

Digital transformation of industrial enterprises: assessing readiness

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Abstract. In the rapidly changing environment of current industrial development, digital transformation of industrial enterprises stands as both a necessity and an opportunity. This study delves into the various aspects of digital transformation, emphasizing the need for further exploration to fully grasp its potential and challenges. Scholars have highlighted the profound impact of digitalization on enhancing efficiency and productivity within industrial sectors, leveraging advanced technologies. This study focuses on defining the main barriers and opportunities of digital transformation of Russian industrial enterprises and develops a robust method for assessing their digital readiness. The method involves analyzing various dimensions, including technology readiness, organizational culture, data capabilities, skills, and understanding of customer needs. By testing the developed method on a selected company specializing in manufacturing and selling packaging products, valuable insights are obtained to guide informed decision-making processes towards achieving digitalization goals.

1 Introduction

In the rapidly evolving landscape of current industrial development, digital transformation of industrial enterprises stands as both a necessity and an opportunity. The scholars have been shedding light on the multifaceted aspects of this transformation, emphasizing the need for further exploration to fully grasp its potential and pitfalls [1-20]. Digital transformation of an enterprise can be defined as the strategic adoption and integration of digital technologies, processes, and capabilities across all aspects of the organization to fundamentally change how it operates, delivers value to customers, and competes in the market. Digital transformation is not merely about implementing new technologies but rather about reimagining business models, processes, and strategies to thrive in an increasingly digital and interconnected world [6, 20].

One of the key insights gleaned from the academic discourse is the profound impact of digitalization on enhancing efficiency and productivity within industrial sectors. By leveraging advanced technologies such as IoT, AI, and data analytics, companies can optimize processes, streamline operations, and unlock new prospects for growth. Different studies have underscored the transformative power of digital tools in revolutionizing

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traditional manufacturing practices, driving cost savings, and stimulating innovations [1, 7, 9].

However, alongside the promises of digital transformation comes a host of challenges that merits thorough examination. The researchers delved into issues such as cybersecurity threats, data privacy concerns, and workforce reskilling requirements so far. The complexities of integrating different systems, ensuring interoperability, and managing digital infrastructure also seem to pose formidable hurdles for industrial firms navigating the digital landscape. Apart from that, the disruptive nature of digitalization necessitates strategic foresight and proactive adaptation to mitigate risks and capitalize on emerging opportunities. It also seems worth delving into opportunities and barriers of the business digital transformation in a specific country (in this case, Russia), since understanding the country-specific nuances enables the development of tailored solutions [12, 20].

The development of tailored tools and frameworks stimulating digital transformation emerges as a pivotal area of focus for scholars and practitioners alike. Designing methodologies for assessing digital readiness, creating implementation roadmaps, and measuring performance outcomes can guide companies through their digital transformation journey. There is the need for further exploration of the opportunities and challenges inherent in the digital transformation of industrial companies in order to develop efficient solutions.

Hence, the purpose of this study is to define main barriers and opportunities of digital transformation of Russian industrial enterprises in the current environment, and to develop a robust method for assessing digital readiness of these companies based on the analysis of academic literature. The application of the provided tool will present valuable insights to guide the initiatives of industrial enterprises and navigate the difficulties of the digital transformation process in the digital era.

2 Materials and Methods

The research methodology is based on the use of general scientific methods, including analysis, generalization, induction, deduction, classification, etc. Additionally, the digital readiness assessment method is developed based on the use of system approach, mathematical methods and expert judgement.

The digital readiness assessment method is developed based on the analysis of academic literature [2, 5, 10, 15]. It involves analyzing various dimensions of enterprise operation, including technology readiness, organizational culture, data capabilities, skills, and understanding of customer needs. Each dimension comprises four variables. The assessment is conducted through expert judgement, with experts drawn from both company employees and independent consultants, including scholars. This section outlines the step-by-step procedure for conducting the assessment and calculating the integrated index of an industrial company's digital readiness.

The variables to be assessed are selected based on a comprehensive review of academic literature and consultation with industry experts. The selected variables are given in Table 1.

Table 1. Dimensions and variables used for the assessment

Dimension	Variables
Technology readiness	Infrastructure, software systems, connectivity, cybersecurity
Organizational culture	Leadership support, innovation culture, change management, collaboration
Data capabilities	Data quality, analytics tools, data governance, integration capabilities

Skills	Digital skills training, talent acquisition, upskilling programs, cross-functional collaboration
Understanding customer needs	Market research, customer feedback mechanisms, personalization capabilities, responsiveness

Each variable is carefully chosen to represent key aspects of digital transformation within industrial enterprises.

Experts participating in the assessment process are chosen based on their expertise and experience in digital transformation within industrial enterprises. They include company employees holding relevant positions in technology, innovation, operations, and strategy, as well as scholars with research and consulting experience in digital transformation and related fields.

Assessment process includes a number of stages. Experts are provided with a detailed explanation of the assessment process, including the purpose, variables to be assessed, and scoring criteria. They are also briefed on the importance of their role in providing accurate and unbiased judgments. Prior to scoring, experts are provided with the weight or coefficient of significance assigned to each variable. These weights reflect the relative importance of each dimension in determining the overall digital readiness of the company.

Each expert independently scores each variable on a scale from 1 to 5, with 1 indicating low readiness or capability and 5 indicating high readiness or capability. The scoring is based on their subjective judgement and assessment of the company's current state. The scoring criteria are presented in Table 2.

Table 2. Scoring criteria used for the assessment

Score	Description
1	Low readiness/capability
2	Below average readiness/capability
3	Average readiness/capability
4	Above average readiness/capability
5	High readiness/capability

Standardized scoring criteria were developed for the assessment. The criteria are shown in Table 3 on the example of technology readiness and organizational structure dimensions.

Table 3. Scoring criteria used for the assessment (for technology readiness and organizational culture dimension)

Dimension	Variable	Score	Description
Technology readiness	Infrastructure	1	Outdated or insufficient infrastructure, hindering digital operations
		2	Basic infrastructure in place but requires significant upgrades
		3	Adequate infrastructure supporting basic digital operations
		4	Advanced infrastructure supporting most digital initiatives
		5	Cutting-edge infrastructure enabling seamless digital transformation
	Software systems	1	Limited or outdated software systems, hindering efficiency and innovation

		2	Basic software systems in place but lacking integration and scalability
		3	Adequate software systems supporting core business functions
		4	Advanced software systems enabling automation and optimization
		5	Cutting-edge software systems driving innovation and competitive advantage
	Connectivity	1	Poor connectivity, leading to frequent disruptions and downtime
		2	Basic connectivity but prone to bottlenecks and performance issues
		3	Reliable connectivity supporting most digital activities
		4	High-speed and stable connectivity enabling seamless collaboration
		5	Ultra-fast and resilient connectivity facilitating real-time data exchange and remote operations
	Cybersecurity	1	Weak cybersecurity measures, vulnerable to cyber threats and attacks
		2	Basic cybersecurity measures in place but gaps in protection and compliance
		3	Adequate cybersecurity measures mitigating common risks and threats
		4	Robust cybersecurity infrastructure with proactive monitoring and response capabilities
		5	Advanced cybersecurity practices ensuring data security and regulatory compliance
Organizational culture	Leadership support	1	Lack of leadership support and vision for digital transformation
		2	Limited support from leadership, with sporadic initiatives and investments
		3	Moderate support from leadership, with clear goals and strategies for digital transformation
		4	Strong support from leadership, actively championing digital initiatives and fostering innovation
		5	Exceptional support from visionary leadership, driving a culture of continuous digital innovation
	Innovation culture	1	Resistance to change and innovation, with a rigid organizational culture
		2	Limited innovation culture, with minimal experimentation and risk-taking

		3	Moderate innovation culture, with some degree of openness to new ideas and approaches
		4	Strong innovation culture, fostering creativity, collaboration, and entrepreneurial spirit
		5	Pervasive innovation culture, encouraging continuous experimentation and disruptive innovation
	Change management	1	Ineffective change management practices, leading to resistance and failure of digital initiatives
		2	Limited change management capabilities, with ad-hoc approaches to managing transitions
		3	Adequate change management practices, ensuring smooth adoption of digital technologies
		4	Effective change management strategies, facilitating organization-wide acceptance and adoption of digital transformation
		5	Exceptional change management practices, driving successful digital transformations with minimal disruptions
	Collaboration	1	Siloed organizational structure, hindering collaboration and knowledge sharing
		2	Limited collaboration across departments, with communication barriers
		3	Moderate collaboration, with cross-functional teams working together on selected projects
		4	Strong collaboration culture, promoting transparency, teamwork and shared goals
		5	Seamless collaboration across the organization, with integrated processes and collective ownership of digital initiatives

The scores provided by each expert for each variable are summed up to obtain a total score for each dimension. The total score for each dimension is multiplied by its respective weight or coefficient of significance. The weighted scores for all dimensions are aggregated to calculate the integrated index of the company’s digital readiness. The validity of the assessment method is ensured through a rigorous review process involving internal validation by industry experts and external validation through comparison with existing digital readiness frameworks. The value of the index of readiness is interpreted based on the developed scale criteria given in Table 4.

Table 4. Scale criteria for the interpretation of index of digital readiness derived from the calculations

Index score (DRI)	Level of readiness	Interpretation
DRI < 40	Low readiness	Indicates significant weaknesses in various parameters of digital readiness. The enterprise has not reached the required level of technological infrastructure, organizational support, information capabilities, personnel skills and understanding of customer needs required for effective digital transformation.
40 ≤ DRI < 55	Below average readiness	Despite some efforts to ensure enterprise digital readiness, there are areas for improvement. The company began to invest in digital technologies and initiatives, but in the identified areas of activity there are problems that need to be eliminated.
55 ≤ DRI < 70	Average readiness	Indicates moderate readiness for digitalization. The organization has made significant progress in some areas, but there are still areas that need further development to ensure an effective digital transformation.
70 ≤ DRI < 85	Above average readiness	Indicates high digital availability. The company ensures the reliable functioning of most of the parameters of digital transformation and is fully capable of applying digital technologies in order to gain competitive advantages.
DRI ≥ 85	High readiness	Reflects exceptional digital readiness. The company excels in all aspects of digital transformation, demonstrating a powerful technological infrastructure, a favorable organizational culture, reliable data processing capabilities, well-developed human resources and a deep understanding of customer needs.

The developed method provides a systematic approach to assess digital readiness of industrial enterprises by considering various dimensions critical to digital transformation.

3 Results

Based on the analysis of academic literature and state policy, several major barriers and opportunities for industry digitalization in Russia have been identified. While there is a growing demand for information and communication technologies in the industrial sector, along with the necessary technological infrastructure, the level of investment may not always meet the required scale. Limited investment often hinders the adoption of digital solutions, impeding progress. Russia’s investment in advanced technologies is lower than that of Western countries, indicating the need for increased funding for digital solutions. Additionally, the Russian industry heavily relies on imported technologies and solutions for digitalization, highlighting a lack of a robust domestic market for digital products [19].

Another significant barrier is the availability of personnel, as adequate skills and talent are essential for implementing and managing digital solutions. The shortage of skilled professionals, coupled with the lack of educational programs in areas such as data analytics, cybersecurity and software development, is mentioned in a number of papers as a barrier to successful digital transformation of enterprises [3, 11, 12]. The rapid evolution of the digital economy necessitates ongoing learning and adaptation, which is not typically integrated into traditional education models [14].

Compatibility problems, data silos, and resistance to change within organizations may slow down the integration process, posing challenges for digitalization. Digital transformation entails fundamental changes in corporate governance, culture and technological chains, not just the introduction of high-tech equipment and software [4]. Some companies may resist digital transformation due to a lack of understanding or willingness to change [13]. It should also be noted that the success of digital transformation largely depends on the relevant regulatory framework, which in Russia is not clear and comprehensive enough. In Russia, the concept of the digital economy is often narrowly defined and associated primarily with e-commerce, while in the global perspective it covers a wider range of activities using digital technologies.

Successful digital transformation opens up new opportunities for further development of enterprises. Among them may be the possibilities of state support, since Russia has launched a national program focused on the development of the digital economy, designed to provide a basis for supporting and stimulating efforts for digital transformation in the industrial sector. In addition, digitalization can be stimulated by the development of digital technology standards and legislative regulation of such phenomena as crowdfunding activities [11].

There is a significant and growing demand for digital solutions in industries such as manufacturing, energy and transportation. Meeting this demand presents opportunities for technology providers and service companies to develop and offer innovative digital products. The use of advanced technologies offers new possibilities for optimizing production processes, improving efficiency and enhancing competitiveness. Despite the initial investment, digital transformation can lead to reduced current expenses through automation and optimization of processes [4].

The long-term outcome of digital transformation might involve strategic public-private partnerships, facilitating knowledge sharing, technology transfer and the development of tailored solutions [3, 18]. Shifting towards private investment is also discussed by scholars and practitioners as a possible solution for accelerating the adoption of promising digital technologies, with leading Russian IT companies playing a significant role [19]. It is also important to emphasize that the COVID-19 pandemic has accelerated digitalization, even in the industrial sector, making online tools essential. Enterprises have been adapting to new realities and rebuilding value chains. Other plausible solutions include creating competency models and personal paths for developing digital skills, providing state support for educational startups, technology ventures and adopting talent development programs [14].

To ensure successful digital transformation within the economic systems of industrial enterprises, it is necessary to apply corresponding mechanisms and tools tailored to their specific needs. These mechanisms should encompass a range of strategies aimed at facilitating the entire process of digitalization, from initial assessment to implementation and beyond. One crucial aspect is the development of methods for digital readiness assessment, enabling enterprises to evaluate their current technological infrastructure, workforce capabilities, and organizational readiness for digital transformation [5, 10]. Digital readiness assessment tools should provide a holistic view of an enterprise's readiness for digital transformation. This includes evaluating technological capabilities, such as existing IT infrastructure, compatibility with digital solutions, and cybersecurity measures. Additionally, evaluating the skills and competencies of the workforce is essential to identify areas that

require upskilling or reskilling to effectively utilize digital technologies. Alongside assessment tools, there is a need to develop frameworks and guidelines that provide step-by-step guidance throughout the digital transformation process. Such guidelines should outline best practices, potential challenges and mitigation strategies, empowering enterprises to navigate the complexities of digitalization with confidence.

The authors attempted to develop a method for assessing digital readiness of industrial enterprises and tested it on a company ‘N’, engaged in manufacturing packaging products. Five experts, including company employees and scholars, assessed enterprise’s digital readiness across five dimensions using the standardized scoring criteria provided. The results of the assessment made by the experts are given in Table 5.

Table 5. Expert scores for assessing digital readiness of the selected company

Dimension	Variable	Score				
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Technology readiness	infrastructure	3	3	2	3	2
	software systems	4	3	3	3	3
	connectivity	4	4	5	3	4
	cybersecurity	2	2	3	3	3
Organizational culture	leadership support	3	3	4	3	3
	innovation culture	3	4	4	5	3
	change management	4	4	4	4	4
	collaboration	4	3	4	4	5
Data capabilities	data quality	3	3	4	3	3
	analytics tools	4	4	4	3	4
	data governance	3	3	3	4	4
	integration capabilities	2	3	3	4	3
Skills	digital skills training	3	3	4	4	3
	talent acquisition	4	4	3	4	3
	upskilling programs	2	2	3	3	2
	cross-functional collaboration	3	4	4	3	4
Understanding customer needs	market research	3	4	3	3	3
	customer feedback mechanisms	4	3	3	4	3
	personalization capabilities	2	2	2	3	2
	responsiveness	3	3	2	4	3

Based on the expert scores provided in Table 5 the index of the company’s digital readiness is calculated and presented in Table 6.

Table 6. Calculation of DRI for the selected company

Dimension	Sum of scores	Weight	Weighted Score
Technology readiness	62	0.25	15.5
Organizational culture	75	0.2	15
Data capabilities	67	0.18	12.06

Skills	65	0.22	14.3
Understanding customer needs	59	0.15	8.85
Index of digital readiness (DRI)			65.71

The obtained results indicate a moderate level of digital readiness within the selected enterprise. With a weighted score of 15.5 out of 25 for technology readiness, significant progress has been made in software systems and connectivity. However, there is noticeable room for improvement, particularly in infrastructure and cybersecurity. Regarding organizational culture, the enterprise receives a score of 15 out of 20, reflecting a robust culture supportive of digital transformation. Nonetheless, there remains untapped potential for further enhancement, particularly in fostering innovation and collaboration.

In terms of data management, the enterprise faces certain problems, as evidenced by the assessment of information capabilities by 12.06 points out of 18. While there are strengths in data quality and analytical tools, there is an urgent need to improve data management processes and integration opportunities to improve the reasonableness of data-driven management decisions. Experts rated personnel skills at 14.3 points out of 22, which indicates that the company has managed to build a reliable system for training personnel in digital skills and attracting talent. Nevertheless, there are opportunities to develop cross-functional cooperation and advanced training in order to adapt personnel to technological advances.

The parameter for understanding customer needs received a score of 8.85 points out of 15. Accordingly, the company demonstrates readiness in this area below average. Some attention is paid to market research and customer feedback mechanisms, there are noticeable gaps in personalization opportunities and responsiveness. Closing these gaps is critical to increasing customer engagement and satisfaction.

The use of the developed method made it possible to identify problematic aspects associated with the digitalization of the activities of the selected company. To stimulate digital transformation, the management of the N industrial enterprise must first focus on these key areas. First, updating and improving the technological infrastructure will ensure the effective implementation of the company's digital initiatives. Equally important is implementing robust cybersecurity measures to protect digital assets and maintain data integrity in the digital environment. In addition, it is important to prioritize strengthening the enterprise's data management and integration capabilities as it is necessary to ensure information quality, security, and compliance. Understanding customer needs is another important aspect of a successful digital transformation.

Investing in market research best practices and enhancing personalization capabilities will enable the company to provide customized products and services that meet individual customer needs. Setting clear key performance indicators and monitoring mechanisms plays an important role in tracking progress and ensuring the effectiveness of actions in the field of digital transformation of the enterprise.

4 Discussion

The method proposed in this study for assessing the degree of readiness of industrial enterprises for digital transformation reflects a structured and comprehensive approach to assessing various aspects critical to the successful digitalization of business systems. Analysis of technological readiness, organizational culture, information capabilities, staff skills and understanding of customer needs provides a holistic view of enterprise readiness for digital transformation. In comparison, capability maturity models assess the maturity of an organization in different areas, but often focus on process maturity rather than specific aspects of digital readiness, potentially overlooking qualitative aspects such as organizational culture or customer understanding [8, 17]. Existing digital maturity assessment practices

often provide an analysis of a company's current health rather than identifying specific areas for improvement or prioritizing strategic intervention. In addition, various methods for assessing an organization's readiness for digital transformation are based on an analysis of factors such as leadership, strategy, culture and technology. Using a systematic approach, these methods may not take into account the specifics of an industrial enterprise, paying more attention to general organizational factors, rather than industrial problems and opportunities [10, 17].

The method proposed in this study has a number of strengths. The use of peer reviews from both employees and external consultants increases the credibility of the assessment. Covering a wide range of aspects of digital transformation provides a more thorough assessment of enterprise digital readiness. The involvement of experts with different experience and knowledge allows you to synthesize these knowledge and judgments, increasing the reliability and reliability of the assessment. The method involves assigning customized significance coefficients to each parameter based on the unique priorities and strategic goals of the enterprise, which allows for a specialized assessment. However, there are some limitations to this solution. In particular, reliance on expert opinions introduces subjectivity and potential bias into the evaluation process, which can affect the accuracy and reliability of results.

This problem is partially solved by involving experts with different experience and using standardized assessment criteria. However, completely eliminating this problem is a difficult task. In addition, while peer review methods provide sufficient insight into an enterprise's current digital readiness, they may have limited predictive power in predicting future trends and challenges. Because digital transformation is a continuous and dynamic process, evaluation results can quickly become outdated.

To enhance the credibility of the suggested method, several considerations could be addressed in further research. Conducting rigorous validation studies, both internally within different industrial enterprises and externally across industries, can strengthen the validity and generalizability of the assessment method. Incorporating objective metrics, such as quantitative performance indicators or benchmarks, alongside subjective judgements can provide a more balanced and comprehensive assessment of digital readiness [2]. This modification would improve the suggested method by diversifying the toolset applied for digital readiness assessment with quantitative evaluation.

5 Conclusions

In conclusion, this study underscores the critical importance of assessing industrial enterprise readiness for digital transformation in navigating the rapidly evolving digital landscape. Main barriers and opportunities of digitalization of Russian industrial companies are determined. The method is developed for assessing digital readiness of industrial enterprises, enabling them to evaluate key dimensions such as technology readiness, organizational culture, data capabilities, skills, and understanding of customer needs. Testing it on the selected company, specializing in packaging products manufacturing and sales, showed that by leveraging expert judgement and encompassing a diverse range of perspectives, the method provides valuable insights into an enterprise's preparedness for digital transformation, thereby facilitating informed decision-making and strategic planning. Further research could focus on enhancing the credibility of the assessment method, for instance, by integrating quantitative metrics alongside expert judgements to provide a more balanced and nuanced assessment of digital readiness.

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