thegrowthhub.biz/digital-maturity-index

Gürder, F. (2022, August 17-18). *Türkiye'deki işletmelerin dijital olgunluğu*. In: Proceedings of the İzmir International Conference on Technology and Social Sciences (IICTSS 2022), New Studies and Trends in Social Sciences, (pp. 40-41), İzmir, Türkiye.

Hamidi, S. R., Aziz, A.A., Shuhidan, S.M., Aziz, A.A., & Mokhsin, M. (2018, March 19-22). *SMEs maturity model assessment of IR4.0 digital transformation*. In: A. M. Lokman, T. Yamanaka, P. Lévy, K. Chen, & S. Koyama (Eds.), Proceedings of the International Conference on Kansei Engineering & Emotion Research, (KEER 2018), (pp 721-732), Kuching, Sarawak, Malaysia. http://dx.doi.org/10.1007/978-981-10-8612-0_75

Haryanti, T., Rakhmawati, N. A., & Subriadi, A. P. (2023). The extended digital maturity model. *Big Data and Cognitive Computing*, *7*(1), 17. https://doi.org/10.3390/bdcc7010017

IEA. (2017). Energy Access Outlook 2017. URL: https://www.iea.org/reports/energy-access-outlook-2017

Karimi, J., & Walter, Z. (2015). The role of dynamic capabilities in responding to digital disruption: A factor-based study of the newspaper industry. *Journal of Management Information Systems*, *32*, 39-81. https://doi.org/10.1080/07421222.2015.1029380

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *Sage Open*, *11*(3). https://doi.org/10.1177/21582440211047576

Leino, S.-P., Kuusisto, O., Paasi, J., & Tihinen, M. (2017). VTT model of digimaturity. In: J. Paasi (Eds.), *Towards a new era in manufacturing: Final report of VTT's for industry spearhead programme*, (pp. 41-46). VTT Technical Research Centre of Finland.

Leroi, A., Martynov, A., (2020). How utilities can regain control of their technology roadmap. Bain & Company. URL: https://www.bain.com/insights/how-utilities-can-regain-control-of-their-technology-roadmap/

Leyh, C., Bley, K., Schäffer, T., & Forstenhäusler, S. (2016, September 11-14). *SIMMI 4.0-a maturity model for classifying the enterprise-wide IT and software landscape focusing on Industry 4.0*. In: Proceedings of the Federated Conference on Computer Science and Information Systems (FedCSIS), Gdansk, Poland.

Majchrzak, A., Markus, M. L., & Wareham, J. (2016). Designing for digital transformation: Lessons for information systems research from the study of ICT and societal challenges. *MIS Quarterly*, *40*(2), 267-277. https://doi.org/10.25300/misq/2016/40:2.03

Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. *Business & Information Systems Engineering*, *57*(5), 339-343. http://dx.doi.org/10.1007/s12599-015-0401-5

NHS. (2019). Connected digital systems-Maturity Index. National Health Service UK.

Nuroğlu, E., & Nuroğlu, H. H. (2018). Türkiye ve Almanya'nın sanayide dijital dönüşümü: Yol haritaları ve şirketlerin karşılaştırması. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *23*(Endüstri 4.0 ve Örgütsel Değişim Özel Sayısı), 1537-1560.

Open Roads Community. (2020). Open Digital Maturity Model. Open Roads Community.

Perera, S., Jin, X., Das, P., Gunasekara, K., & Samaratunga, M. (2023). A strategic framework for digital maturity of design and construction through a systematic review and application. *Journal of Industrial Information Integration*, *31*, 100413. https://doi.org/10.1016/j.jii.2022.100413

PwC. (2015). The digitalization of utilities. PwC.

PwC. (2019). Digital operations study for energy - Power and utilities. PwC.

Remane, G., Hanelt, A., Wiesboeck, F., & Kolbe, L (2017). *Digital maturity in traditional industries–an exploratory analysis*. In: Proceedings of the 25th European Conference on Information Systems (ECIS 2017).

Schuh, G., Anderl, R., Gausemeier, J., ten Hompel, M., & Wahlster, W. (Eds.) (2018). Industrie 4.0 Maturity Index: Managing the Digital Transformation of Companies. Acatech.

Schumacher, A. S., Erol, S., & Sihn, W. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP*, *52*(1), 161-166. https://doi.org/10.1016/j.procir.2016.07.040

Svahn, F., Mathiassen, L., & Lindgren, R. (2017). Embracing digital innovation in incumbent firms: How Volvo Cars managed competing concerns. *MIS Quarterly*, *41*(1), 239-253. http://dx.doi.org/10.25300/MISQ/2017/41.1.12

TÜBİSAD. (2023). Türkiye'nin dijital dönüşüm endeksi 2022. TÜBİSAD.

TÜSİAD. (2017). Türkiye'nin sanayide dijital dönüşüm yetkinliği. TÜSİAD.

Vial, G. (2021). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2) 118-144. https://doi.org/10.1016/j.jsis.2019.01.003

Westerman, G., Calméjane, C., Bonnet, D., Ferraris, P., & McAffee, A. (2011). Digital transformation: A roadmap for billion-dollar organizations. MIT Sloan Management.

Williams, P. A. H., Lovelock, B., Cabarrus, T., & Harvey, M. (2019). Improving digital hospital transformation: Development of an outcomes-based infrastructure maturity assessment framework. *JMIR Medical Informatics*, *7*(1). https://doi.org/10.2196/12465

World Economic Forum. (2018). The digital enterprise: Moving from experimentation to transformation. URL: https://www.weforum.org/publications/the-digital-enterpise-moving-from-experimentation-to-transformation/

Zaoui, F., & Souissi, N. (2020). Roadmap for digital transformation: A literature review. *Procedia Computer Science*, *175*, 621-628. https://doi.org/10.1016/j.procs.2020.07.090