

Article

Digital Maturity Assessment Model for the Organizational and Process Dimensions

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Abstract: (1) Background: Ongoing research indicates that it is reasonable to separate a company's digital maturity assessment by relating it to organization and process levels. The lack of such models in the literature should be considered a research gap. This article aims to present a model framework for assessing enterprise digital maturity that considers two dimensions—organizational and process. The organizational dimension reflects the overall level of digital transformation and refers to the implemented concepts, solutions, and management tools covering the entire enterprise structure. The process dimension focuses on the level of operational divisions. (2) Methods: Analyses were conducted according to the developed research procedure, which included five steps. The research used the following methods: a critical literature analysis, an analysis of the obtained results and their synthesis for the formulated model, and verification and validation of the developed assessment tool and procedure in a selected enterprise based on interviews with managers and direct observations. (3) Results: Based on the literature review, eleven digital maturity areas of the model were defined, and five levels of assessment were formulated for each area. A diagnostic tool for enterprise self-assessment consisting of 105 questions was also developed. (4) Conclusions: The developed model was positively reviewed by the managers of the assessment team that audited the selected enterprise based on it.

Keywords: DMM; DTMM; digital transformation; Industry 4.0; digital organization; digital processes; maturity levels



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1. Introduction

For many years, intensive development of digitization and technologies that support digital transformation has been observed in various areas of life and industry. In its initial development phase, digitization was identified with the creation of electronic versions of documents or sounds [1]. However, this trend is currently perceived from a broader perspective, and it is defined as the manifold socio-technical phenomena and processes of adopting and using digital technologies in a more overall individual, organizational, and societal context [2]. Therefore, a critical aspect of digital transformation should be the development of awareness in organizations that the digitization process is not limited only to the support of processes by various types of information and communication technologies, but concerns fundamental changes that take place in organizational strategy, business processes, organizational knowledge, and the whole socio-technical organizational system [3,4]. As Hein-Pendel et al. note [5], digital transformation affects the entire company and its employees through reorganizing processes, business models, and organizational structures and making changes to corporate culture. Digital technology transforms the internal and external elements of the organization and their mutual relations, and these changes improve the company's efficiency [6]. For this reason, many researchers emphasize in their publications that it is necessary to introduce a multidisciplinary digital transformation to ensure an enterprise's competitiveness (e.g., in [5,7]). Many organizations set a goal to

take advantage of the opportunities offered by the ongoing digital transformation [8]. The literature research conducted over the last five years indicates [9] that there is significant potential for current digital processes to support organizations' sustainable development. In many publications, the authors point to the positive impact of digital transformations on the integration of sustainable supply chains ([10,11], among others). By building a digital platform and integrating data analytics into supply chain management, digital knowledge from various sources is made available, which maximizes value for partners [12]. On the other hand, however, business organizations are under pressure from stakeholders to address various digital challenges and improve business operations through digital knowledge, data, and technological innovations to preserve the integrity of the ecosystem through a digital knowledge management system [13].

The ongoing digital transformation is generating demand for the creation of tools to assess the level of advancement in an organization, referred to as digital maturity. Digital maturity is a state of digital transformation that illustrates an organization's changes in digital technologies and the associated new opportunities to improve its processes [7]. A growing number of digital maturity models developed by researchers, consultants, and government departments from across the globe are appearing in numerous publications [14]. The digital maturity assessment models described in the literature usually apply to organizations [15–17] or the supply chain [13,18–21]. Their purpose is to assess the general level of digitization concerning the analyzed organization or set of enterprises constituting participants in the supply chain. This is justified in the case of market leaders and global organizations at a high level of organizational development. However, in many companies from the SME sector and in organizations still in the intensive growth/development phase, the global approach to assessing organizations is inadequate for their information needs. These enterprises often introduce innovations in a stepwise manner, which may cause temporary disproportions between individual areas of operational activity. When assessing maturity, the adopted organizational level may lead to an incorrect assessment and the inability to carry out a benchmarking analysis at the required level of detail. For this reason, one can find maturity assessment models dedicated to only one activity area in the literature. Examples of such research are [22–24]. However, in this case, the evaluators' attention is focused only on the analysis of the local potential of a given area, and, as was emphasized above, digital transformation must be of a strategic nature and refer to existing business models, the organizational culture, and the whole socio-technical organizational system. For this reason, maturity assessment models dedicated to a selected area of operational activity show us only a fragment of the assessed reality.

Most of the digital maturity models (DMMs) described in the literature refer to manufacturing enterprises, and as noted by [25], production is the primary and dominant area of business in which digital transformation is implemented. For this reason, situations where digital transformations primarily cover the production area often occur in manufacturing enterprises. At the same time, other processes (including logistics services) are still carried out traditionally, or their digital transformation process is carried out with a significant delay compared to production processes. Numerous discussions with managers carried out by the author as part of open and dedicated training courses indicate that the existing disproportions between individual operational areas are a severe barrier to conducting a reliable maturity assessment and drawing conclusions to further accompany digital transformation. This is of particular importance in the case of digital maturity assessments carried out as part of various types of benchmarking analyses, where, as a result of the comparison, the company's position relative to the competition is to be indicated and improvement solutions are to be developed. Therefore, the audit proceedings' results may vary significantly depending on the purpose of the conducted analysis and the assessment team members. In the case of the maturity assessments for the purposes of competition and following the example of the production area, the results may be very optimistic. In contrast, the results may be more pessimistic in the case of internal audits and referring to other operational areas. When introducing digital transformation to an organization,

it is also worth noting that different needs for digitization and susceptibility to such a transformation characterize individual business areas. Processes that are entirely carried out within the organization, such as production, are characterized by a greater vulnerability to changes, including digital transformation. This is because the company's management wholly controls and supervises them. On the other hand, the processes carried out at the interface of the organization and its business partners, such as logistics, depending on the relationships between enterprises and one organization's management, do not fully influence their implementation. For this reason, the success of the implemented changes, including digital transformation, depends on the involvement of all entities participating in this process and the mutual relations between them. This observation justifies separating digital maturity assessments and referring them to the level of the organization and selected processes (areas of operational activity). This approach is highly recommended by managers participating in training discussions. This will allow one to assess the level of digital transformation in the organization concerning the strategy of action and its implementation in individual operational processes.

This article aims to present a framework of a model for evaluating the digital maturity of enterprises, which considers two dimensions—organizational and process dimensions. The organizational dimension reflects the general level of digital transformation and refers to the implemented concepts, solutions, and management tools covering the entire enterprise structure. The process dimension is focused on the level of individual areas (divisions) of operating activities and relates primarily to processes associated with the flow of products (production and logistics). Such a limitation of the process dimension results from the fact that both operational divisions are the most challenging area of digital transformation, as they are associated with physical service processes, not just with the flow of information. Therefore, the proposed digital maturity assessment model will indicate whether a digital transformation should be carried out locally in the enterprise (only in selected areas/processes) or should be comprehensive and cover the entire organization. The main contributions of the presented results should be considered:

- Identification of assessed areas of digital maturity in models described in the literature in the last decade.
- Development of a framework for a digital maturity assessment model, considering two levels of analysis.
- Proposing a five-step scale for evaluating the level of digital maturity for defined areas of digital maturity assessments.
- Formulating the stages of the procedure for using the maturity assessment model to improve the digital transformation in organizations.
- Developing a diagnostic tool to audit the current state.
- Implementation of the proposed solution in the selected company.

The structure of the article is shown in Figure 1.

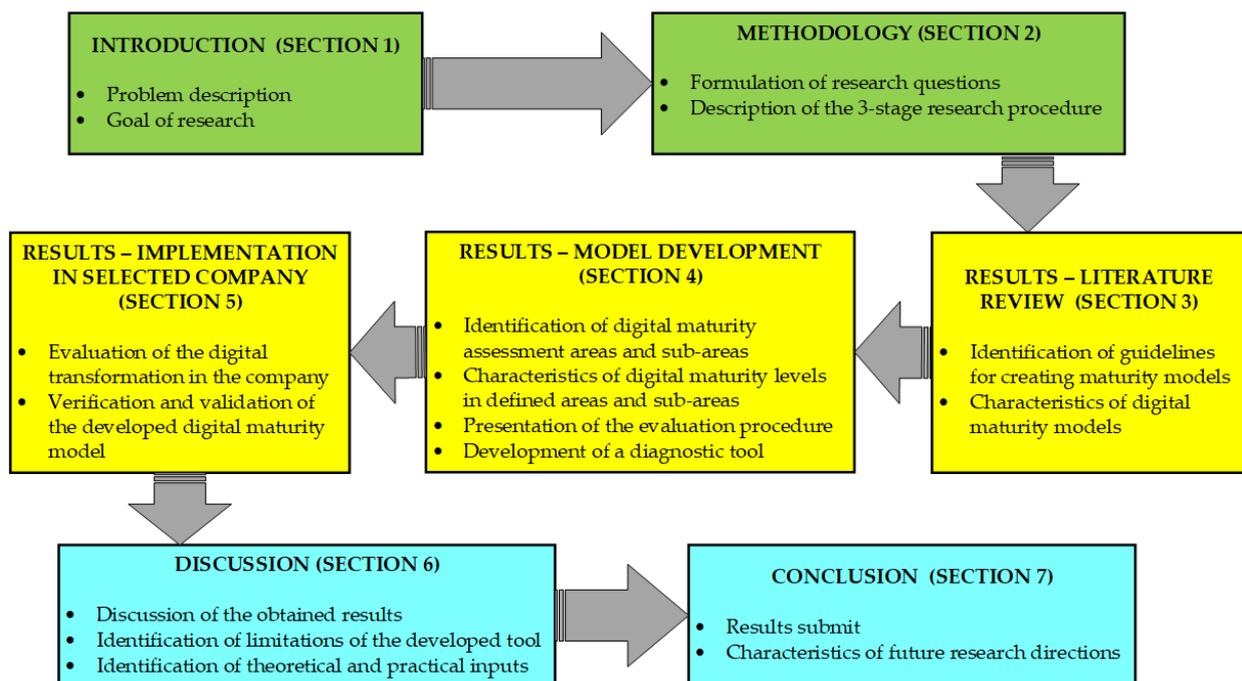


Figure 1. Structure of the article.

2. Methodology

For the purposes of the conducted research, five research questions were formulated. The answers obtained will be the input material for the defined framework of the assessment model and the formulated levels of digital maturity. To identify the current research gap, it is necessary to analyze existing models for assessing digital maturity and identify the areas covered. For this purpose, it is required to prepare a targeted literature review to answer question QR1. Given the stated aim of the two-area maturity assessment, it is necessary to identify the scope of the impact of digital transformation in enterprises. The research indicates that certain aspects of digital transformation must be implemented at the organizational level for implementation to be effective and efficient. However, a specific set of digital solutions must be implemented at the process level to achieve the desired results. The research results focused on seeking answers to QR2 and QR3 will help formulate these scopes in both areas evaluated. The answers obtained regarding the research questions formulated in this way will also allow defining the framework for the evaluation model to be created. However, the goal of the ongoing research is not only to create a model solution but also to develop tools that will allow practical use of the developed solution. Accordingly, part of the ongoing research is developing an assessment procedure and a self-assessment tool that companies in the audit process can use. It is necessary to answer questions QR4 and QR5 to achieve this goal.

- QR1: What ranges of an organization's digital maturity are analyzed in the models for evaluating the level of digital transformation described in the literature in the last decade?
- QR2: Which areas of digital transformation concern the level of the organization, and which can be implemented and should be assessed at the level of the process/spheres of activity?
- QR3: How can one assess the levels of digital transformation in the organizational dimension and process dimensions?
- QR4: How can one conduct a maturity assessment process for active digital transformation in an organization?
- QR5: Can the company independently carry out an assessment based on the developed digital maturity model?

Obtaining answers to the questions formulated in this way required the development of a research procedure that would allow obtaining the required results. This procedure, with the planned results, is presented in Figure 2.

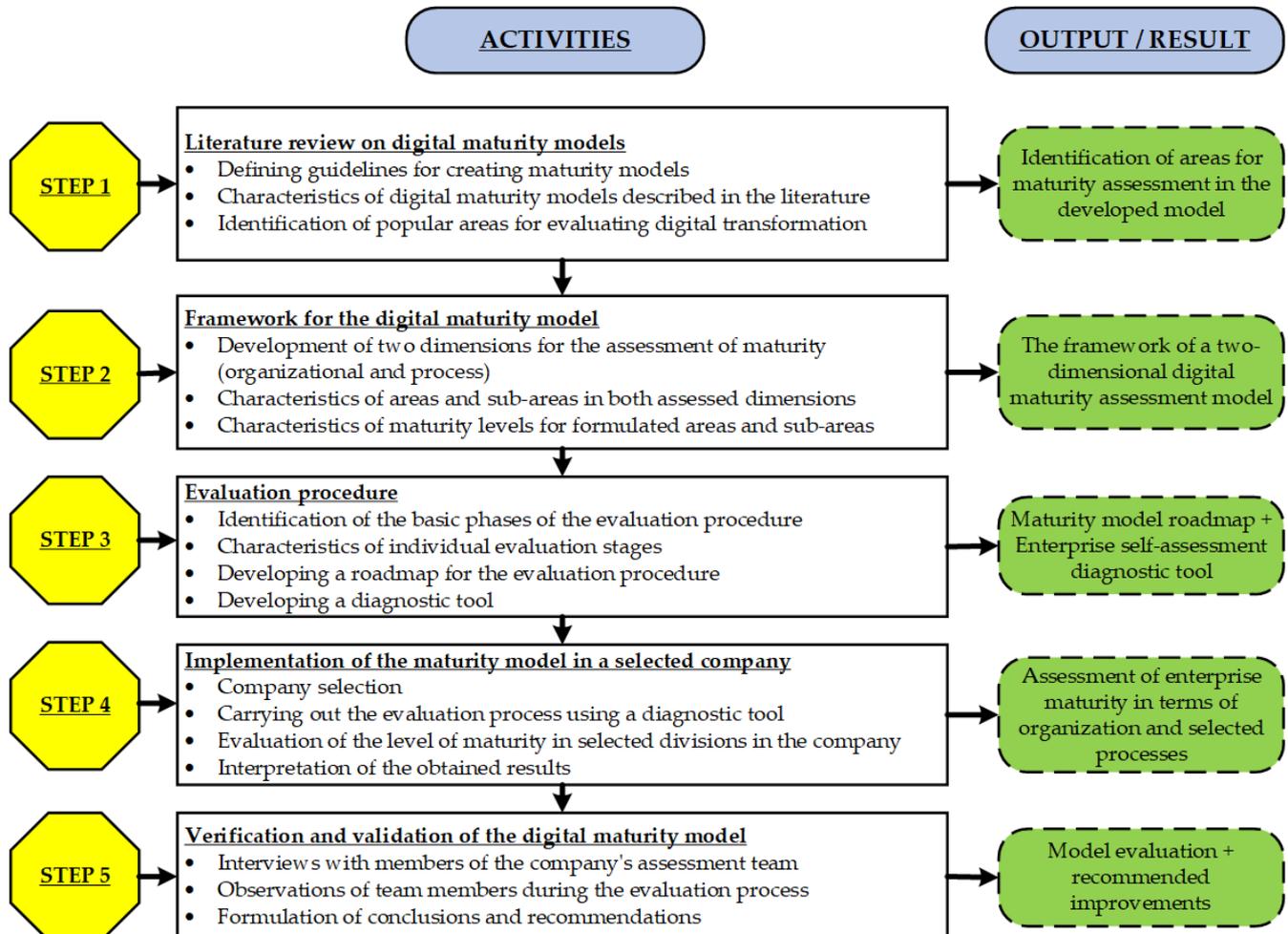


Figure 2. Research procedure.

The literature review on research models was conducted based on the Scopus database. In the process of identifying publications thematically consistent with the research area, the following search was formulated.

TITLE-ABS-KEY:

"digital transformation assessment" OR "Industry 4.0 maturity assessment" OR "digital maturity assessment" OR "digital maturity model"

The extension of the set of keywords used in the search process with the wording "Industry 4.0" resulted from the fact that, according to Carrijo et al. [26], the nomenclature for digital maturity models is not unanimous in academia and, therefore, Industry 4.0 maturity is also considered DMM.

As a result of the search, 123 documents meeting the formulated requirements were obtained. This collection is limited to publications in English and available in the "Open Access" system. In this way, 52 articles were accepted for analysis. At the stage of substantive research, articles that did not directly describe digital maturity assessment models or that related to maturity assessment models dedicated to sectors not associated with the industry were eliminated. At the same time, however, the set of analyzed models was supplemented with characteristics presented in review articles, which, in their results, described the effects of publications that were not included in the group of 52 papers accepted for analysis.

Based on the conducted research, the main areas of digital transformation assessment in enterprises were identified, and guidelines for building maturity models were defined.

The identified areas for evaluating the digital transformation were subjected to a critical analysis to determine the scope of possible evaluation and the level of impact. The crucial point of this investigation was to answer the question of whether a given area of digital transformation must be implemented at the level of the entire organization or whether it can exist locally concerning a selected group of processes implemented in a chosen sphere of the company's operational activity (without connection to the general business model). On this basis, the assessment areas were classified into two distinguished dimensions in the model. The qualification results were verified and confirmed as part of a discussion held during a scientific seminar on the digitization of operational processes. The seminar was attended by 15 representatives of science with a Ph.D. degree or higher, specializing in areas such as logistics systems and supply chain management, production technologies, organization management, decision support systems, and cyber-physical system design, and eight representatives from industry in managerial roles in logistics and production departments. The analysis results made it possible to formulate and characterize the digital maturity assessment model framework at the level of organizations and processes. Due to the two dimensions of the assessment, this model will be referred to as DMM-OP in the rest of the article.

Based on the literature review carried out in stage 1 regarding the described digital maturity assessment models and the guidelines for creating maturity assessment models, a five-point assessment scale was formulated for each of the analyzed maturity criteria. Then, the characteristics of individual levels of digital transformation were prepared, which will apply to the assessment of each area.

The developed maturity assessment model is scientific and utilitarian. For this reason, it is necessary to develop an evaluation procedure and a diagnostic tool that will allow the managers employed in the organization to carry out the evaluation and application process. Therefore, an evaluation procedure was developed using a block diagram, which presents the successive stages of the research procedure. Then, diagnostic questions were formulated for each criterion based on the prepared characteristics of the maturity criteria and the defined assessment scale. The formulation of the diagnostic questions allows the respondent to answer only YES/NO, facilitating further analysis and inference.

The diagnostic form and the evaluation procedure developed based on the proposed DMM-OP model were used for the self-assessment of the selected enterprise. Implementing both elements of the DMM-OP model allowed for its verification and validation. The verification included an assessment of (1) the unambiguity of the concepts used, (2) the completeness and validity of the areas included in the model framework, (3) the comprehensibility of the assessment procedure, and (4) the correctness of the defined assessment levels. The verification was based on observations made during the implementation of the audit process by the assessment team, consisting of selected managers from the company. In addition, as part of the detailed verification, face-to-face interviews were conducted with members of this team to gather their opinions and conclusions. The validation of the model concerned the assessment of the level of fulfillment of the managers' requirements for the assessment function and for supporting decision-making processes regarding the digital transformation being carried out. In this way, it was possible to formulate an assessment of the effectiveness of applying the DMM-OP model in business practice. The empirical research made it possible to develop recommendations for improving both the diagnostic tool and the evaluation procedure.

3. Results—Literature Review

3.1. Guidelines for Creating a Maturity Model

A maturity model (MM) is a set of various tools and practices that enable the assessment of an organization's management competence, as well as the improvement of critical factors leading to the achievement of the assumed objectives [27]. These models are of

fundamental importance for managers, as they allow them to understand what needs improvement in the organization and in what areas [26]. Agreani et al. [28] emphasize that the maturity model should provide the organization with (1) measures for auditing and benchmarking, (2) a measure of progress between current assessment and goals, and (3) a set of tools to understand strengths, weaknesses, and opportunities.

When analyzing the characteristics of various maturity models, some common features can be distinguished that should be considered when creating such tools. These characteristics are presented in Table 1.

Table 1. Characteristics of maturity models (based on: [26,29]).

Characteristic	Description
Object of evaluation	The objects that are the subject of the maturity assessment, this may include technology, systems, people, project management, etc.
Dimensions	Defined areas of the organization's capabilities, which characterize the various elements of the maturity of the object to be assessed. These dimensions should be unambiguous and enable a comprehensive assessment to be made.
Levels	The maturity state of the evaluated object; it usually includes five levels (Level 1—initial; Level 2—managed; Level 3—defined; Level 4—quantitatively managed; Level 5—in optimization).
Maturity principles	There are two types of maturity models: (1) a continuous model, which evaluates based on the average level achieved in various dimensions, and (2) a staged model, in which all the elements of a given level must be achieved for the organization to move to a higher level of maturity.
Assessment	Qualitative (interviews) or quantitative (questionnaires with Likert scales).

Also noteworthy are the guidelines on the structure of the maturity assessment models developed by Schumacher et al. [15]. These researchers analyzed 72 papers on maturity models and, on this basis, formulated the following characteristics for the created MM framework [15]:

- Maturity levels—models are typically built on five levels, with 1 being the lowest; in some models, level 0 is also considered.
- Dimensions—maturity is usually assessed in 4 to 16 dimensions.
- Assessment mode—self-assessment or by an external auditor.
- Representation method—numerical representation, commonly visualized using radar charts.

From the point of view of the MM being created, it is also essential to approach the very process of evaluation and use the results obtained in its course, i.e., the so-called principles of representation (Corrijo et al. called them “maturity principles” [26]). Kosieradzka [30], like Corrijo et al. [26] and Chrapko [31], distinguished two models of representation in MM—constant and continuous. In the fixed representation, a specific number of process areas is assigned to each maturity level. Reaching a given maturity level means that all assessed areas have received a minimum positive rating at this level (reaching maturity level 3 means that all assessed areas have achieved a positive rating of at least 3). In this approach, the principle of cumulation applies, and the improvement of the organization is incremental [30]. Each process area is assessed individually according to the adopted maturity scale in the continuous representation. The selection of implemented practices in the selected field depends on the available resources and the adopted development goals. Thanks to this, the organization gains excellent flexibility in the selection of actions and the

ability to set priorities for improvements implemented in the assessed areas, which are key from the organization's point of view [30].

3.2. Digital Transformation Maturity Models

Digital transformation (DT) is the result of the digitization and digitalization of economies and societies, and it is an ongoing process. The term "digital" indicates that the changes will be driven by information technologies that allow real-time data processing and intelligently derive information to provide stakeholders with improved knowledge of processes and products [32]. These changes have been intensified by the Industry 4.0 concept, which emphasizes the importance of cyber-physical systems, especially in production [25]. The COVID-19 pandemic has also impacted the acceleration of digital transformation processes. The research results indicate that companies advanced in digitization processes are more resistant to this crisis [33,34]. At the same time, McKinsey's Global Survey [35] of executives found that digitization of companies' customer and supply chain interactions and internal operations accelerated by three to four years. At the same time, the share of digital or digitally enabled products in their portfolios accelerated by a shocking seven years.

Digital transformation in industry is defined as a process that consists of several phases, leading the company to meeting the digital world's requirements perfectly [26]. The use of digital maturity assessment models can contribute to increasing the individual enterprise readiness to use advanced digital technologies at all levels, which should be considered [5]. The purpose of the development of maturity models is to provide means to assess the company's current maturity to implement Industry 4.0 aspects and to identify specific measures that will help the organization reach a higher level of maturity to maximize benefits [36]. The use of DMMs in practice allows managers to provide an estimate of the current capabilities and maturity of the organization and general directions toward the desired maturity level.

Digital maturity models can be used to compare and position enterprises on the supported market and allow control of the digital transformation in such a way as to move from the current state to the desired level of maturity [37,38]. However, it should be remembered that digital transformation affects the organization in different ways depending on the sector and the place of the organization in the supply chain. Research results indicate that customer-oriented and B2C (business-to-customer) organizations are subject to faster and stronger influences of digital transformation than organizations operating in the B2B (business-to-business) model [26]. This has a significant impact on the benchmarking analysis of the results obtained from the conducted digital maturity assessment.

The research results presented by Zoubek and Simon [39] indicate that most of the digital maturity assessment models have the following characteristics:

- They are built on the same or similar principles as CMMI (Capability Maturity Model Integration).
- The analyzed parameters are always areas for evaluation and graded levels.
- Assessment is made in different areas/dimensions (both expressions are used interchangeably); for some models, the areas are further extended to sub-areas.
- Assessment levels are arranged logically from the lowest to the highest level. Each level has its name and characteristics for the requirements and properties to meet a given level within a given area.
- For some models, company readiness is expressed quantitatively as a readiness index.

At the same time, research by Schummacher et al. [40] indicates that most digital maturity assessment models are holistic. In this approach, the authors propose multidimensional conceptual maturity and guidance models that define current and target maturity levels. There are also DMMs in the literature, which are characterized by a specific approach. In these models, the area of maturity assessment is strictly defined, e.g., from the perspective of value creation processes [41], assessing maturity knowledge-intensive

business processes [42], digital information systems [29], big data usage [43], or Logistics 4.0 [22–24,37,39].

There are many models for evaluating digital maturity. They are created by academics, consulting companies (e.g., Deloitte, PWC), or market research companies (Forrester, VTT). However, there is still a continuous exponential increase in their numbers. This is because there are many challenges, such as limited empirical research on the validation of developed solutions or small extensions of the actionable properties of these models in guiding their application [26]. A critical analysis of DMMs developed by consulting firms and academics is detailed in [26]. According to the research presented in [8], digital maturity assessment models are often characterized by the following deficiencies:

- Many DMMs lack the required methodological rigor, as they are more practical than academic in nature.
- Most DMMs evaluate areas that have not been empirically verified, which raises questions about their relevance and fit to the organization's needs.
- Many DMMs are based on the assumption of linear evolution occurring in the digital transformation process and ignore industry and organizational specifics, which many authors criticize.

These deficiencies should be considered and limited in the new models for evaluating digital maturity.

As part of the conducted research, review articles were also analyzed, the purpose of which was to identify and compare various DMMs. On this basis, it was possible to identify the most frequently occurring assessment areas in DMM models to define assessment areas in the developed DMM-OP. Table 2 lists the areas of assessment distinguished in literature reviews, considered by researchers as primary in the models of evaluating digital maturity.

Table 2. Areas of assessment distinguished in literature reviews.

Hein-Pensel et al. [5]	Schumacher et al. [44]	Angreani et al. [28]	Hellweg et al. [21]
Technology	Strategy	Strategy	Business
Employees	Leadership	Leadership	Organization
Data	Customers	Customers	Process & Method
Organization and Processes	Products	Products	Technological
Strategy and Management	Operations	Operations	
Products and Services	Culture	Culture	
Corporate Environment	People	People	
Customer	Governance	Governance	
Corporate Culture	Technology	Technology	

Hein-Pensel et al. [5] analyzed 24 DMMs. On this basis, they distinguished nine recurring areas of maturity assessment together with an indication of their dominance. The three most common assessment areas are Technology (n = 24), Strategy and Management (n = 22), and Organization and Processes. The lowest scores were given to two assessment areas: Customers (n = 7) and Corporate Environment (n = 5). Hellweg et al. [21] analyzed 28 DMMs and distinguished only four assessment areas on their basis. Technological (n = 23) and Business (n = 16) were the most frequently assessed areas. Schumacher et al. [44] examined 62 DMMs and developed their own DMM model proposal on this basis. However, they did not analyze the frequency of occurrence of each assessment area. Such an arrangement was presented by Angreani et al. [28] based on the analysis of 17 DMMs. It is worth noting that the highlighted areas are exactly the same as those in [44]. According to the results obtained by Angreani et al., most often in DMMs, the following areas were assessed [28]:

- Technology and Operations (n = 17);
- People and Products (n = 16);
- Strategy (n = 15) and Governance (n = 14).

The final range of assessment criteria, along with the frequency of their use in DMMs, was defined based on the most up-to-date and extensive literature review (a review article published in 2023, including 44 DMMs) developed by Haryanti et al. [17]. The frequency of use of individual assessment areas in DMM models is shown in Figure 3.

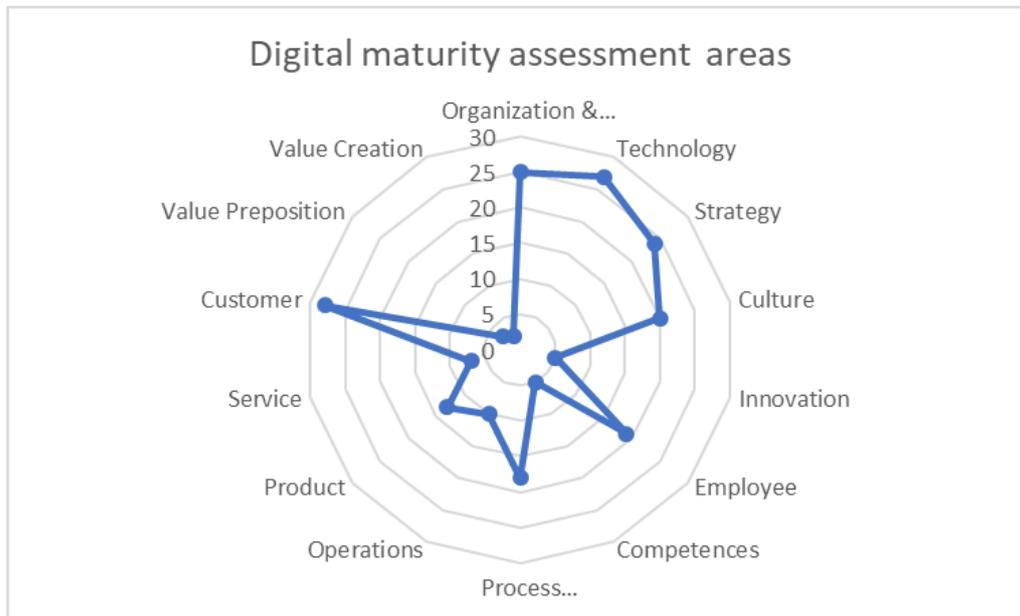


Figure 3. Frequency of using the identified areas of digital maturity assessment in DMMs (based on [17]).

Finally, it is worth noting that according to the research presented in [45], there is a common understanding that maturity regarding Industry 4.0 cannot be based on one dimension alone; hence, several dimensions are introduced. Based on the analysis of numerous DMMs, the authors of this publication distinguished two main dimensions, including individual areas of the maturity assessment. Both dimensions, together with the areas assigned to them, are presented in Figure 4.

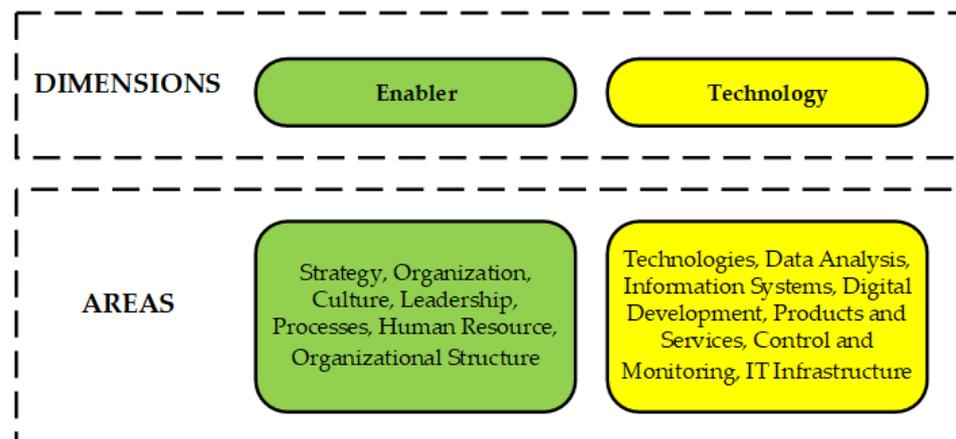


Figure 4. Enabler and technology dimension (based on [45]).

As proposed by de Silve et al. [45], the two-dimensional nature of the maturity assessment carried out confirms the need to create multidimensional models of digital maturity in an organization.

To summarize the literature review results, it should be mentioned that the areas assessed in the digital maturity models described in the literature so far converge and focus

on several recurring areas of analysis. These relate to the impact of digital transformation on the organization's processes, management strategies, and changes in technology and data analysis. Some of these changes must encompass the entire organization for digital transformation to be effectively implemented. However, some solutions can be applied area-wise and independently of the activities of other divisions. For this reason, it makes sense to assess digital maturity in the company in two dimensions—at the level of the entire organization and concerning specific processes (operational division).

4. Results—Model Development

The areas of the proposed DMM-OP model were defined based on the literature research. Following the adopted assumptions, these areas have been divided into two dimensions of the implemented digital transformation—the level of organization and process. Therefore, in the following parts of the article, the following system of terms will be used to describe the framework of the DMM-OP model:

- *Dimension*—refers to the level of the organization affected by digital transformation. The model distinguishes two dimensions: (1) an organization dimension and (2) a process dimension. The organizational evaluation applies to the entire enterprise. The assessment in the process dimension refers to a specific operational division, which may be, for example, production or logistics.
- *Area*—refers to the scope of activity that is the subject of the assessment; the model also assumes the introduction of sub-areas that may specify the content of the evaluation.
- *Level*—the level of implementation of the assumptions regarding fulfilling the requirements applicable to digital readiness.

The assessment areas for both dimensions are shown in Figure 5.

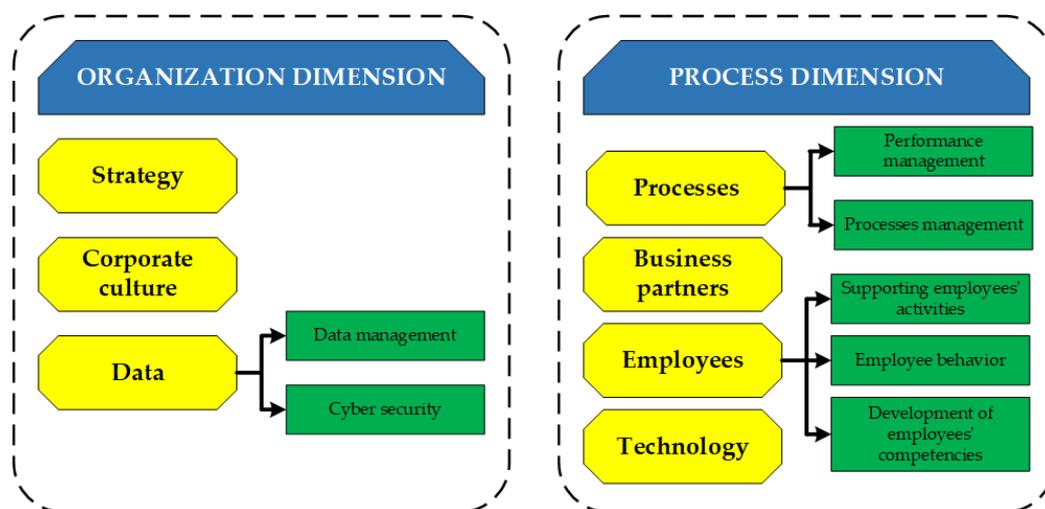


Figure 5. The areas of digital maturity assessment are divided into two dimensions of the analysis.

The characteristics of each identified maturity assessment area are presented below.

Strategy: This assessment area is critical for the efficient and effective implementation of digital transformation in an organization, because without developing a coherent implementation strategy that will be accepted by the board and managers and implemented by them, the organization will not achieve its transformation goals. It is also worth noting that the level of digital transformation in this area will strongly influence changes in other areas. The digitization strategy concerns financial resources allocated to the implementation of transformation processes, methods of communication in the organization, preparation of employees for digitization, and setting out a roadmap for the introduced changes [40]. The low level of digital transformation in strategy means managers lack commitment and readiness to introduce changes and lack risk assessment related to the implemented

transformation. The digital transformation introduced in the strategy will provide the organization with central coordination and direct the changes introduced to the implemented digital transformation.

Corporate culture: Corporate/organizational culture refers to the shared values, norms, attitudes, and assumptions that determine how employees and managers work, handle their responsibilities, and influence behavior [5]. Its impact is significant because it is rooted in the beliefs of the members of the organization and reflects what has already worked in the past. Bettoni et al. [46] emphasize that corporate culture is of great importance for a successful digital transformation, as only by changing it is it possible to achieve the full benefits of digitization. The transformation causes a change in the relationship between man and machine—changing machines from passive recipients of commands into conscious collaborators [5].

Data: This category applies in most DMMs to raw and source databases, data structures, and issues such as data integrity [5]. This category assesses the potential of collected operational data to implement complex analytical systems, optimize processes, and make decisions [43,46,47]. Data are considered an essential component for the effective use of digital technology. For this reason, the subject of assessment in DMMs in this category is the availability and quality of the data used in the organization and their integration and security [46,48]. Therefore, the DMM-OP model distinguishes two sub-areas for assessing maturity:

- Data management.
- Cyber security.

Processes: This category usually concerns the organization of processes and the focus on creating a framework for the processes of creating value for the company. This area usually includes transformation processes and evaluation of previous activities [5]. In this area, the level of digitization, automation, and optimization of operations carried out in primary and supporting processes is assessed. The critical issue is also the systematization and automation of measurements and their use for analyses aimed at optimization and proactive management of ongoing processes. For this reason, two sub-areas have been distinguished here:

- Performance management.
- Processes management.

Business partners: Most DMM models distinguish the Customers area in their assessment. This is due to the trend of mass customization and coordinated marketing strategies, which are causing a steady increase in the importance of customer service in organizations [49]. Therefore, this category assesses both the ability to incorporate customer requirements into production or service [44] and the specific handling of the resulting structures [50]. Customers are the only element of the corporate environment that also appear as a category in numerous DMMs [5]. However, from the point of view of the digital transformation in logistics processes, it is equally important to implement digital technology and information integration in cooperation with other business partners, e.g., material suppliers and service providers (logistics operators and transport companies). For this reason, the Business Partners area was adopted for assessment in the DMM-OP model, which covers organizations cooperating with the company within the supply chain, including primarily suppliers and customers.

Employees: Most digital maturity assessment models focus primarily on the development of employee digital competencies in this area [5]. Developing skills is perceived as a critical step for the organization to be competitive and implement Industry 4.0 tool solutions [16]. However, from the point of view of the transformation process itself, employees' attitudes toward digitization are also necessary. Resistance to change and reluctance to cooperate between people and machines will effectively block all activities aimed at digitization processes. Employee fundamentals will be affected by the extent and adequacy of support offered by the digital solutions implemented by the enterprise. The

legitimacy and numerous benefits the employees achieve in using digital technologies in their daily duties will determine their acceptance of the implemented changes. For this reason, three sub-areas have been distinguished in this area, which should be subject to assessment:

- Supporting employees' activities through digital solutions.
- Employee behavior.
- Development of employees' competencies.

Technology: Technology is considered a critical area of digital transformation [17]. It focuses on technical infrastructure [43,47], the level of its automation, and machine self-control capabilities, as well as information and communication systems and integration of network services [46]. For this reason, the attention of many researchers in this area focuses on issues related to [17]: (1) Information Systems, (2) Security Management, and (3) Infrastructure. In the DMM-OP model, this area has been limited to issues related to infrastructure, and elements related to it are subject to the assessment of the level of digital maturity.

Individual areas and sub-areas are analyzed and assessed on five levels. The general characteristics of individual levels are presented in Table 3. A detailed description of the assessment levels for each researched area is attached in Table S1 in Supplementary Materials.

The model assumes that the lowest level 1 is the so-called baseline from which the enterprise begins its digital transformation. However, in extreme cases, it is also possible to score at level 0, which is not included in the rating scale above. This will apply to a situation where the assessed area is not supported by any ICT tool (no systemic use of even a PC), and the organization's employees report strong resistance to implementing digital transformation. However, the author assumes that such an organization will not be interested in using the proposed DMM-OP tool to assess maturity. If it wants to prepare for the implementation of digital transformation, it will be aware that it is at the beginning of the road. Instead, it can use DMM-OP to chart future directions of change.

The evaluation procedure includes 11 implementation stages divided into four assessment phases. The individual stages of the procedure are shown in Figure 6. It should be emphasized that the evaluation process is repeatable based on the PDCA cycle. This means that the application stage is the basis for formulating recommended changes that initiate re-evaluation. For this reason, the last step in the roadmap is connected to stage 1, as the implemented changes create the need to re-assess the maturity.

The developed model uses a diagnostic tool prepared as a questionnaire for the organization's self-assessment. For this reason, the evaluation process should include appointing an evaluation team consisting of representatives of top management and selected managers of operational divisions subject to evaluation (e.g., production, logistics). This team will be responsible for conducting a self-assessment of the level of digital maturity and drawing conclusions. Depending on the competence and knowledge of current digital trends, this team may also develop further recommendations for changes in selected business areas. Without appropriate knowledge, an external expert specialist in the area indicated for changes should be added to the assessment team. The team's composition should be variable and adjusted to the area of the assessment. Persons responsible for the organizational level's maturity assessment can be this team's core. However, they should not be responsible for the evaluation at the process level.

The DMM-OP adopts a continuous representation model. According to [30], this means that each area is assessed individually, thanks to which it is possible to prioritize the implemented digital transformation. The principles of continuous representation adopted in the evaluation process are presented in Figure 7.

Table 3. Digital maturity assessment levels.

Levels	Description
Level 1—Basic	<p>There is a low level of digitization in the area. IC technologies support some activities, but no centrally controlled system solutions exist. Individual innovative projects are implemented, but at the local level, without affecting other business areas. Digital transformation does not have the highest priority in the changes implemented in the organization. Employees need to feel the personal benefits of starting to use IC tools to support their work. Only relevant data are stored by the organization, but their collection is not continuous and is not always supported by IT solutions. The collected data are not the basis for systematic analyses to improve processes.</p>
Level 2—Discovery	<p>The company is starting a process of changes aimed at digital transformation. It has a digital transformation plan and defined milestones. IT tools and standards supporting systematic data collection and analysis are being implemented. Employees are open to changes and digital innovations supporting operational processes. ICT tools and mobile devices support their work. The process of developing their digital competencies begins. The company implements continuous improvement and change management strategies. The processes in the company are standardized, and the fundamental processes have been digitized. The measurement of process efficiency based on procedures, indicators, and goals is also introduced. The enterprise provides business partners with critical data in digital form.</p>
Level 3—Developed	<p>The company is focused on growth through its digital transformation. Critical data from various sources are integrated at the enterprise level, centrally collected, systematically analyzed using IT tools, and used to optimize processes within the enterprise. The data collection process is supported by sensors monitoring the process and machine operation, and cloud computing is used for data storage and distribution. Analytical tools support decision-making processes. Employees perceive digital technologies as a value supporting the implementation of processes and actively share information in interdisciplinary teams.</p>
Level 4—Integrated	<p>The company has reached a high level of digital transformation. Modern technological solutions are used in the field of process automation as well as data analysis and management. These solutions are based on integrated IT platforms that support all processes carried out in the company. At the same time, information integration also applies to business partners, which means mutual sharing of data in real time and a coherent planning process based on data analysis from both partners' systems. Autonomous devices are included in operational processes. Employees are focused on active human-machine cooperation and can manage the risks associated with digitization.</p>
Level 5—Leadership	<p>The enterprise has reached the peak of digital transformation. The latest technological solutions in process automation and data analysis are used. Autonomous solutions support operational processes, the Internet of Things concept, and artificial intelligence. Employees have the required digital competencies, which are constantly developed and updated as part of training. The company continuously analyzes and evaluates current trends in digital transformation and implements best practices in its operations. At the same time, it is itself the initiator of many innovative solutions that promote and support digital transformation in the served market.</p>

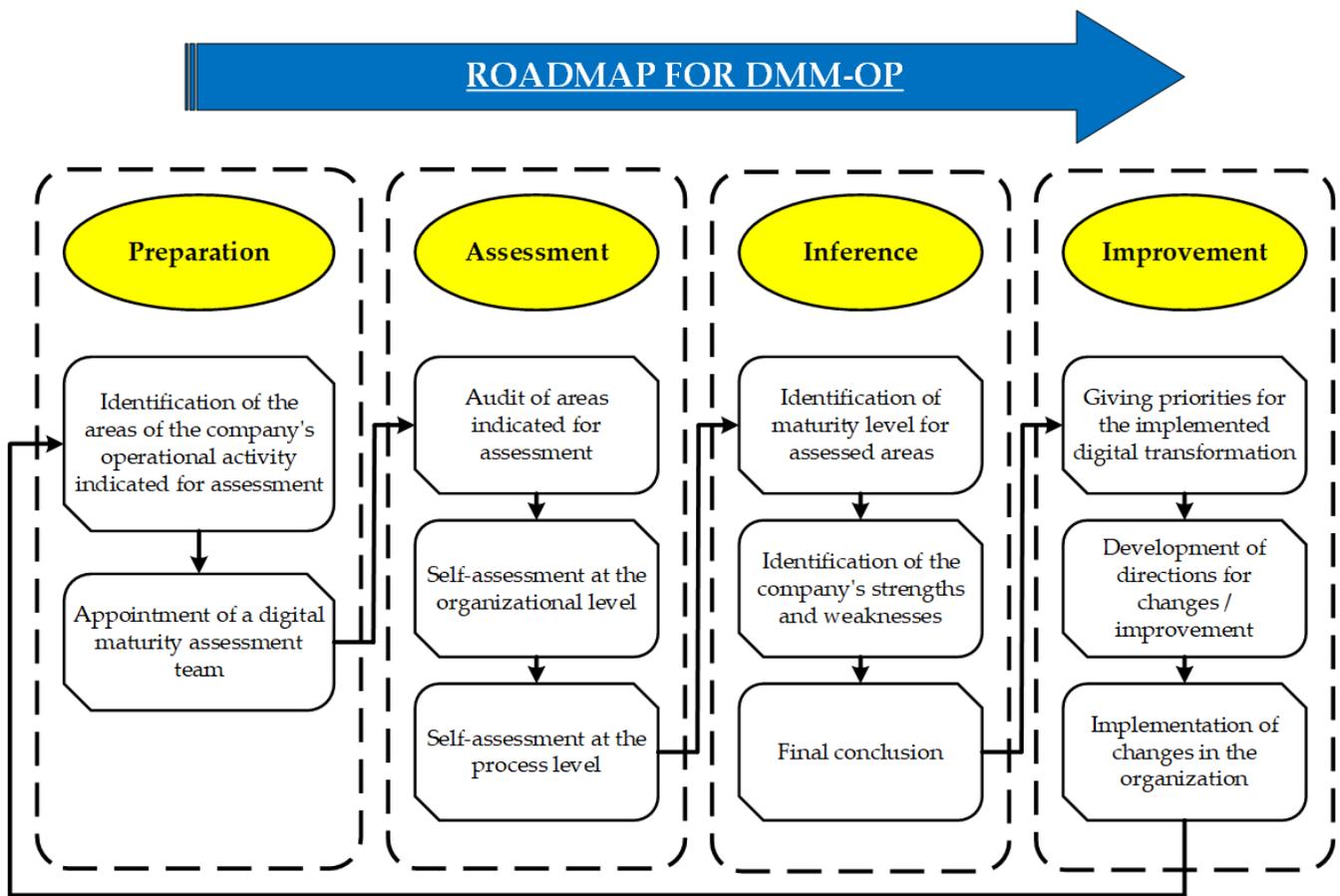


Figure 6. Stages of organization evaluation according to the DMM-OP.

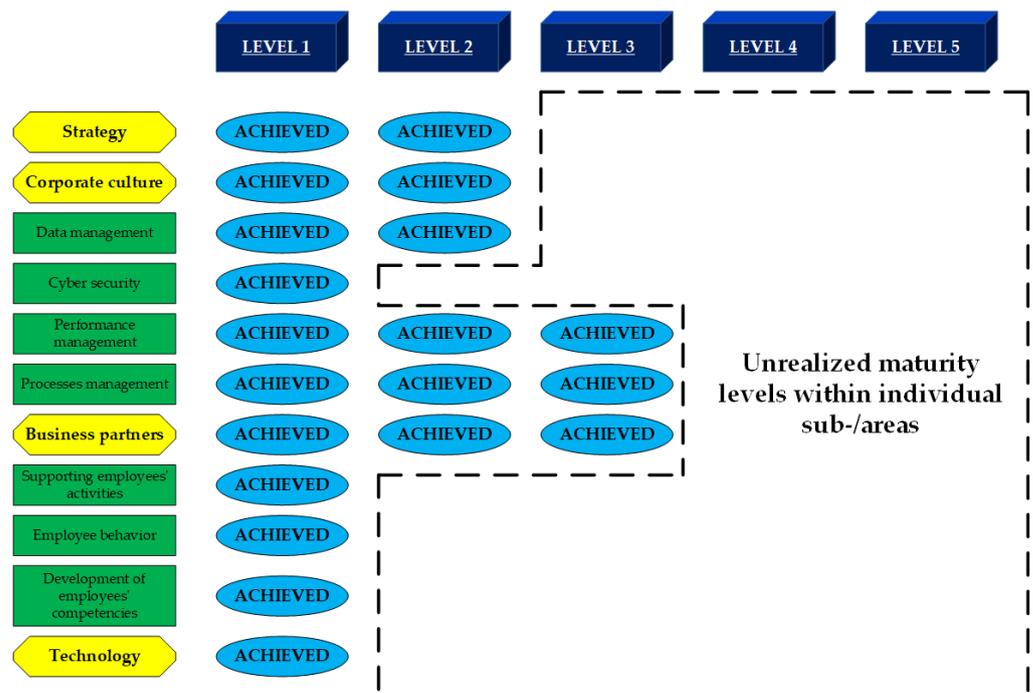


Figure 7. Continuous representation rules applied in the DMM-OP.

The diagnostic tool consists of 105 questions. The formulation of the diagnostic questions allows the respondent to answer only YES/NO, facilitating further analysis and inference. An example question is shown in Figure 8.

EMPLOYEES - Supporting employees' activities		
Q1: Are IT solutions implemented that support employees' work in the operational division under assessment?	YES	NO
Q2: Is a digital assistant or other mobile tools supporting the work of employees used in the assessed operational division?	YES	NO
Q3: Are augmented reality technologies and tools used systematically in the assessed operational division to support employees?	YES	NO
Q4: Are the assessed operational division employees supported by autonomous solutions (mobile robots, AUV)?	YES	NO
Q5: Do autonomous solutions provide employees with goal-oriented information and support the development of organizational intelligence?	YES	NO
Q6: Are best practices implemented in the assessed operational division, as a result of which autonomous facilities and organization intelligence support employees?	YES	NO

Figure 8. An example of a diagnostic question in the DMM-OP.

For each positive answer, the respondent receives one point. According to the continuous representation, each of the areas is assessed individually. The level of maturity in DMM-OP is evaluated for each assessed sub-area and if it does not occur at the area level. Due to the adopted two-dimensional scope of assessment, the level of maturity should also be assessed at the level of organization and processes. The level of maturity for each sub-area is estimated according to Formula (1), while the level of maturity of the assessed dimensions is estimated according to Formula (2).

$$AML_S = \frac{\sum_{k=1}^n X_k}{n} \quad (1)$$

$$DML = \frac{\sum_{S=1}^N AML_S}{N} \quad (2)$$

where:

- AML_S —sub-area/area maturity level.
- DML —dimension maturity level.
- X_k —positively verified question for a given sub-area/area.
- n —number of questions in the set for a given sub-area/area.
- N —number of sub-area/areas in dimension assessed.

For the values of the AML_S and DML indicators, the following model of qualifying the result to the level of digital maturity was adopted (Figure 9).

BASIC	DISCOVERY	DEVELOPED	INTEGRATED	LEADERSHIP
<0 ; 0.3)	<0.3 ; 0.5)	<0.5 ; 0.7)	<0.7; 0.9)	<0.9 ; 1>

Figure 9. The range of values of AML_S and DML indicators qualified to the distinguished maturity levels.

The DMM-OP model assumes equivalence of all assessed maturity areas. For this reason, individual areas have not been assigned weights (priorities) that should be taken into account (an example of a model with weights assigned is [24]). However, if the company sets priorities in implementing digital transformation in its digitization strategy, it is possible to introduce weights into the assessment procedure.

5. Results—Implementation in a Selected Company

5.1. The Use of DMM-OP to Assess Digital Transformation in a Manufacturing Company

The DMM-OP model was used to assess the level of maturity in a selected manufacturing company from the electronics sector. This company from the SME sector produces electrical components on behalf of customers. The company is intensely focused on customers' needs, which is reflected, among others, in the individualization of manufactured products. The company has a modern and automated collection of production machines. However, material flows are handled by a traditional logistics system.

The company has set up a digital maturity assessment team. The evaluation team included six people: the vice president of the board, the development director, the production director, the logistics manager, the IT director, and the personnel development specialist. The selection of the team resulted from the scope of the maturity assessment. The company decided that the assessment process should cover the organizational dimension and, at the level of the process dimension, two divisions: production and logistics. Each team member was assigned selected areas for assessment, and after the diagnosis, the obtained results were discussed with the entire team. The application phase was also carried out together.

Figures 10–12 show the results of the obtained assessments broken down into organizational and process dimensions, with the results of both divisions presented for the process dimension.

The results presented above clearly indicate that, in terms of organization, the company has already achieved a very high level of digital transformation; out of the four assessed areas, as many as three reached the “Integrated” level and one reached the “Developed” level. Such a high level of digital transformation is forced mainly by the sector in which the company operates and by the high requirements of the customers it serves. The company is currently in the intensive development phase and gaining new markets for its products; therefore, following the current digital trends is mandatory.

As seen in Figure 12, the Production division is also advanced in the digital transformation process. Three of the seven areas assessed achieved the “Integrated” level, and the “Employee behavior” sub-area was rated “Leadership”. However, there is still potential for change in this process dimension, as three sub-areas/areas still have the “Developed” level. Two of these areas are related to significant financial investments, which the company implements systematically but in small steps because it is in the SME sector. However, considering the high scores in other maturity areas, it is clear that the organization has potential for further development.

The comparison of the results for Logistics and Production, presented in Figure 11 as a radar chart, reveals a significant disproportion in implementing digital transformation between these divisions. The company's strategy and corporate culture at a high level of digitization means that the employees of the Logistics division are already very well prepared for changes—this is confirmed by the “Integrated” level for the “Employee behavior” sub-area. However, this is the only area with a high level of digital maturity in this division. All other areas (except for “Processes management”) only reached the “Discovery” level. This means that standards and analyses supported by basic IT tools are

already used in this division. However, there is still a lack of full integration, automation, and optimization of processes. Therefore, it is necessary to continue introducing changes and technological innovations because, at the moment, this division is a bottleneck in cooperation with production and limits the possibilities of its further development.

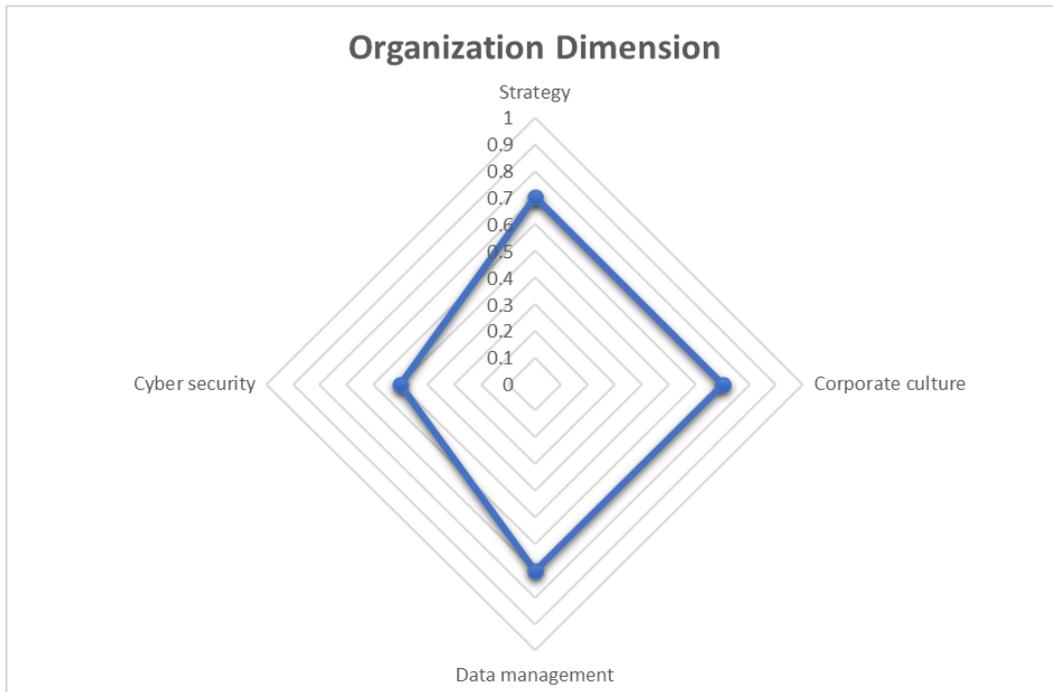


Figure 10. Evaluation of the level of maturity for areas in the organization dimension.

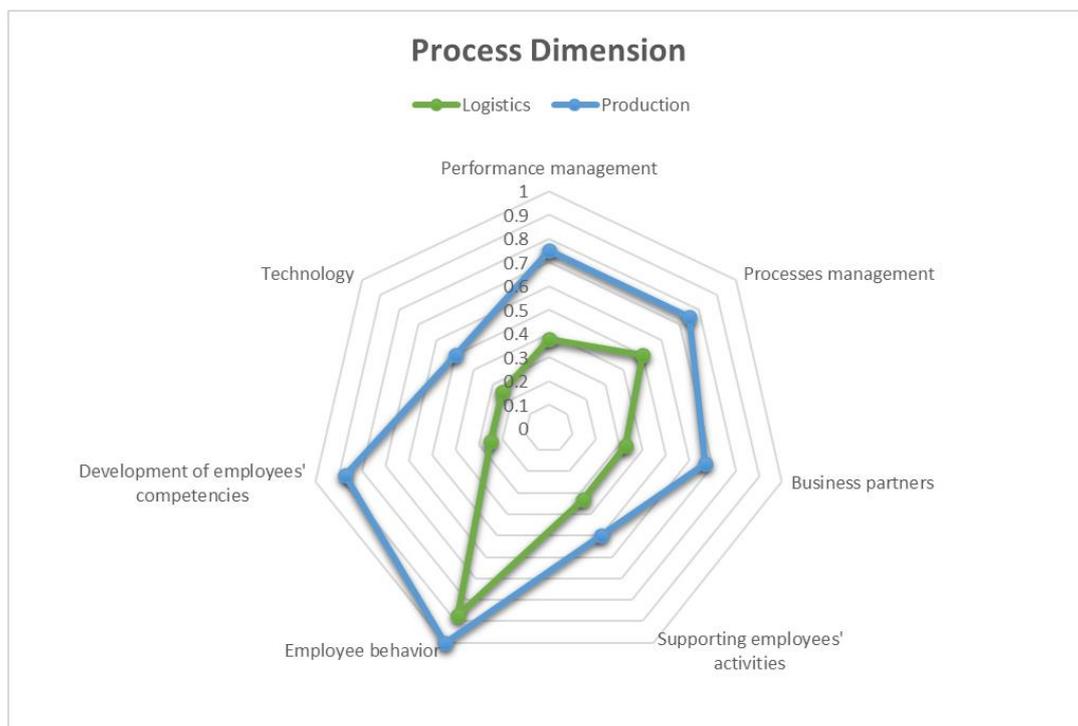


Figure 11. Evaluation of the level of maturity for areas in the process dimension (for Logistics and Production).

Organization Dimension		Process Dimension		
		Division	Logistics	Production
Strategy	0.7	Performance management	0.375	0.75
Corporate culture	0.7	Processes management	0.5	0.75
Data management	0.7	Business partners	0.33	0.67
Cyber security	0.5	Supporting employees' activities	0.33	0.5
		Employee behavior	0.875	1
		Development of employees' competencies	0.25	0.875
		Technology	0.25	0.5

Figure 12. Evaluation of the level of maturity for areas in the organization and process dimension—summary.

It is worth noting that the results obtained by the selected company confirm the observations of managers described in Section 1, “Introduction”. In this case, we have a high intensification of digital changes in the Production division, which is considered a key area of operating activity. On the other hand, the digitization of logistics processes is not carried out in parallel with production and organization management changes. Logistics processes are still carried out traditionally, limiting the efficiency of the entire operating system. However, thanks to the use of DMM-OP, it will be possible to develop the directions of necessary changes in the Logistics division and give them the appropriate priority.

5.2. Model Verification and Validation

Implementing the DMM-OP model made verifying the correctness of its most important elements and the procedure possible. The verification assessment included mainly:

1. Unambiguity of terms used in research tools and their complexity level.
2. Completeness and validity of the areas adopted in the model for assessment.
3. Understanding of the procedure for the assessment team.
4. Correctness of the adopted maturity assessment levels for individual areas.

The developed diagnostic tool should be used in the self-assessment process carried out by team members. For this reason, the critical issue is the unambiguity of the terms used in the formulated questions. The users of the tool highly appreciated the unambiguity and comprehensibility of the questions used in the diagnostic tool. Only two phrases required explanation: (1) organization intelligence and (2) digital assistant. Therefore, both terms have been defined in the glossary of terms attached to the diagnostic questionnaire.

Team members pointed out that the developed research tool is expansive at 105 questions. However, after the evaluation procedure, they concluded that all the questions used in the survey were required to obtain the assumed level of completeness of the diagnosis of the current state. The verification also confirmed the legitimacy of all assessed areas in the DMM-OP. All areas in both dimensions are important for the digital transformation process in the organization.

Managers positively assessed the comprehensibility of the procedure. A clear division into four implementation phases allowed the team to prepare better and plan the implementation of the entire evaluation process. Team members emphasized the importance of distinguishing two separate procedures in the assessment phase for the organization and process dimensions. The benefits of introducing a division into individual areas in the diagnostic survey were also emphasized. Thanks to this, it was possible to assign team members to evaluate each sub-area.

Based on the results obtained in the assessed enterprise, the author verified the correctness of the adopted maturity levels for each area. These characteristics were considered correct and adequate for the possible further development of the company.

At the same time, based on interviews with evaluation team members, it was possible to validate the DMM-OP model. Model validation is concerned with the answer to the question:

- VQ1: Does DMM-OP meet the requirements of managers regarding the tool assessing the current level of digital transformation in their organization?
- VQ2: Does DMM-OP meet the requirements of managers regarding the further framework for digital transformation being formulated for their organizations and possible directions of change?

The evaluation team members highly appreciated the fulfillment of their requirements regarding supporting the current state diagnosis process by the proposed DMM-OP tool. They found the developed tool useful and significantly supported the analysis processes. Its usefulness in establishing a further framework for digital transformation was also highly appreciated. However, team members noted that the top level of digital transformation described in several areas regarding “best practices” is very general. It requires evaluators to know these best practices, which may apply to the entire market or only to a given region or sector. For this reason, at the last stage, it is justified to use the support of an expert who will have extensive and up-to-date knowledge of the current possibilities and solutions used in the digital transformation of enterprises.

6. Discussion

The developed digital maturity assessment model considers three types of resources in the organization that should be covered by digital transformation and the relationships between them. These are (1) employees, (2) devices, and (3) information. These resources form a complex human–cyber–physical system responsible for the effectiveness and efficiency of processes carried out by a company. Each of these assets has its own path of digital transformation and other factors that will influence it. Therefore, it is necessary to remember the mutual relations between these three components, which can support but also limit the processes of implemented changes.

The proposed DMM-OP is an attempt to combine the holistic and specific approaches distinguished by Schumacher [40]. It allows one to assess the overall approach to digital transformation applicable throughout the organization and create the basis for implementing digital solutions at all management and operational levels. At the same time, however, it allows one to verify whether this transformation is being implemented in all operating divisions at the same level and whether the idea of digitization is only the domain of managers or also applies to operational employees.

The model’s verification and validation show that the assessment areas, the evaluation procedure, and the diagnostic tool meet the assumed requirements and the managerial staff’s decision-making needs. The developed theoretical framework also aligns with the guidelines described in the literature [22]. The model includes assessing 11 defined areas, evaluated on a five-point Likert scale (i.e., following most described models [26]). The assessment is carried out following continuous recommendations, which enables the actual level of digitization in each division covered by the assessment process and facilitates the development of a framework for planned, further digital transformations in the enterprise. The adopted decentralization of the maturity assessment level was positively assessed by the assessment team members who used the DMM-OP during its verification. At the same time, the managers of the assessed divisions in the analyzed example emphasized the importance of the two-dimensional nature of the assessment. This feature of the model is significant when there are disproportions in the company between individual divisions regarding the digital transformation being carried out. When analyzing the successive stages of digital maturity in the assessed areas, it is worth noting that:

- Level 1 focuses on the basic potential of the enterprise and its readiness to join the digital transformation.
- Level 2 checks the level of standardization and analytical potential of the company.
- Level 3 focuses on internal integration regarding processes, data, and employee readiness.

- Level 4 takes digitization processes outside the enterprise and checks the level of digitization in cooperation with business partners.
- Level 5 is focused on using the best practices related to digital transformation, supported by the latest technological developments.

When creating DMM-OP, the author tried to use all the good patterns described in the literature related to building such models. It is also worth emphasizing that thanks to the empirical tests carried out in the selected company, the deficiencies identified by Remane et al. [8] in many DMM models described in the literature were limited. However, the author is aware of some limitations of the created solution. First of all, the self-assessment research tool considers the current availability of digital transformation, which constantly evolves and provides new solutions. This affects the characteristics of individual maturity levels. What is considered today to be high digital maturity may correspond to the level of “Developed” or even “Discovery” in a few years. Therefore, both the DMM-OP model and the self-assessment tool will need to be updated along with technological progress and changes in the current digital transformation. The second limitation is the universal nature of the developed model. The adopted universal approach was an intentional action because one aim of the created solution was the possibility of its use in enterprises in various sectors. The price for this, however, is that it does not consider the specifics of selected sectors that may affect the pace and direction of the ongoing digital transformation. As emphasized by Carrjio et al. [26], digital transformation affects the organization in different ways depending on the sector and the place of the organization in the supply chain. For this reason, it may be necessary to consider this specificity in some cases.

The obtained results contribute to both science and practical applications. The developed framework of the DMM-OP model indicates the possibility of a new two-dimensional approach to assessing digital maturity. The use of maturity assessment areas based on other DMMs in the structure of the model did not mean their simultaneous duplication. The characteristics of the maturity levels and the questions formulated in the diagnostic tool differ from the solutions known. The proposed bidimensionality of the assessment is a new approach to the issue of evaluating digital maturity in an organization. The developed diagnostic tool and evaluation procedure also have verified practical applications. They can be used to assess digital maturity by enterprises, primarily manufacturing enterprises, but also commercial companies serving various sectors of the economy.

7. Conclusions

The developed digital maturity assessment model is dedicated primarily to manufacturing enterprises but can also be used to assess commercial enterprises. It was built based on a literature review as well as interviews and discussions conducted with the management staff of manufacturing companies. Thanks to this, it meets the methodological rigor and simultaneously meets the information needs of managers (which has been positively verified in the selected company). The results obtained through the research procedure also allowed answering the research questions posed at the beginning of the article. Figure 13 shows the sections where the presented results answer the formulated research questions.

The described DMM-OP model has been positively verified and validated using a selected company as an example. Members of the assessment team who used the procedure and diagnostic tool in the audit process confirmed the unambiguity of the concepts, the completeness and validity of the designated assessment areas, and the usefulness of the DMM-OP model. At the same time, managers emphasized in interviews that the DMM-OP model highly satisfied their requirements in assessing the level of digital maturity and as a tool to support decision-making processes regarding further directions of digital transformation. Therefore, as part of further research, the DMM-OP model will be used to diagnose the level of digitization in a selected group of manufacturing companies in the production and logistics divisions. These studies will allow not only to assess the scope of digital transformation in the assessed organizations but also to carry out a comparative

analysis of various enterprises and identify current digital trends in multiple sectors of the economy.

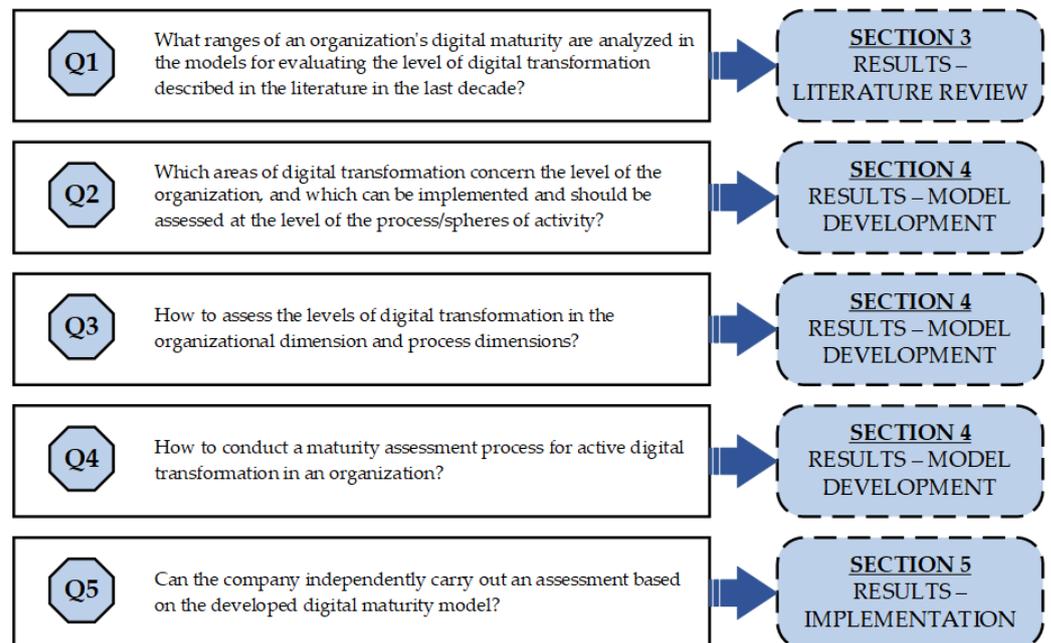


Figure 13. Sections answering research questions.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su152015122/s1>. Table S1: Digital maturity assessment levels.

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