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Digital Transformation Journey Guidance: A Holistic Digital Maturity Model Based on a Systematic Literature Review

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Abstract: For a successful digital transformation, organizations must create an accurate roadmap and manage the process effectively. A digital maturity model is a critical success factor as it enables organizations to assess their current situation and create roadmaps aligned with their goals; however, a comprehensive systematic literature review covering the maturity models proposed by academia and consultancy firms is hard to find. Further, the existing models are sector-oriented, not organization-oriented, and do not consider the transformation journey holistically, but instead focus on model dimensions. This study first undertakes a comprehensive and up-to-date systematic literature review by applying the PRISMA approach using a bibliometric analysis tool capable of providing visual maps, then developing a unique holistic digital maturity model that covers several aspects of an organization's digital transformation journey, from strategy to governance, and asking relevant questions. The hierarchical structure, comprising dimensions and sub-dimensions, presents content beyond the scope of other models. The results of the digital maturity assessment can be interpreted in parallel with the stages of the digital transformation. Consequently, the new holistic and sector-independent digital maturity model can be used by organizations in both the private and public sector.

Keywords: digital transformation; digitalization; digital maturity; digital maturity model; digital transformation journey

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1. Introduction

Digital transformation (DT) is defined as the application of novel digital technologies to facilitate significant business improvements, leading to either improved client experience and streamlined operations or the development of new business models [1]. It involves identifying organizational needs, designing new processes, or redesigning existing ones by utilizing digital technologies to provide value to customers, businesses, and other key stakeholders [2–5]. Given that DT has social, technological, and managerial impacts across all levels of the organization, it should be managed from a holistic perspective [6,7]. Additionally, the transformation component implies substantial changes forthcoming in the organization in terms of structure and strategies [4]; therefore, DT can be regarded as an adoption process that must be actively designed, initiated, and implemented [8]. It can also be viewed as a journey that enables organizations to create value by bringing together internal and external capabilities to achieve their goals with digital solutions. In this journey, each institution passes through certain stages according to its own vision and maturity.

Kurmann and Arpe identified top management support, cross-functional collaborations, flatter hierarchies, and intensified people management as crucial success factors in DT implementation [9]. In addition, companies should utilize digital technologies and customer-centered performance indicators as business practices for DT [10]. They should also assess their business models to avoid situations in which they are unable to compete or even survive [11]. Therefore, the success of DT is not only dependent on technology

but also on the strategies implemented to change business processes. Managers in diverse sectors agree that DT should bring the organization from a state of being satisfied by marginal efficiency improvements to a state of implementing basic innovation principles and developing disruptive strategies [12].

Digitization, digitalization, and DT are the three stages of digital advancement in organizations [7,13]. Digitization is defined as the encoding of analog data into a digital arrangement, which enables computers to store, process, and disseminate such information, while digitalization refers to how information technology (IT) or digital technologies can be utilized to change existing business processes. The creation of new mobile communication channels enables clients to easily connect with the organization can be seen as digitalization [7]. IT is a primary enabler of digitalization because it offers novel business opportunities by transforming processes such as distribution, communication, and business relationship administration [7,13]. The last stage of digital advancement, DT, redesigns critical processes to augment a firm's business approach to value creation [13,14].

Organizations face the challenge of matching appropriate digital approaches and actions during their DT journey due mainly to the basic complexity of IT administration and the lack of research on how firms can systematically adopt DT [15]. Many organizations face diverse problems, including cultural and talent gaps and weak collaboration between IT and other business processes [16]. According to a McKinsey report [17], DT requires organizations to reskill human resources, adjust their culture, promote closer IT–business process connections, and meticulously measure digital value; therefore, the success of DT is not only dependent on technology but also on the strategies implemented to change business processes. Employees and their working styles also help to bring these processes to life. In this context, it is unavoidable to examine an organization's capabilities, culture, and human capital profiles. The impact of these dimensions on digitalization studies can also be seen in the elements examined and supported in the literature [18].

The need for balanced and holistic management of different activities in DT requires that digital maturity models are put into practice. Hence, this study focuses on three critical research questions to investigate the key roles digital maturity models play in DT.

- Q_1: What is the importance of maturity models within DT?
- Q_2: In what contexts is a digital maturity model considered?
- Q_3: How should a holistic and generic model be designed? What dimensions should it have?

The study makes two key contributions. First, noting that the most recent survey covers papers published until 2020, the present study includes an up-to-date comprehensive survey for the identification of relevant maturity models for DT that can be applied to organizations in different sectors. The comprehensiveness of the survey is mainly based on the fact that digital maturity models developed by both academia and consultancy firms are considered. Another distinctive feature of the survey is that, in addition to the frequently used Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach, a bibliometric analysis tool called Biblioshiny [19] was utilized to generate visual maps. Second, a more significant contribution is the development of a new holistic digital model that can be applied to all organizations, independent of their sector and size.

The remainder of this paper is organized as follows. Section 2 provides background information on the concepts that are utilized in the paper for the description of digital maturity and digital maturity models. Section 3 outlines the methodology used to conduct a systematic literature review of papers published until the end of 2022. Section 4 presents the results of this review, while Section 5 introduces the new digital maturity model and its novelties compared to existing models. Lastly, Section 6 concludes the paper.

2. Background

We devote this section to clarifying the concepts that are related to digital maturity, its levels, its assessment, and digital maturity models which are used for the assessment of

the digital maturity level of organizations. We note that the effective management of DT depends heavily on digital maturity models.

2.1. Digital Maturity

Digital maturity is closely related to DT and is defined by Gökalp and Martinez [14] as the state in which an entity's digital technology has transformed its activities, skill engagement, and business frameworks. Hägg and Sandhu [13] call it a situation where a transformation has occurred in an organization which has managed to address problems associated with digital business landscapes. Schumacher et al. [20] define maturity as a condition of being perfect or complete, which implies the advancement of a system's development phase. Teichert [21] uses the term DT maturity to identify that the linkage between DT and digital maturity encompasses technological and managerial components. Gartner [22] defines digital maturity as the level at which an organization has implemented digital technologies and processes to drive business performance and enable DT. Based on these definitions, digital maturity can be summarized as a critical indicator that reveals the performance of DT adaptation.

Digital maturity assessment is a process of evaluating an organization's level of digital maturity by assessing its capabilities, readiness, and progress in implementing digital technologies to transform its business operations and remain competitive in the digital age. This assessment involves analyzing an organization's performance in key areas, such as strategy, culture, processes, technology, and data analytics, using various frameworks, models, and tools to measure the organization's digital maturity level. According to literature and shared sources such as Ross and Beath [23]; Nambisan and Sawhney [24]; Westerman, Bonnet, and McAfee [25]; Berman and Marshall [26]; and Kagermann, Wahlster, and Helbig [27]; digital maturity assessment is crucial for organizations looking to thrive in the digital age. The process enables organizations to identify gaps in their digital capabilities and provides them with insights into areas they need to improve to stay competitive.

2.2. Digital Maturity Models

According to Berghaus and Back [28], a maturity model offers guidance on the approach companies adopt to plan and implement DT. Maturity frameworks primarily facilitate the evaluation of the status quo and implies a potential, expected, or usual development path to the target position [14]. Digital maturity models assist organizations in analyzing their capacity to respond to DT based on predefined milestones [29].

Berghaus and Back [28] argue that digital maturity models include dimensions and sub-dimensions that outline areas of improvement and measure maturity at distinct levels, pointing to the path of evolution toward full maturity. Specifically, a dimension refers to a measurable and isolated element that portrays a substantial, critical, and separate component of digital maturity [21]. In a later section, we review 60 maturity models developed by academia and consultancy firms and mention their dimensions as well as sub-dimensions.

3. Methodology

A systematic literature review was conducted to analyze existing studies on the concept of digital maturity. The stages of the review are shown on the right-hand side of Figure 1 and are based on the PRISMA approach, the steps of which are depicted on the left-hand side [30]. The PRISMA approach was introduced in 2009 by renaming and updating the standards set in the Quality of Reporting of Meta-analyses (QUOROM) conference for improving the quality of reporting systematic reviews [31].

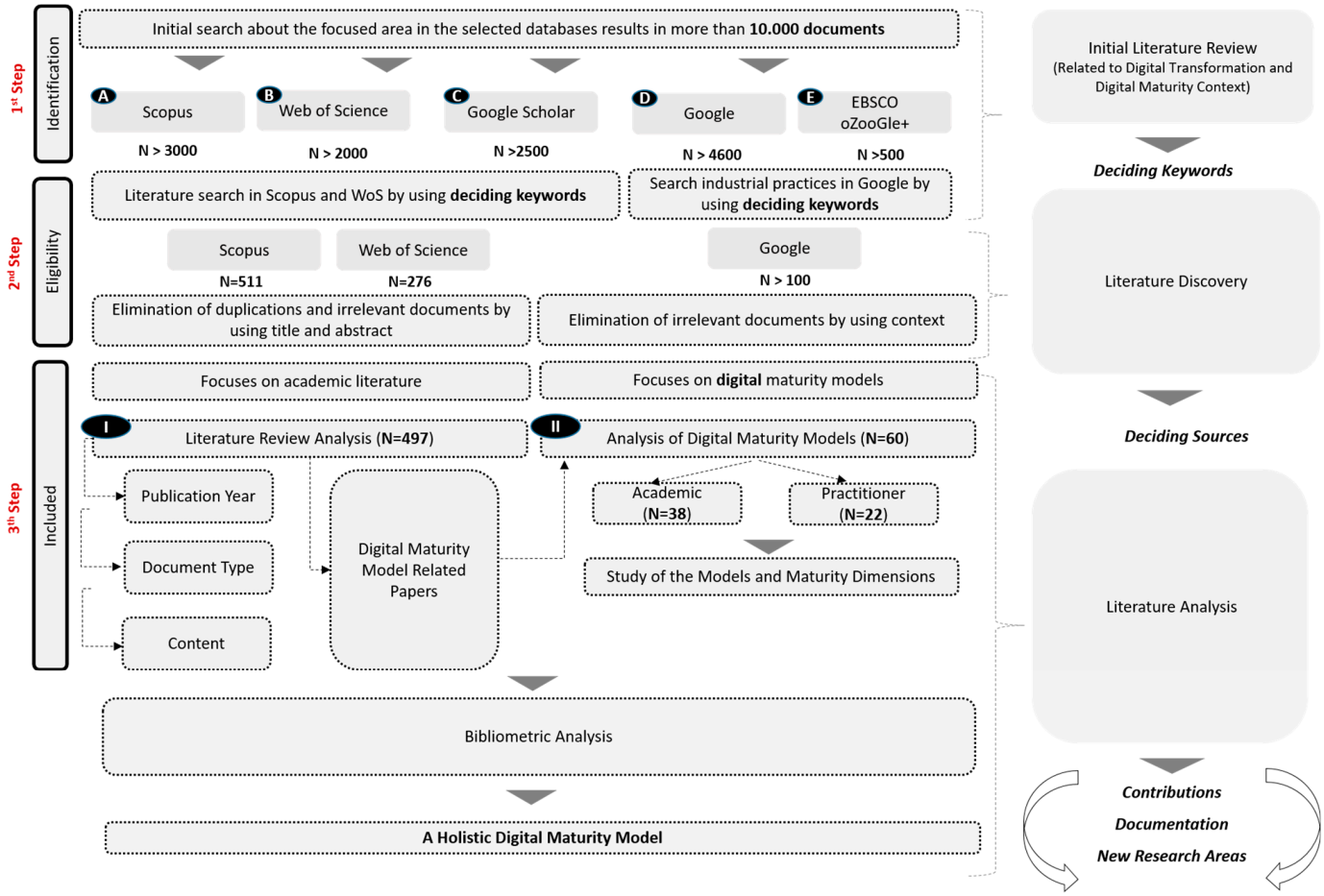


Figure 1. Methodology for systematic literature review.

The first step comprised scanning the literature using a wide range of concepts so that all the studies related to the digital maturity model in the context of DT are considered. More than 10,000 publications were found based on the keywords listed in Table 1. These keywords are indicative of the relevance of these publications to the concept of digital maturity.

Table 1. Digital-maturity-related keywords.

"Digital Maturity"	"Digital Readiness"
"Digital Transformation" AND "Digital Maturity"	"Digital Readiness Model"
"Digital Transformation Maturity"	"Digital Readiness Assessment"
"Digital Maturity Assessment"	"Stages of Digital Transformation"
"Digital Transformation Assessment"	"Digital Maturity Levels"
"Digital Transformation Capability Maturity Model"	"Phases of Digital Transformation"

In the second step, the source documents were determined by eliminating duplicate and irrelevant documents by reading abstracts and removing the duplicates across different databases. The Scopus and Web of Science (WoS) databases were scanned for academic studies, while Google search engines were used to find studies by consultancy firms. The Scopus and WoS databases were compared, and the former, being larger, was found to include the documents found in the latter; therefore, we decided to proceed with the Scopus database.

The third step involved analyzing the documents to find the answers to the research questions aimed at (i) marking the importance of digital maturity models in DT and (ii) presenting a holistic digital maturity model based on the analysis and the gaps in the literature.

This section is divided into the literature review analysis targeted to answer the first two questions and the digital maturity models analysis that checked if the documents selected in the literature review focused on digital maturity models and answers the third question. The last was further divided into academic articles, consultancy firm reports, and white papers.

The fourth step was bibliometric analysis, a research method that supports measurement-based analysis of scientific literature. Bibliographic mapping tools generate maps that summarize various attributes of documents and their relationships [32]. An inspiring example of bibliometric analysis is the paper by Uribe-Toril et al. [33] where the authors review the literature in the field of Energy, Economy, and Environment for a duration of 17 years. This paper has been a motivation for using bibliometric analysis in our study to boost the systematic literature review.

The Biblioshiny tool was selected owing to its superior features and visualization capabilities than those of other tools [19]. Table 2 presents a comparison of existing tools for bibliometric analysis and their visualization capabilities.

Table 2. Comparision of bibliometric analysis and visualization tools [34].

	Thematic Network	Author Network	Reference Network	Other Networks	Evolution	Performance	Burst Detection	Spectrogram	Geospatial	Visualization
Science Mapping Analysis Tools										
Bibexcel	•	•	•	•	•	•			•	External software
Biblioshiny	•	•	•	•	•	•	•	•	•	Network, three-fields plot, word cloud, tree map, historiograph, strategic diagram, evolution map, and world map
BiblioMaps	•	•	•	•		•			•	Network
CiteSpace	•	•	•	•		•	•		•	Tree ring, geospatial map
CitNetExplorer			•							Network
SciMAT	•	•	•	•	•	•				Strategic diagram, cluster network, overlapping map, evolution map
Sci^2 Tool	•	•	•	•			•		•	Temporal, geospatial map, topical, network
VOSviewer	•	•	•	•		•				Network, overlay, density
Libraries										
Bibliometrix	•	•	•	•	•	•	•	•	•	Network, three-fields plot, word cloud, tree map, historiograph, strategic diagram, evolution map, and world map
BiblioTools	•	•	•	•		•			•	Network
Citan						•				Bars, bow plots, and pie chart
Metaknowledge	•	•	•	•			•	•		Timeline graph, spectrogram, and network
scientoText		•				•				
SxientoPy					•	•				Timeline graph, bar graph, evolution graph, and word cloud

Figure 2 outlines the Biblioshiny tool process comprising three phases: preparation, data analysis, and data visualization and evaluation. The preparation phase involved downloading a dataset comprising all relevant documents as a .bib file from Scopus, and the data analysis phase involved inputting the .bib file into Biblioshiny, which performs

a bibliometric analysis step by reducing the data and creating a network matrix. The last phase involves generating various mappings for visualization and evaluation.

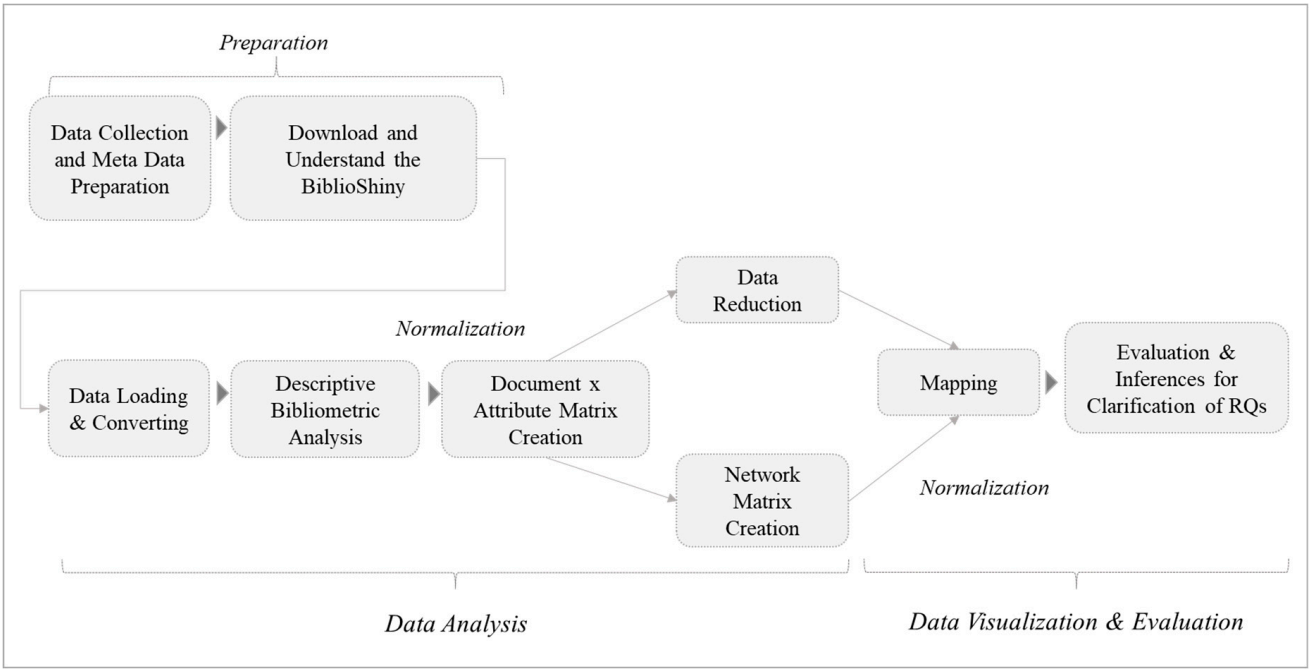


Figure 2. Bibliometric analysis using BiblioShiny [19,35].

3.1. Method Used for Literature Review Analysis

The literature review analysis conducted in this study utilizes the two types of analyses provided by the Biblioshiny software: one focused on the domain and another focused on the knowledge structure, as shown in Figure 3. Domain-focused analysis is based on sources (journals, conference proceedings, etc.), documents, and authors, whereas knowledge-structure-focused analysis makes use of conceptual, intellectual, and social issues. This study considers the sources and documents in terms of domain to obtain a general overview of the publications and carry out document analysis. The general overview provides a summary of the number of sources, publications, and citations that can be referred to as metadata. Document analysis was performed based on keywords. In terms of knowledge-structure-focused analysis, we used only the conceptual structure. This enabled us to analyze the relationships and trends of the concepts using the three Biblioshiny networks: co-occurrence networks, thematic maps, and thematic evolution.

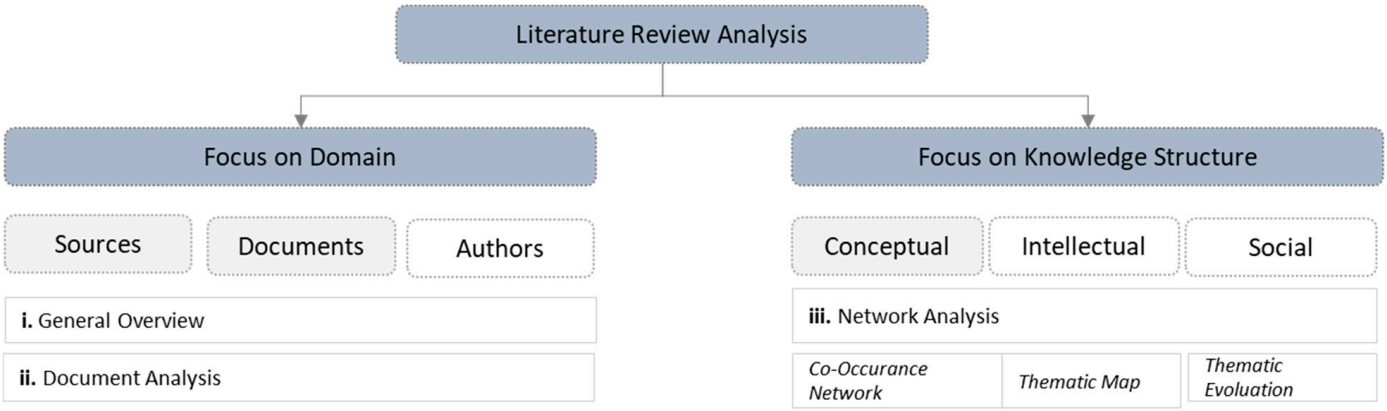


Figure 3. Literature analysis scope using BiblioShiny.

A co-occurrence network, which helps to study the evolution of the subject area over time, was used to understand the topics covered by the subject area under investigation. In the network, each node is represented by a keyword used by the authors in the documents. The size (diameter) of a node increases when the associated keyword is used in a larger number of documents. An edge or link exists between a pair of nodes (keywords) if both the keywords exist in the same document. The strength of a link, which measures the degree of association between a pair of keywords, increases as the number of co-occurrences of the corresponding keywords increases.

The second type of network, called a thematic map, groups the documents into four clusters represented by a bubble based on two features of the keywords: centrality degree and density degree [36]. The centrality degree shows the importance of the keywords, whereas the density degree measures the development of keywords over time. In a thematic map, the size of the bubbles representing the clusters depends on the number of keywords assigned to the clusters. The position of the bubbles was set according to the Callon centrality and the density of the cluster [19]. Both types of maps have been utilized in many recent studies regarding various research disciplines [37,38].

3.2. Digital Maturity Model Analysis Method

This analysis groups the documents containing digital maturity models into two groups, as shown in Figure 4. Irrespective of their origin, the documents were analyzed based on the dimensions used in the proposed maturity model. A dimension was defined as a criterion in the model for the assessment of digital maturity.

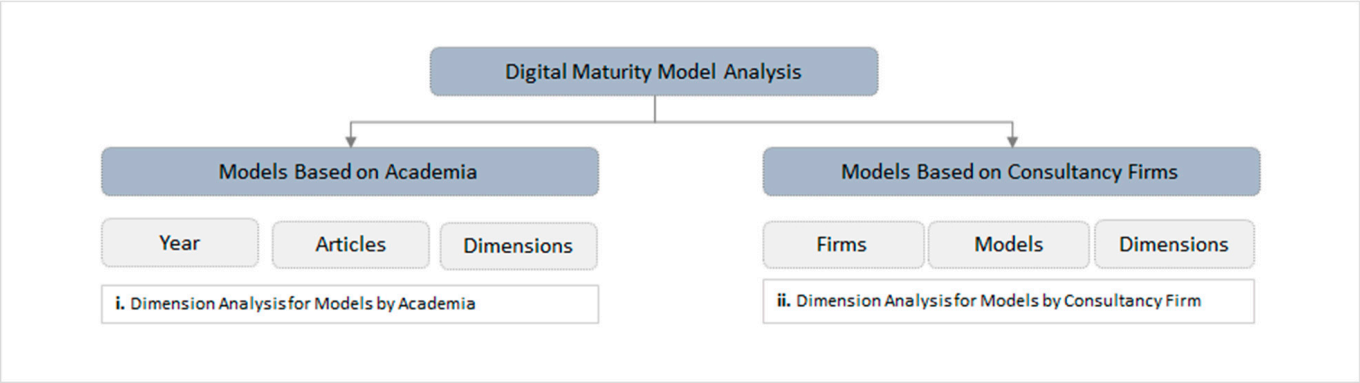


Figure 4. Digital maturity model dimensions focused literature analyis scope.

4. Literature Review Results

The results from the literature review of all documents until the end of 2022 and the digital maturity model analysis are presented in the following subsections.

4.1. Results Based on Literature Review Analysis

4.1.1. Domain-Focused Analysis

Focusing on the domain of the documents, the development of publications over the years and publication performance based on citations and document types were analyzed. The first analysis provides a general overview of the number of sources, publications, and citations that can be referred to as metadata.

General Overview: As seen in Figure 5, the first document with the scope of digital maturity was published in 2004. Since then, the documents have grown at 3.7%. A total of 1481 authors contributed to the publications, and international cooperation in authorship was 14%. To date, over 20,000 references have been provided to 497 scanned documents, and the average citation performance of the articles was 6.2.

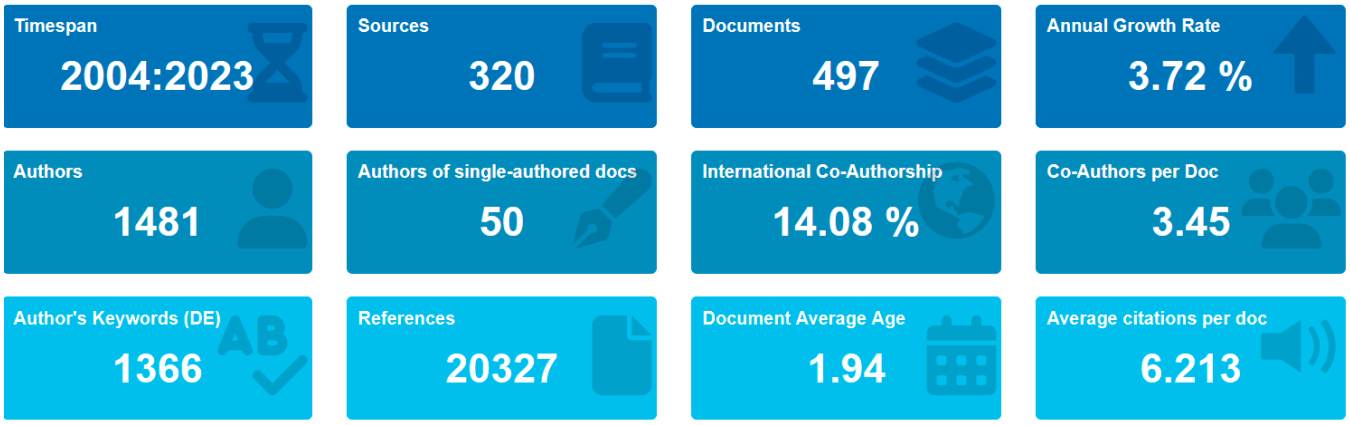
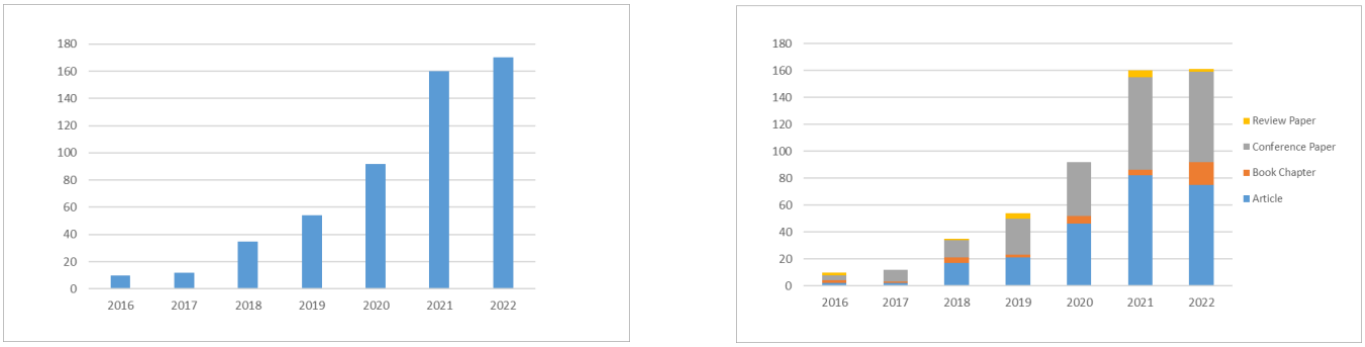


Figure 5. The main information provided by BiblioShiny based on literature review metadata.

In parallel to the growth of DT studies, the annual number of publications on digital maturity has also increased steadily since 2018, as can be seen in Figure 6a. A significant share of the increase can be attributed to the conference papers as Figure 6b indicates.



(**a**) (**b**)

Figure 6. (**a**) The annual number of publications. (**b**) The annual number of document type.

As Figure 7 shows, along with the number of publications, the average number of citations received by each publication increased significantly after 2016.

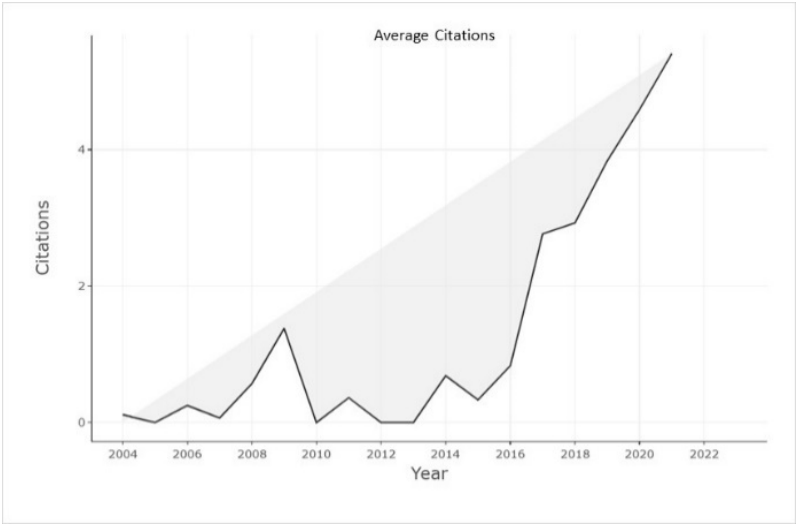


Figure 7. Average number of citations per publication by year.

Document Analysis: This analysis is performed based on keywords. As Figure 8a,b show, when all keywords or the 100 most frequently used are considered, the papers are concentrated across only four: Industry 4.0, digital maturity, maturity model, and digital technologies.

(**a**) (**b**)

Figure 8. (**a**) Word cloud for all keywords. (**b**) Word cloud for 100 keywords.

When the cumulative occurrences of the keywords are plotted in Figure 9 on an annual basis, it is observed that digital maturity ranks second after DT. Note that Figure 9 only displays the total number of times the most frequent keywords appeared by year 2022 while the numbers for other years can be read on the plot. For example, DT and digital maturity appeared 131 and 106 times, respectively, by 2022.

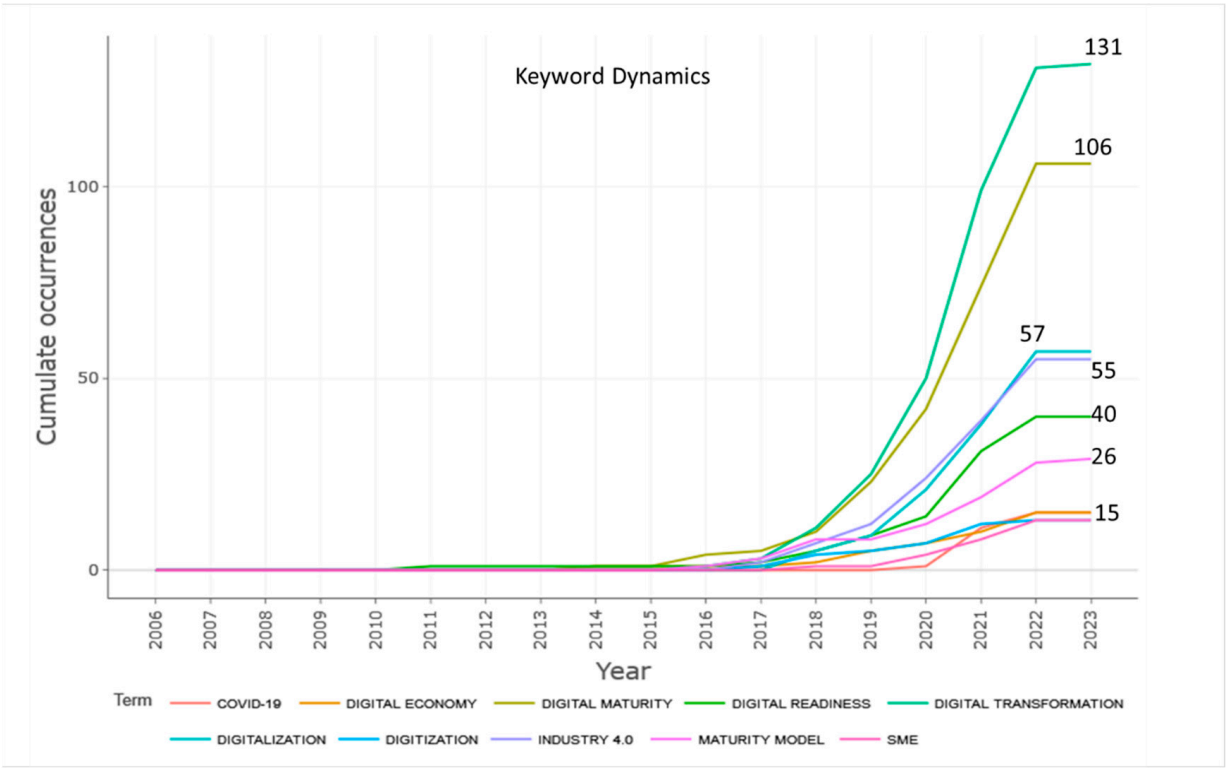


Figure 9. The dynamics of frequently used keywords.

The most commonly used keywords are shown in Figure 10. When the trend topics of the documents are analyzed, digital maturity is still the winner; digitalization creates a new wave after digitization and progresses in parallel with digital maturity.

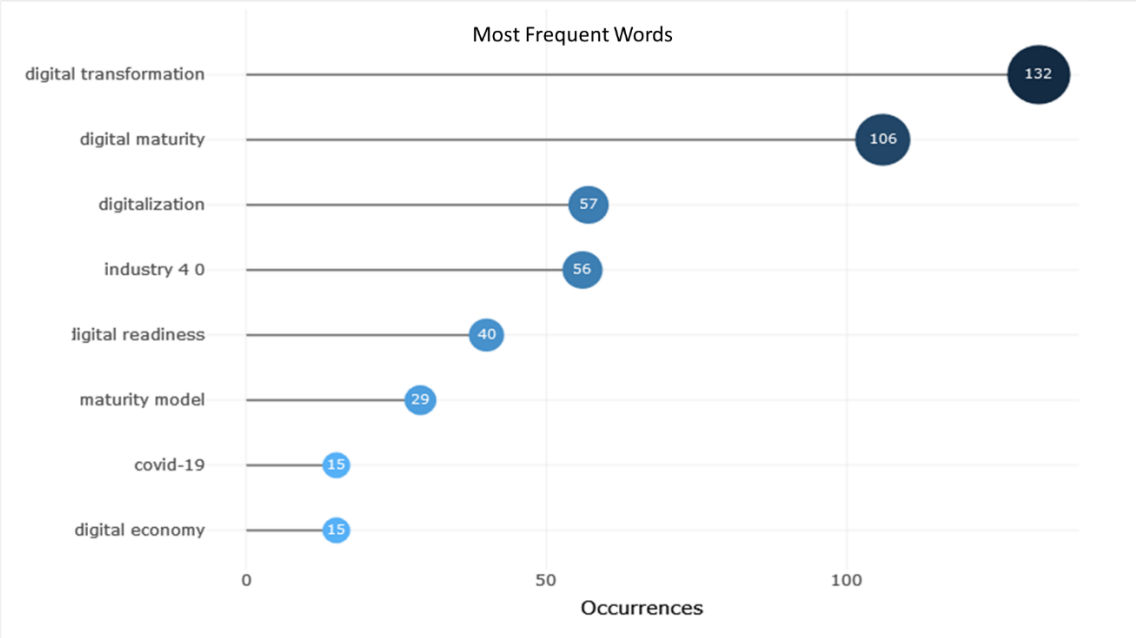


Figure 10. Most frequent keywords.

However, the importance of digital solutions and big data, which reveal the solutions and effects of DT, increased, as shown in Figure 11.

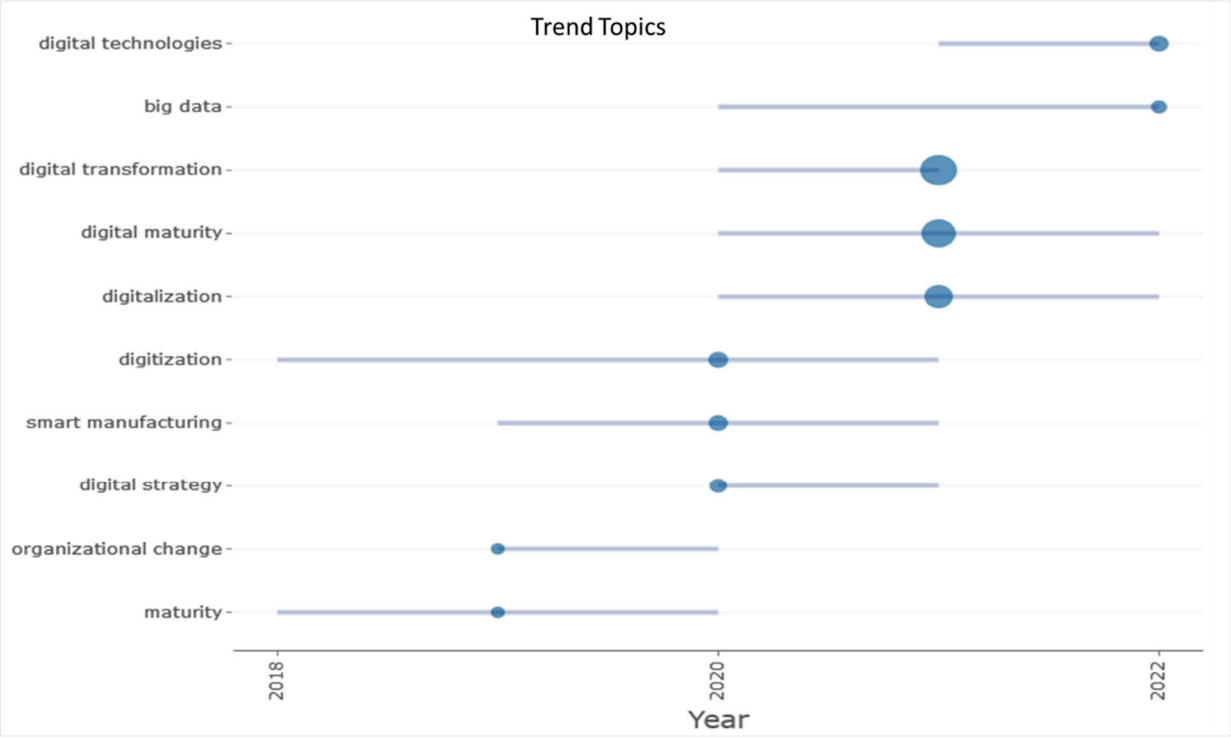


Figure 11. The evolution of trend topics.

4.1.2. Knowledge-Structure-Focused Analysis

This analysis enables the investigation of the relationships of the concepts and their trends using the Biblioshiny network types: co-occurrence network, thematic map, and thematic evolution. As shown in Figure 12, the co-occurrence network indicates that DT occurs most frequently with digital maturity, digitalization, and Industry 4.0. According to the results of the thematic map, which shows clusters with respect to the density and centrality of the keywords, the keywords DT, digital maturity, and digital model form a separate and powerful cluster among all publications (Figure 13). The second significant cluster was obtained by the keywords digitalization and Industry 4.0. Digital readiness ranks third, followed by the COVID-19 cluster.

Figure 12. Co-occurrence network.

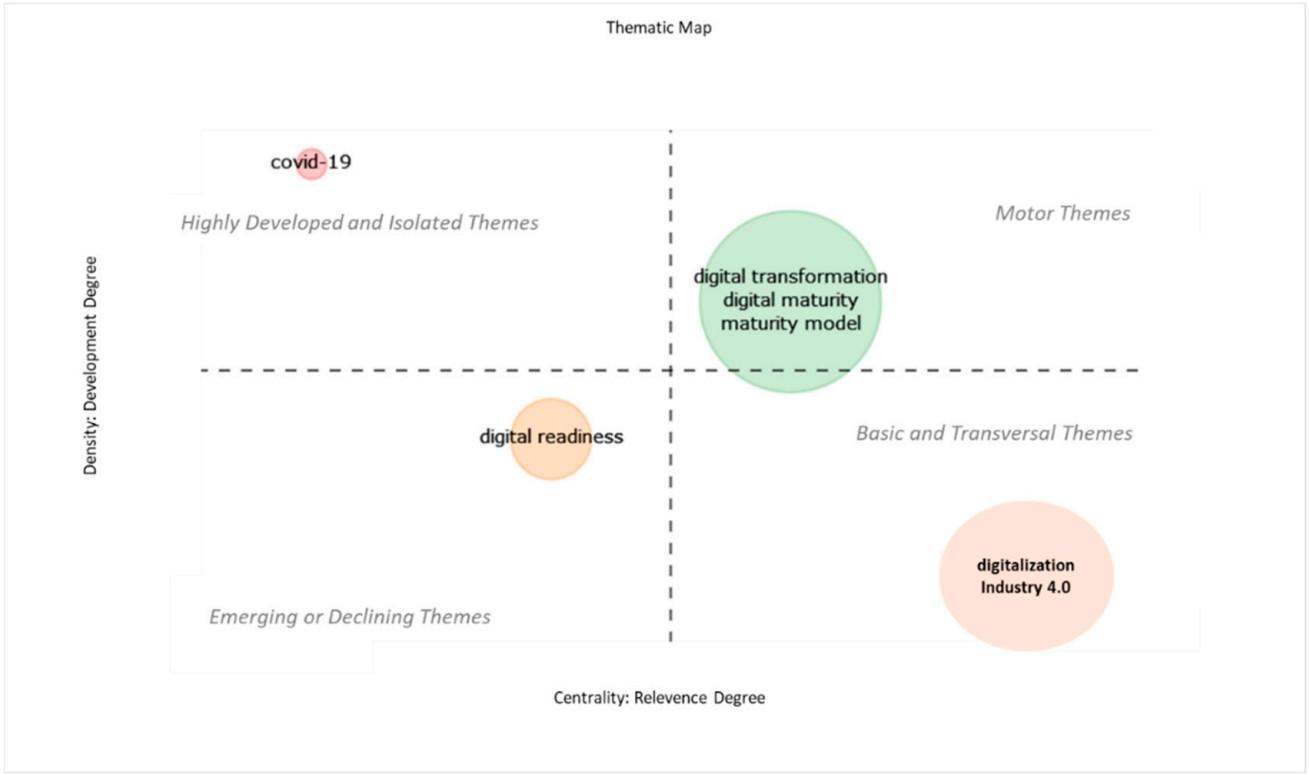


Figure 13. Thematic map.

Biblioshiny is an R package that provides an interactive interface for bibliometric analysis. One of the features of Biblioshiny is the ability to generate a thematic evolution map of research themes that have developed over different time periods. Themes are basically clusters of author-defined keywords selected in each paper. The map is created as follows: First, for each time period in question, a network is created from the articles in the database where the nodes of the network represent the keywords found in the articles, and the edge between a pair of keywords implies that these two keywords co-occur in a number of articles. Then, as the number of articles having the two keywords increases, the strength of the edge (or equivalently, the similarity of the keywords) also increases.

A clustering algorithm is utilized to group the keywords based on the similarities among them. Each cluster corresponds to a research theme. Hence, the colored boxes found at each time period of Figure 14 denote different research themes. When one or more keywords exist both in a theme at time period t and another theme at time period $t + 1$, there is a connection between these themes across periods.

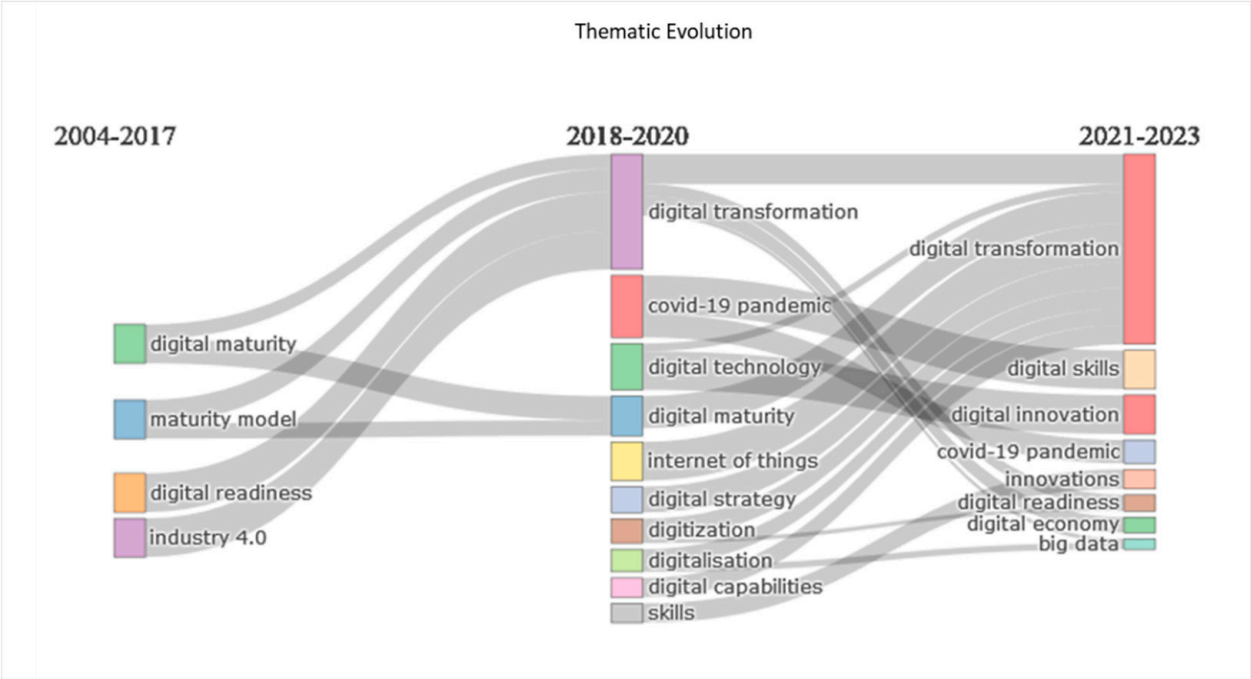


Figure 14. Thematic evolution map.

Owing to the sharp increase in the number of documents in 2018, the time horizon was divided into three time periods: 2004–2017, 2018–2020, and 2021–2022. In the thematic evolution map in Figure 14, the digital maturity theme in period 2004–2017 is seen to have connections with itself and DT theme in period 2018–2020; moreover, it has also ties with the theme of maturity model in the first two time periods.

The analyses made in this section reveal two main results as the answer to the first research question (Q1) with regard to the place of digital maturity in DT. First, the number of publications where DT and digital maturity are discussed together has increased over the years. Second, the connection between these two concepts is much stronger and more closely related in comparison with the connection between all keywords.

4.2. Results Based on Digital Maturity Model Analysis

The increasing importance of DT, its successful implementation, and its failures have triggered both academia and consultancy firms to develop models allowing the systematic monitoring of projects related to DT. We found five review papers on digital maturity models, two of which were published in 2019 and three in 2020, as shown in Table 3. Within

the scope of digital maturity, the most recent review paper considers documents published until 2020; this study, therefore, updates the literature review by two years. Moreover, existing review papers focus mainly on maturity models applicable to small- and medium-sized enterprises, while this study focuses on all papers independent of the sector, making it possible to propose a holistic and comprehensive model.

Table 3. Review papers on digital maturity models.

Reference	Focus Years of Literature Review	Number of Examined Models	Scope of Models	Analysis Method	Contribution/ Findings	Limitations
Hajoary [39].	2011–2020	53 Industry 4.0 maturity and readiness models	Academia and consultancy-firm based	Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)	Proposes a holistic model in 10 main dimensions	Based on the Industry 4.0 literature and considers only manufacturing organizations
Hizam-Hanafiah et al. [40].	2000–2019	30 Industry 4.0 readiness models	Academia and consultancy-firm based	Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)	Performs dimension analysis and groups them under 6 main dimensions	Focuses only on SMEs and analyzes a limited number of maturity models
Soomro et al. [41].	2007–2019	22 digital readiness models	Academia based	–	Defines 4 critical success factors to achieve digital readiness	Academic and technology focused and analyzes a limited number of maturity models
Teichert [21].	2018–2018	24 digital maturity models	Academia and consultancy-firm based	–	Determines that most of the digital maturity models are manufacturing-oriented and that a wide variety of digital maturity model stages exist	Literature review of only academic publications from 2018
Williams et al. [42].	2011–2016	6 maturity models	Academia based	–	Proposes a digital maturity model for SMEs based on 6 dimensions	Focuses only on SMEs and analyzes a limited number of maturity models

After eliminating documents with models that do not qualify as digital maturity models, the remaining models are examined in detail by dividing them into two categories: models developed by academic papers and models proposed by consultancy firms. For each category, a subsection is devoted to the dimensions included in these models and targeted application areas.

4.2.1. Digital Maturity Models of Academic Papers

Table 4 presents the list of academic works on a digital maturity model, 49% of which are conference papers, 41% journal papers, and the remaining 10% book chapters; 80% of these book chapters were developed for specific sectors, and only 20% had an enterprise-wide perspective. All publications were analyzed with respect to four criteria. The first relates to whether a maturity model is proposed based on an analysis of the existing models; only 30% of the studies developed a new maturity model. The second criterion was that the developed model should be holistic; only 21% of the models were holistic. The third criterion asks whether the model is developed with a specific sector in mind; 65% of the models were sector-oriented. The last addresses the existence of a case study that supports the model; 40% of the models related to a case study. Only one study was found to have developed a new holistic model based on the analysis of existing models in the literature and presented an application of the model in the retail sector [43]. Thus, the

results of the analysis show a holistic model based on a comprehensive literature review has not been developed yet.

Table 4. Maturity models existing in academic papers.

Reference	Document Type	Dimensions	DA	HM	SM	CS
AL-Ali and Marks [44].	Article	1. Digital Transformation Vision, Strategy, Leadership, and Communication, 2. Digital Transformation Talent, Skills, and Knowledge, 3. Digital Transformation Processes, Controls, and Digital Technologies, 4. Digital Transformation Technology Infrastructure, 5. Approach to Understand and Communicate Customers			√	
Barry et al. [45].	Conference Paper	1. Structural, 2. Informational, 3. Environmental, 4. Security, 5. Quality, 6. Financial, 7. Cultural, 8. Innovation, 9. Participate	√			
Yang and Xu [46].	Conference Paper	1. Strategy and Organization, 2. Infrastructure construction, 3. Business Innovation and Transformation, 4. Supply Chain Ecological Construction, 5. Digital Performance			√	
Duncan et al. [47].	Article	1. Strategy, 2. IT Capability, 3. Interoperability, 4. Governance and Management, 5. Patient-Centered Care, 6. People, Skills, and Behavior, 7. Data Analytics			√	
Goumeh and Barforoush [48].	Conference Paper	1. Customer, 2. Ecosystem, 3. Law, 4. Strategy, 5. Operation, 6. Technology	√		√	
Alsufyani and Gill [49].	Conference Paper	1. Interaction Layer, 2. Technology Layer, 3. Human Layer, 4. Security Layer, 5. Environment Layer	√			
Cordes and Musies [50].	Conference Paper	1. Customer Experience, 2. Innovation, 3. Process Digitalization, 4. Information Technology, 5. Digital Skills, 6. Strategy, 7. Culture, 8. Governance, 9. Organization, 10. Collaboration	√			
Yezhebay et al. [51].	Conference Paper	1. People, 2. Leadership, 3. Strategy, 4. Technology, 5. Operation, 6. Product				
Almasbekkyzy et al. [52].	Conference Paper	1. Strategy, 2. Technology, 3. Operations, 4. Organization and Culture			√	√

Table 4. *Cont.*

Reference	Document Type	Dimensions	DA	HM	SM	CS
Salume et al. [53].	Article	1. Strategy, 2. Leadership, 3. Market, 4. Operations, 5. Culture, 6. People, 7. Governance, 8. Technology Capability			√	√
Borštnar and Pucihar [54].	Article	1. Digital Technology, 2. Management, 3. HR, 4. Strategy, 5. Digital Business Model, 6. Role of Informatics			√	√
Aslanova and Kulichkina [55].	Conference Paper	1. Strategy, 2. Organization, 3. People, 4. Technologies, 5. Data	√			
Weritz et al. [56].	Conference Paper	1. Capabilities Absorptive Capacity, 2. Agility and Flexibility, 3. Cross-functional Collaboration, 4. Innovation Capability, 5. Market Orientation, 6. Relational Capability			√	√
Colli et al. [57].	Article	1. Governance, 2. Technology, 3. Connectivity, 4. Value Creation, 5. Competences	√		√	√
Bandara et al. [58].	Conference Paper	1. Products and Services, 2. Technology and Resources, 3. Strategy and Organization, 4. Operations, 5. Customers, 6. Governance, 7. Employees	√		√	
Schumacher et al. [59].	Article	1. Technology, 2. Products, 3. Customers and Partners, 4. Value Creation Processes, 5. Data and Information, 6. Corporate Standards			√	√
Canetta et al. [60].	Conference Paper	1. Strategy, 2. Processes, 3. Technologies, 4. Product and Services, 5. People	√		√	
Rossmann [61].	Conference Paper	1. Strategy Capability, 2. Leadership Capability, 3. Market Capability, 4. Operational Capability, 5. People and Expertise Capability, 6. Cultural Capability, 7. Governance Capability, 8. Technology Capability	√	√		
Akdil et al. [43].	Book Chapter	1. Strategy and Organization, 2. Smart Products and Services, 3. Smart Business Processes	√	√		√
Gimbel et al. [62].	Article	1. Organization, 2. Product, 3. Value Chain, 4. Ecosystem, 5. Operations, 6. Customer, 7. Transformation Management, 8. Cloud and Data		√		
Horvat et al. [63].	Article	1. Organization of Product and Logistics, 2. Employees and Communication, 3. Management and Strategy, 4. Technology, 5. Interim Cooperation			√	

Table 4. *Cont.*

Reference	Document Type	Dimensions	DA	HM	SM	CS
Bibby and Dehe [64].	Article	1. Factory of the Future, 2. People and Culture, 3. Strategy			√	√
Botha [65].	Article	1. Technology, 2. Behavior, 3. Events			√	√
Hamidi et al. [66].	Conference Paper	1. Strategy and Organization, 2. Smart Factory, 3. Smart Operations, 4. Smart Product, 5. Data-driven Services, 6. Employees			√	√
Sjödin et al. [67].	Article	1. People, 2. Process, 3. Technology			√	
Mittal et al. [68].	Conference Paper	1. Finance, 2. People, 3. Strategy, 4. Process, 5. Product	√		√	
De Carolis et al. [69].	Conference Paper	1. Organization, 2. Processes, 3. Technologies, 4. Monitoring and Control			√	√
Gökalp et al. [70].	Book Chapter	1. Asset Management, 2. Data Governance, 3. Application Management, 4. Process Transformation, 5. Organizational Alignment	√	√		
De Carolis et al. [71].	Book Chapter	1. Organization, 2. Processes, 3. Technologies, 4. Monitoring and Control			√	
Von Leipzig et al. [72].	Article	1. Strategy, 2. Technologies, 3. People, 4. Governance, 5. Culture, 6. Product, 7. Operations, 8. Leadership		√		√
Klötzer and Pflaum [73].	Conference Paper	1. Competence(s), 2. Innovation Culture, 3. Cooperation, 4. Strategy Development, 5. Process Organization, 6. Complementary IT System, 7. Smart Product and Factory, 8. Offering to Customer, 9. Structural Organization			√	√
Leino and Anttila [74].	Conference Paper	1. Strategy, 2. Information Technology, 3. Business Model, 4. Customer Interface, 5. Organization and Processes, 6. People and Culture		√		
Valdez-de-Leon [75].	Article	1. Strategy, 2. Organization, 3. Technologies, 4. Ecosystem, 5. Operations, 6. Customers, 7. Innovation			√	
Schumacher et al. [20].	Article	1. Product, 2. Customers, 3. Operations, 4. Technologies, 5. Strategy, 6. Leadership, 7. Governance, 8. Culture, 9. People			√	√

Table 4. *Cont.*

Reference	Document Type	Dimensions	DA	HM	SM	CS
Berghaus and Back [28].	Conference Paper	1. Customer Experience, 2. Product Innovation, 3. Strategy, 4. Organization, 5. Process Digitization, 6. Collaboration, 7. Information Technology, 8. Culture Expertise, 9. Transformation Management		√		√
Rogers [76].	Book Chapter	1. Customer, 2. Cloud and Data, 3. Innovation, 4. Competition, 5. Value		√		
Ganzarain and Errasti [77].	Article	1. Processes, 2. Product, 3. Value Network, 4. Market			√	
Leyh et al. [78].	Conference Paper	1. Basic Digitization Level, 2. Cross-Departmental Digitization, 3. Horizontal and Vertical Digitization, 4. Full Digitization, 5. Optimized Full Digitization			√	

DA: Dimension Analysis, HM: Holistic Model, SM: Sector-Based Model, CS: Case Study and Assessment Results.

A total of 236 dimensions were identified in the 38 publications analyzed and was reduced to 123 by eliminating the common ones. Finally, 12 dimensions were obtained by grouping similar and frequently used ones: strategy, technology, operations, products and services, governance, people, customers, processes, innovation, culture, value and value chains, and leadership. It was found that both alignment with the strategies to maximize the value targeted by DT and the technology, as well as the processes, products, services, and operations where the technology is applied to realize the strategies, play a crucial role. Further, governance and leadership must support the impact of transformation on employees and culture.

4.2.2. Digital Maturity Models of Consultancy Firms

Table 5 displays the publications that developed digital maturity models proposed by consultancy firms. It can be observed that 90% of these publications present a sector-independent model. An analysis was conducted to determine the main dimensions considered. This results in strategy, culture, technology, operations, process, organization, and customer experience.

Table 5. Consultancy-firm-based maturity models and dimensions.

References	Consultancy Firms' Model Name	Dimensions
Bain & Company [79].	Digital Readiness Survey	1. Business Model, 2. Digital Strategy, 3. Enablers, 4. Orchestration
Deloitte [80].	Deloitte Digital Maturity Survey	1. Strategy, 2. Innovation, 3. Experience, 4. Digital Channels and Sales, 5. Digital Marketing, 6. Data and Insights, 7. Cyber Security
Earley Information Science [81].	Digital Transformation Roadmap	1. Technology, 2. Process, 3. People, 4. Content
Ernst & Young (EY) [82].	Global Business Service Maturity (GBS)	1. Strategy, 2. Operations, 3. Control and Measurement
Felch et al. [83].	Digital Capability Assessment (DCA)	1. Strategy and Leadership, 2. People and Culture, 3. Product and Service, 4. Customer Experience, 5. Enterprise Enablement

Table 5. *Cont.*

References	Consultancy Firms' Model Name	Dimensions
Gartner (internal source)	Digital Business Maturity Model	1. Digital Strategy and Execution, 2. Customer Experience Management, 3. Digital Product, Service and Digital Revenue, 4. Infonomics, 5. Digital Channels and Ecosystem, 6. Business Agility, 7. Innovation Culture, 8. Digital Leadership, 9. Digital Workplace
Gartner Digital Execution Scorecard [84].	Digital Execution Scorecard	1. Generate Digital Revenue, 2. Excel in Customer Experience, 3. Organizational Excellence, 4. Optimize Asset Utilization, 5. Minimize Risk
Geissbauer et al. [85].	Digital Transformation Framework	1. Digitalization Value Chain, 2. Digital Business Model and Customer Access, 3. Digitalization of Product and Service
Gill and Van Boskirk [86].	Digital Maturity Model 4.0	1. Technology, 2. Insight, 3. Organization, 4. Culture
IMPULS [87].	Industry 4.0 Readiness	1. Strategy and Organization, 2. Smart Factory, 3. Smart Operations, 4. Smart Products, 5. Data-Driven Services, 6. Employees
KPMG [88].	Digital Business Aptitude (DBA)	1. Strategy, 2. Governance, 3. Talent, 4. Process, 5. Infrastructure
Li et al. [89].	Altimeter's Digital Maturity Assessment	1. Customer Experience, 2. Leadership and Culture, 3. Marketing and Sales, 4. Technology and Innovation, 5. Data and Analytics
McKinsey (internal source)	Digital Quotient (DQ)	1. Strategy, 2. Culture, 3. Organization, 4. Capabilities
Runfrictionless [90].	BSC's The Digital Acceleration Index (DAI)	1. Business Strategy Driven by Digital, 2. Customer offer and Go-To-Market, 3. Operations, 4. Support Functions, 5. New Digital Growth, 6. Changing Ways of Working, 7. Leveraging the Power of Data and Technology, 8. Integrating Ecosystems
Runfrictionless [90].	Digital Transformation Framework	1. Digitize the Customer Experience, 2. Digitize the Products and Services, 3. Digitize Operations, 4. Digitize the Organization
Runfrictionless [90].	Industry 4.0 Digital Operations Self-Assessment	1. Business Models, Product and Service Portfolio, 2. Value Chain and Processes, 3. Market and Customer Access, 4. IT Architecture, 5. Organization and Culture, 6. Compliance, Legal, Risk, Security and Tax
Runfrictionless [90].	Digital Transformation Framework	1. Customer Experience, 2. Operational Processes, 3. Business Model, 4. Digital Capabilities
Schuh et al. [91].	Industry 4.0 Maturity Index	1. Information Systems, 2. Culture, 3. Process, 4. Organizational Structure
Tmforum [92].	Digital Maturity Model	1. Strategy, 2. Customer, 3. Operations, 4. Technology, 5. Organization and Culture
Tmforum [93].	Open Digital Framework (ODF) DMM Readiness Check Assessment	1. Information Systems, 2. Deployment and Runtime, 3. Implementation, 4. Governance
Tmforum [94]	Digital Maturity Model	1. Strategy, 2. Customer, 3. Operations, 4. Technology, 5. Data, 6. Culture
World Economic Forum [95].	Digital Competency Framework	1. Company Transformation, 2. Market Transformation, 3. Digital Workforce Transformation

5. Discussion and a New Holistic Digital Maturity Model

Given that digital maturity models play a paramount role in DT, act as a catalyst in the DT journey, and there does not exist a holistic model in the literature, the goal of this study is set as developing a comprehensive new digital maturity model that addresses all of the critical factors and capabilities required by the entire DT regardless of sector or size of an organization. After the model development, the next goal is determined as devising an approach for implementing the new model.

The analysis of the existing models developed by both academia and consultancy companies reveals the scope of the existing digital maturity models. Furthermore, this analysis sheds light on the common dimensions that are utilized in the models and also helps to identify some specific dimensions that may provide new perspectives. Thus, the output of this analysis provides an answer to the research question Q_2. An important conclusion one can draw from the analysis is that a systematic methodology is not adopted in the process of model development, and there is a need for a holistic digital maturity model.

5.1. Digital Transformation Journey

The term "digital transformation journey" has been around for a while, but it is difficult to pinpoint the specific person or organization that first mentioned it; however, one of the earliest mentions of DT in a business context can be traced back to a report published by MIT Center for Digital Business in 2011 titled "Digital Transformation: A Roadmap for Billion-Dollar Organizations". The report discusses how digital technologies are disrupting traditional business models and emphasizes the need for companies to embrace DT to stay competitive. Since then, the term "DT journey" has become more widely used since companies of all sizes and different sectors recognize the importance of DT. In this paper, the DT journey is defined as the endeavor to acquire digital capabilities and turning them into an asset. This journey requires identifying current areas of improvement, creating a roadmap according to the goals, and ensuring that plans and projects help to reach strategies and goals.

The literature review indicates that no holistic maturity model can be implemented within a DT journey. The existing models had been modified and extended with new dimensions and sub-dimensions to incrementally increase their coverage and usability. This study argues that, to maximize the value that a digital maturity model can provide to the DT journey, the latter must be defined as comprising four stages: awareness, readiness, planning, and execution (see Figure 15).

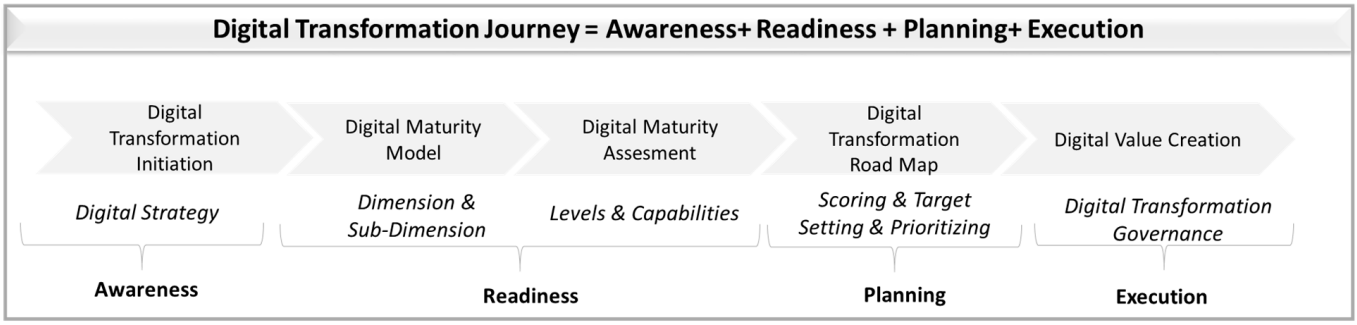


Figure 15. Digital transformation journey.

- Awareness: This pertains to an organization's decision to initiate DT within the framework of a strategy or strategic initiative to achieve its goals.
- Readiness: The first of this two-step process is the development of a reference model that can reveal the extent and scope of DT, the gaps the organization needs to close, and the improvement areas that require new approaches to implement the intention

set forth in the awareness stage. The second step is to perform an assessment based on this model.

- Planning: This provides an input for the creation of a digital roadmap by scoring the assessment results in parallel with the goals and priorities set by the organization.
- Execution: This deals with the systematic implementation and maintenance of the continuity and sustainability of the roadmap.

This concretization of the DT journey and the place and importance of the maturity model in this journey carries the proposition based on the literature study and analysis made for the first research question (Q_1).

5.2. The New Holistic Digital Maturity Model

The results and limitations of the systematic literature review studies published to date (Table 4) show that there is a lack of a systematic approach in the creation of the dimensions and sub-dimensions of proposed models. These dimensions and sub-dimensions are rather developed based on existing model comparisons. There is also a need for a new holistic model. In line with these needs, first of all, the design approach for developing dimensions and sub-dimensions of the holistic model was revealed. Then, the main dimensions of the model were determined based on six questions given below that are inspired by the WH questions.

The proposed holistic digital maturity model, illustrated in Figure 16, is expected to play a catalyst role in the defined DT journey by answering the following six questions:

- What is DT aimed at?
- What value does it offer?
- In which processes should the organization apply digital projects?
- Which technologies support the DT?
- Who implements the DT?
- How is DT sustained?

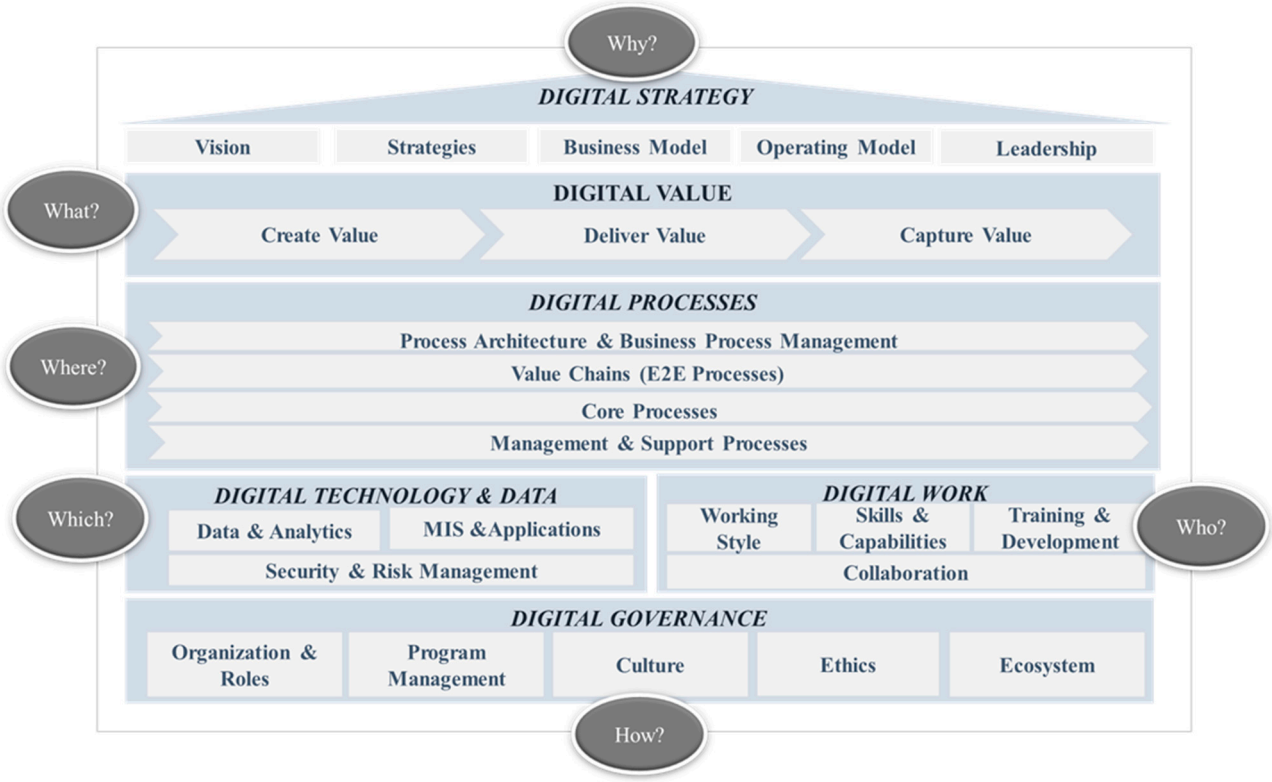


Figure 16. The new holistic digital maturity model.

The design based on these questions and the dimensions as well as sub-dimensions defined in this context also provide the concrete proposition to the third research question (Q_3).

The model enables the organization, based on its assessment, to identify the gaps between the current situation and goals. It has 6 dimensions and 24 sub-dimensions, which not only includes all the dimensions and sub-dimensions of the existing models but also all the issues that need to be addressed in a DT journey.

As the first dimension of the model, digital strategy focuses on assessing the extent to which corporate-level vision, strategic direction, and goals for DT can create value. Five sub-dimensions were defined to serve this purpose. The "vision" sub-dimension examines the DT vision and what is understood by DT. The "strategies" sub-dimension deals with the DT strategy and how the competitive advantage that can be achieved by DT is defined. The "business model" sub-dimension is related to the new value proposition presented with digitalization and the extent to which a new extension is desired in the existing product and service portfolio. The "operation model" sub-dimension investigates to what extent digitalization affects the current operation model and the organization. The "leadership" sub-dimension examines the level at which digitalization studies are embraced and internalized by the leaders. In this model, the strategy sub-dimension stands out as a standalone component, and in a limited number of models, the business model and leadership are defined as separate dimensions.

Digital value, which is the second dimension, focuses on the assessment of both the impact of DT on the value and product portfolio offered to the customer and the scope and dimensions of differentiation in customer value processes. Three sub-dimensions were defined within this dimension. The "create value" sub-dimension questions the role of digitalization in offering new value to the customer and the difference it creates in the value proposition. The "deliver value" sub-dimension investigates the impact of digitalization on the capability of offering new and innovative products/services. In the "capture value" sub-dimension, the focus is on evaluating the new and innovative products offered to customers through digitalization, new customers, existing-customer market share, and competitive advantage. Although the holistic view of this dimension is not perceived under the umbrella of digital value dimensions in the reviewed models, new products are handled in different dimensions in the context of new product launch, innovation, and offering new value to customers.

Digital processes are the third dimension, focused on the assessment of the extent to which DT has been implemented for the processes. Four sub-dimensions were defined here. The "process architecture & business process management" sub-dimension examines how the processes and process architecture of the organization are affected by strategies, and how the digitalized processes are managed. The "value chain" sub-dimension deals with the effect of digitalization on the value chain and the interaction among processes. The "core processes" sub-dimension investigates basic processes, such as operations, supply chain, and sales, in which digitalization will be carried out and to what extent it will create impact and changes in these processes. The "management & support processes" sub-dimension concentrates on the effects and changes that digitalization will create in management and support processes. In the reviewed models, this completeness is not observed under the umbrella of digital processes; instead, the focus is mainly on operational processes. In the proposed model, the evaluation of the effect of digitalization in all processes of the organization is valuable in terms of both enabling the application of a sector-independent model and uncovering the additional benefits of digitalization.

The fourth dimension, "digital technology and data," focuses on the evaluation of technologies and solutions that put DT into practice in a sustainable way. Three sub-dimensions exist here, the first one being "data & analytics," which examines how digitalization affects data-based decision-making and transforms it into value. The "management information systems (MIS) and applications" sub-dimension is related to how technological solutions are selected and managed in the digitalization process. The "security and risk management" sub-dimension examines how security and risk factors that emerge in parallel with digital-

ization are taken into account and managed. In fact, the reviewed models mostly focus on information technology, rather, MIS, and enterprise resource planning (ERP) applications, whereas security and data are considered in separate sub-dimensions in only a limited number of models.

Digital work, as the fifth dimension, addresses the assessment of the effects of DT on an organization's work pattern as well as the scope and dimensions of new skills that employees must acquire. The first of the four sub-dimensions is the "working style." It studies the change in the working style that needs to emerge in parallel with digitalization and the management of this change. Working styles stand out with both the difference in the way of doing business and the diversity of participation. The focus is on employees who digitalize their jobs in parallel with the DT, benefit more from digital solutions, and conduct their work through digital platforms. The "skills and capabilities" sub-dimension examines the new knowledge and skills that employees should possess in parallel with digitalization, and the new capabilities the organization needs. The "training and development" sub-dimension focuses on how the development of the employees should be supported. The "collaboration" sub-dimension examines how digitalization affects the cooperation of the employees with technology. In the reviewed models, the digital work dimension does not cover all these sub-dimensions, and focuses mainly on the knowledge, skills, and development of employees under "people." Considering the effects of the working environment and collaboration sub-dimensions on employees, in addition to employee focus, this may contribute to the literature within the scope of maturity models.

Digital governance, the sixth and last dimension, focuses on the assessment of how managerial and cultural issues are handled to ensure the successful implementation and sustainability of DT. Five sub-dimensions served this goal. The scope of the "organization and roles" sub-dimension is related to the identification of the changing organizational structure and roles as a result of digitalization and management. The "program management" sub-dimension addresses how digitalization is managed within the scope of a program and how the attainment of the results is ensured in alignment with the strategic objectives. The "culture" sub-dimension studies the effects of the changes to be experienced in the digitalization process on the existing culture and how the process is managed. The "ethics" sub-dimension examines how ethical issues that arise within the scope of digitalization are defined and managed. In the "ecosystem" sub-dimension, the focus is on how the external interaction provided by digitalization is managed in a different way and how to ensure that this interaction is transformed into value. Digital governance is included in existing maturity models with the exception of ethical issues; therefore, its inclusion in the proposed model is believed to be a contribution, because it is considered a critical component in the success of the DT process.

5.3. Comparison of the New Holistic Digital Maturity Model with Existing Models

To clearly indicate the similarities and dissimilarities of the proposed model, the dimensions of the models examined in the literature review are compared to those of the proposed model, as shown in Table 6. The comparison is based on the extent and frequency of each sub-dimension of the proposed model being met in the existing models. The focus of the existing academic models appears to be on the digitization of key processes. Other important focuses are customer value creation, digitalization strategy, digitalization program management, and culture. The proposed model's sub-dimensions that have not been addressed in existing models are vision, operation model, processes other than operational processes, security, ethics, training and development issues that support employee adaptation, and managing changes in the working environment.

Table 6. Comparison with existing academic and consultancy-firm models.

Dimensions	Sub-Dimensions	Number of Times Existing in Other Models (Academic)	Number of Times Existing in Other Models (Consultancy)
1. Digital Strategy	1.1. Vision	0	0
	1.2. Leadership	3	3
	1.3. Strategies	6	11
	1.4. Business Model	2	3
	1.5. Operating Model	0	0
2. Digital Value	2.1. Create Value (Innovation)	7	10
	2.2. Deliver Value	3	9
	2.3. Capture Value	3	11
3. Digital Processes	3.1. Process Architecture and Business Process Management	0	0
	3.2. Value Chains (E2E Processes)	0	2
	3.3. Core Processes	16	13
	3.4. Management and Support Processes	0	4
4. Digital Technology and Data	4.1. Data Analytics	2	6
	4.2. MIS and Applications	4	12
	4.3. Security and Risk Management	0	3
5. Digital Work	5.1. Working Style	0	2
	5.2. Skills and Capabilities	3	4
	5.3. Training and Development	0	1
	5.4. Collaboration	3	
6. Digital Governance	6.1. Organization and Roles	4	2
	6.2. Ecosystem	2	2
	6.3. Program Management	6	4
	6.4. Culture	6	10
	6.5. Ethics	0	0

In the maturity models developed by consultancy firms, the focus is on creating value, implementing digitalization in basic processes, innovating by means of digitalization, and supporting it with cultural change. The sub-dimensions that are not considered in comparison with the proposed model are the vision and operation model, which are important parts of digital strategy management and enterprise process management, ensuring the management of digitalized processes and support of digital work, including digitalization and employee-technology collaboration. Another advantage of the new model is its structure, where the answers to the questions framed based on the sub-dimensions are related to targeted capabilities, as shown in Tables A1–A5 in Appendix A. This allows the model to be used both independently of sectors and the creation of a development plan depending on the gap between the current and targeted situations.

To use this model for the assessment of an organization, five maturity levels were defined in each dimension. These levels are called intention, beginner, adopter, performer, and transformer. Several questions were prepared for each sub-dimension; the answers to these questions measure the digital maturity (or readiness) level in each dimension. The intention level is the most immature and implies ad hoc studies. This means that there

is no systematic approach or planned roadmap. At the beginner level, commitment and improvement studies have been initiated or planned, but no output or value has been created. The adopter level indicates that fundamental structures and studies have been completed and are ready to create value. In addition, there were some valuable outputs. The performer level corresponds to the status where value is created, and digital projects are common and mature. The transformer level implies that revenue is obtained as a result of digital projects or new business, or new products are created, and the organization has adopted DT.

The maturity levels can also be associated with the widely accepted stages of Industry 4.0, which are digitization, digitalization, and DT, as shown in Figure 17. The digitization stage refers to the action or process of digitizing, that is, the conversion of analog data to digital data. Digitalization is a more fundamental change compared to digitizing existing processes or work products, whereas DT, the most advanced stage, implies a significant change in the business model caused by digital technologies [7,13].

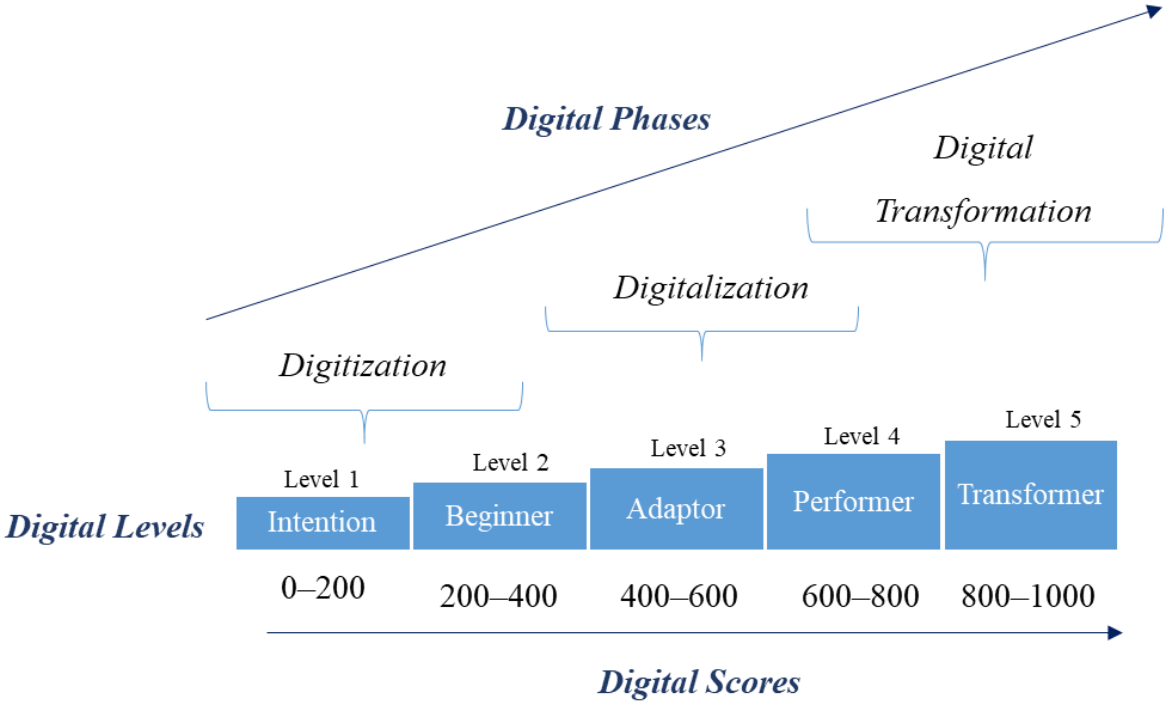


Figure 17. The relationship of digital maturity levels to digital stages and scores.

The intention level, where digital examples are not observed in the processes at the beginning of the digitalization process, can be associated with the digitization stage. At the beginner level, pilot studies are conducted, in which digital solutions are introduced into business processes. The adaptation level is where efficiency and effectiveness are achieved in the organization's business processes by means of digital solutions. At the performer level, efficiency and effectiveness are ensured through digital solutions implemented in all business processes to ensure operational excellence. At the transformer level, a new product with digital characteristics is offered to the market to attract existing and new customers, leading to a competitive advantage. While the maturity levels defined in the proposed model are parallel to those used in the literature, the main difference is that the reference competencies created under each level are associated with digital stages. This feature allows for a qualitative analysis based on digital stages. The maturity assessment also generates a score with a maximum of 1000. Score intervals are defined based on expert opinions, helping to identify the digital stage that best describes the organization.

6. Conclusions

Organizations strive to implement DT successfully to achieve sustainable success in their operations. This requires the assessment of the organization's current digital maturity level based on several dimensions. The best approach for this assessment and building a roadmap to implement DT is to use a digital maturity model. This study focuses on establishing the place and importance of digital maturity models and revealing their catalyst role in DT. The contributions of this paper can be divided into three categories: theoretical, practical and socio-technical contributions.

Theoretical contributions are made in the contexts of DT and digital maturity. First, the paper provides a more comprehensive and effective approach in assessing digital maturity, which is a key aspect of the DT journey. This is achieved through a rigorous and widely recognized methodology known as the PRISMA approach, which was used in a comprehensive and up-to-date systematic literature review. This review, conducted for the first time in the literature, was complemented by a bibliometric analysis through the Biblioshiny tool, which allowed for a clear and easy observation of the trends of the topics considered in a vast amount of articles related to DT and digital maturity. Second, the study highlights the importance of maturity models in the DT process, which includes awareness, readiness, models and model-based evaluations, planning, and execution steps. The development of a digital maturity model and evaluations based on this model can act as a catalyst and establish the milestones of the DT journey. Overall, these theoretical contributions enhance our understanding of DT and digital maturity and provide valuable insights for researchers and practitioners in the field.

The practical contributions of the study provide useful implications for organizations seeking to successfully implement DT. To this end, a "Holistic Digital Maturity Model" is proposed to extend existing maturity models in the literature by incorporating novel sub-dimensions such as vision, operation model, ethics, and process architecture. These sub-dimensions refer to various capabilities and critical success factors in the DT process, and the proposed model's unique structure enables a clear and specific assessment of an organization's digital maturity level. Furthermore, the model's capability of identifying an organization's current status with respect to the digitalization stages can effectively guide organizations towards a desired status. By focusing on targeted capabilities, organizations can prioritize their efforts and resources for implementing DT and ensure a more effective and efficient transition towards digitalization. The model provides a roadmap for planning and executing DT activities for corporations in the business sector, public organizations, and NGOs. The model's structure can also help organizations evaluate their progress and measure the effectiveness of their DT initiatives over time.

The study also makes a socio-technical contribution by recognizing that ethics, technology, and the human perspective are all relevant considerations in DT. The model includes sub-dimensions related to these aspects. Ethics is recognized as a sub-dimension, enabling organizations to identify potential ethical issues that may arise during the DT process. Technology is acknowledged as a critical component in the journey towards digital maturity, and the model includes sub-dimensions related to technology infrastructure and usage. The human perspective is also recognized as important, and the model includes sub-dimensions related to culture, capabilities, and training and development, among others. By considering these aspects, organizations can ensure a more balanced and sustainable DT that takes into account not only technological advancements but also ethical considerations and human aspects. By encouraging improved collaboration through the use of digital tools, enabling remote work and flexibility, requiring upskilling and reskilling to remain competitive, and creating individualized employee experiences, DT has had a significant impact on employees. Additionally, it has prompted the adoption of agile work procedures, enabling organizations to react to changes more quickly. Overall, as both employees and organizations adjust to the constantly changing business landscape, these changes are reshaping the workplace and defining the future of work [96]. The digital work dimension

within the proposed holistic model allows for the examination and management of all these elements within the scope of the DT journey.

There are some limitations to this study. First, it was not possible to include maturity models that have been developed specifically for individual companies. Second, while the proposed maturity model is generic, it may be necessary to determine the importance of dimensions and sub-dimensions based on the size and sector of the company. Therefore, it may be appropriate to use multicriteria decision-making techniques to assign suitable weights to each dimension and sub-dimension rather than assigning equal weight to all sub-dimensions as is currently the case. Despite these limitations, the maturity model can be applied to companies of different sizes and sectors to assess their maturity level across each dimension and sub-dimension, providing an opportunity to develop targeted solutions to accelerate DT.

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Appendix A. Digital Maturity Assessment Questionary for Strategy Dimension

Table A1. Sub-dimension-based questions and capabilities for the Digital Strategy—Vision (1a).

			Maturity Levels and Capabilities			
Sub-Dimension	**Questions**	**Intention**	**Beginner**	**Adaptor**	**Performer**	**Transformer**
Vision (1a)	At what stage are you in the digitalization process?	Understanding and embodying the benefits to be gained from digitalization	Identifying visions and directions for digitalization	Getting started with realizing the vision for digitization	Providing gains that affect business results with digitalization	Entering new business areas with digitalization, producing digital products
	What is your vision for DT, and how big is it?	No defined vision, no concrete strategy or objectives defined	Limited to automation studies	Creating competitive advantage with digitalization in some functions/processes (functional strategy)	Creating a competitive advantage with digitalization that spans the entire organization or its intended scope (business strategy)	Creating disruptive competitive advantage by directing new product and service strategies (DT strategy) to achieve a share of the digital economy
	At what level and to what extent is digitization addressed?	Triggered by employees	Some functions, business units have set targets related to digitalization	Some functions are being implemented on the basis of business units	Supporting the targets with digitalization studies	Strategies are implemented through digitalization studies

Table A2. Sub-dimension-based questions and capabilities for the Digital Strategy—Leadership (1b).

		Maturity Levels and Capabilities				
Sub-Dimension	**Questions**	**Intention**	**Beginner**	**Adaptor**	**Performer**	**Transformer**
Leadership (1b)	How important and prioritized is digitalization for senior management, and what level of determination is demonstrated?	Top management does not have any determination, it is not among their priorities	Interested in trends and competitive conditions, brought up by some functional leaders	Seems strategically important and supported in targeted functions/ business units	All of the digitalization process and studies are supported, and senior management takes a role as a sponsor in all critical projects	Considered as part of corporate change and transformation, owned and led by the entire senior management team
	What is the size of the resource/budget allocated to the DT process?	No budget and resource allocation provided	Creating budget projections for necessary improvements and infrastructure	Ensuring minimum budget allocation for necessary improvements and infrastructure	Budget planning and realization that supports corporate-level plans and targets	Long-term budget planning and allocation, covering all resource and investment requirements for transformation

Table A3. Sub-dimension-based questions and capabilities for the Digital Strategy—Strategies (1c).

		Maturity Levels and Capabilities				
Sub-Dimension	**Questions**	**Intention**	**Beginner**	**Adaptor**	**Performer**	**Transformer**
Strategies (1c)	What dimensions of strategic competitive advantage are targeted in the DT process?	Not in a defined state	Reducing costs	Reducing costs, reducing risks, optimization, process excellence	Reducing costs, reducing risks, optimization, operational excellence	Earn additional income from new products, business excellence
	Have strategic performance indicators and targets for digitalization been determined?	No	KPIs for the process have been determined	KPIs to evaluate the impact on operational performance have been determined	KPIs to evaluate the impact on strategic performance have been determined	KPIs to evaluate performance against the competition have been determined

Table A4. Sub-dimension-based questions and capabilities for the Digital Strategy—Business Model (1d).

Sub-Dimension	**Questions**	**Intention**	**Beginner**	**Adaptor**	**Performer**	**Transformer**
Business Model (1d)	What is the new value proposition offered?	Not in a defined state	No additional value proposition	Activation of existing products and service delivery processes	Support the develop-ment/improvement of existing products and services	Allowing us to introduce brand new products and services
	Do digital strategies require defining a new business model?	No	Improvement in the existing business model	Defining a new business model	Operating the new business model	Creating value with the new business model

Table A5. Sub-dimension-based questions and capabilities for the Digital Strategy—Operating Model (1e).

Sub-Dimension	Questions	Intention	Beginner	Adaptor	Performer	Transformer
Operating Model (1e)	To what extent is the current operating model capable of supporting digital strategies?	Not at all	On a functional basis, independent of other functions and business units	Process-based functions require interregional standardization and integrations	Requires standardization and integrations on the basis of business units	To what extent is the current operating model capable of supporting digital strategies?
	How does the current operating model require us to address digital targets?	Nothing	Limited	Functional based	Process based	Enterprise wide

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