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Identification and Analysis of Readiness Factors for Quality 4.0 Implementation: A Case of Serbia

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Abstract:

Research Question: What are the key factors influencing company readiness for implementing Quality 4.0, and how are these factors interrelated in ISO 9001:2015-certified companies in Serbia? **Motivation:** Although Quality 4.0 promises improvements in efficiency, decision-making, and customer value, empirical evidence on organisational readiness in developing and transition economies, including the Western Balkans, is still limited. Understanding readiness in this context is important for planning realistic implementation strategies. **Idea:** The study identifies and analyses readiness factors for Quality 4.0, examines their relationships, and proposes a model for assessing company readiness that combines factor-based and overall assessments across people, technology, and process dimensions. **Data:** A cross-sectional questionnaire survey was conducted among employees of ISO 9001:2015-certified companies in Serbia. The questionnaire was sent to more than 1,500 companies using a list-based email frame derived from public registers, resulting in 184 valid responses (an estimated response rate of around 12%). The instrument included general questions, subjective readiness ratings, and 65 items grouped into 13 readiness factors. **Tools:** Descriptive statistics were used to describe readiness levels. Reliability was assessed with Cronbach's alpha test. Pearson correlation analysis examined relationships between the factors and overall readiness, while t-tests and one-way ANOVA tested differences in readiness perceptions across respondent and company characteristics. **Findings:** Objective readiness was assessed as medium (overall mean 3.4 on a five-point scale), while subjective readiness was somewhat lower (mean 3.0). Top management support had the highest readiness score (M = 4.05), while integration of processes and systems (M = 2.31) and use of modern technology (M = 2.85) had the lowest scores. All readiness factors were positively and significantly correlated with overall readiness at the 1% level; use of modern technology showed the strongest correlation (r = .623), and customer focus the weakest (r = .303). **Contribution:** The study offers an empirically tested model for assessing Quality 4.0 readiness in a developing economy, combining people, technology, and process factors in a single framework. The results provide guidance for managers and policymakers in prioritising actions for Quality 4.0 implementation and form a basis for comparative and longitudinal research on Quality 4.0 readiness.

Keywords: readiness factors, human potential, technology, processes, implementation, Republic of Serbia, Western Balkans

JEL Classification: L23, L25, L29

1. Introduction

Quality 4.0 refers to the fourth phase in the evolution of quality management (Chiarini and Kumar, 2022). It represents an advanced practice of actions and management methods (Vlastaridou et al., 2022), based on the use of modern technologies (Dias et al., 2022; Sader et al., 2022). Quality 4.0 pertains to the future of quality and organizational excellence (Turner & Oakland, 2021). It is believed that the integration of traditional quality management with technological capabilities will completely transform the approach to quality in manufacturing units (Christou et al., 2022; Liu et al., 2023; Sureshchandar, 2023). Quality management will become more efficient (Fonseca et al., 2021) and effective (Broday, 2022), improve product performance

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(Que et al., 2023), enable real-time process monitoring (Mittal et al., 2022), accelerate decision-making and improve its quality (Arsovski, 2019; Rifqi et al., 2021), increase user satisfaction (Bodi, 2020), optimize costs (Singh et al., 2022), and more. In the existing body of literature, Quality 4.0 is often described as the digital transformation of quality management, in which Industry 4.0 technologies such as the Internet of Things, cyber-physical systems, advanced data analytics, artificial intelligence, and cloud computing are integrated with established quality principles and tools (Abnoulgid et al., 2025; Bousdekis et al., 2023; Liu et al., 2023; Oliveira et al., 2024; Ranjith Kumar et al., 2022; Sader et al., 2022; Zonnenshain & Kenett, 2020). This concept extends traditional approaches by linking real-time data collection, automated process control, and predictive analytics with continual improvement, risk-based thinking, and customer focus. As a result, Quality 4.0 is not limited to technology adoption; it also requires changes in leadership behaviour, organisational culture, employee skills, and process design so that people, technology, and processes are aligned in one integrated system.

The first step in the successful implementation of Quality 4.0 is the assessment of the company's readiness (Sureshchandar, 2022; Zulfiqar et al., 2023) to manage quality in Industry 4.0 (Conde et al., 2022), as the evolution of quality lags behind technological evolution (Maganga and Taifa, 2022a). Readiness assessment is important as it determines priorities, plans actions, allocates resources, and more. A lack of clear insight into the current state of the company's readiness cannot ensure the stabilization of the implementation process (Dias, 2021).

Despite the growing body of work on Quality 4.0, several gaps remain. Many empirical studies focus on large manufacturing economies or specific sectors and often examine a limited set of readiness factors (Antony et al., 2023; Maganga & Taifa, 2022; Nenadal et al., 2022; Sommerhoff, 2021; Zulfiqar et al., 2023). Evidence from transition economies and from contexts where digital infrastructure and human resources are still developing, such as the Western Balkans, is still scarce. In addition, only a small number of contributions combine a systematic literature-based identification of readiness factors with quantitative testing of their interrelationships within one integrated model (Liu et al., 2023; Oliveira et al., 2024; Ranjith Kumar et al., 2022; Sureshchandar, 2023). This study addresses these gaps by developing and empirically testing a readiness model for Quality 4.0 in ISO 9001:2015-certified companies in Serbia, focusing on the interplay between people, technology, and process factors and on the differences between subjective and objective readiness assessments.

Reviewing the current literature on Quality 4.0, the factors influencing company's readiness were first identified, followed by an analysis of their interrelationships and the determination of which factors have the greatest or least impact on readiness. Finally, a theoretical model was presented, which can be used to assess the company's readiness.

2. Related Works

Research on Quality 4.0 readiness has identified key factors across various industries and regions. Antony et al. (2023) studied 147 senior management professionals from America, Asia, and Europe, identifying 8 readiness factors. Alzahrani et al. (2021) focused on higher education institutions, identifying 11 factors influencing their transformation. Industry-specific studies also provide valuable insights. Arsic et al. (2022) applied the Entropy-TOPSIS method to evaluate ISO 9004-2018 elements, identifying 7 readiness factors. Khourshed and Gohar (2023) developed a methodological roadmap for the service sector, identifying 20 factors. Maganga and Taifa (2022) explored the transition from traditional quality methods to Quality 4.0, identifying 13 factors. Mittal et al. (2023) examined the furniture industry, defining 19 readiness factors across 4 dimensions. Maturity assessments also contribute to understanding readiness. Mtotywa (2022) developed a Quality 4.0 maturity index based on 7 dimensions and 28 factors, while Mtotywa and Dube (2023) identified 8 factors in the mining industry. Nenadal et al. (2022) assessed Czech companies, identifying 22 factors across four dimensions. Regional studies further expand the perspective. Salimbeni et al. (2023) examined knowledge flow in Argentina, identifying 10 factors across four dimensions. Schneider (2021) categorized 8 factors in management and operational levels. Sony et al. (2020) surveyed European and American respondents, identifying 8 factors related to motivations and barriers.

Additional studies include Subramaniam (2021), who assessed the technological impact on quality professionals in Malaysia, Zulfiqar et al. (2023), who presented a self-assessment tool based on 5 factors, and Zulqarnain et al. (2022), who studied developing countries, identified 10 readiness factors. These studies collectively provide a comprehensive understanding of Quality 4.0 readiness across different sectors and regions. Beyond individual readiness studies, several authors have examined Quality 4.0 from a broader

conceptual and strategic perspectives. Recent literature reviews describe how Quality 4.0 combines digital technologies, data analytics, and traditional quality principles and summarise different maturity models and capability frameworks that organisations can use to plan their transformation (Bousdekis et al., 2023; Hafid et al., 2025; Illes et al., 2017; Liu et al., 2023; Oliveira et al., 2024; Ranjith Kumar et al., 2022; Sader et al., 2022). These reviews point out that many contributions focus on technological solutions and performance outcomes, while the integration of people and process-related aspects is still less developed, especially in empirical work. Other studies analyse Quality 4.0 from a strategic point of view and show that leadership, organisational culture, and stakeholder involvement can be as influential as technology-related factors when organisations invest in digital quality initiatives (Carvalho et al., 2024; Rico et al., 2024; Salimbeni et al., 2023).

In addition, bibliometric and mapping studies show that most published research on Quality 4.0 comes from industrialised economies and from sectors with strong manufacturing traditions (Alsadi et al., 2025; Maganga & Taifa, 2022; Nenadal et al., 2022). There is still a lack of empirical data from developing countries and small transition economies and limited evidence on how existing readiness models behave in such settings. Studies from Tanzania, the Czech Republic, South Africa and other contexts report different sets of dominant factors and different maturity levels, which suggests that contextual variables such as infrastructure, regulatory environment, and human capital may influence readiness profiles in a systematic way (Maganga & Taifa, 2022; Mtotywa, 2022; Mtotywa & Dube, 2023; Nenadal et al., 2022; Zulqarnain et al., 2022). The present study contributes to this stream by applying a readiness model in the context of Serbian ISO 9001:2015-certified companies and by providing empirical evidence that can be compared with results from other countries in future research.

3. Western Balkans Background and Serbia's Thematic Role

The Western Balkans faces challenges in business modernization due to underdeveloped infrastructure, a shortage of skilled personnel, and an organizational culture that tends to resist change. The specific challenges encountered by this region differ from those faced by developed countries, making this research unique, while also relevant for other developing nations.

The commitment of companies to quality and continuous improvement is evident from the high level of ISO 9001:2015 certification in the region. In 2022, a total of 8,513 certificates were issued (ISO, 2022). Of this number, over 70% of the certificates were in Serbia and Croatia, with more than 40% in Serbia alone, making the research sample in Serbia representative of the implications for Western Balkan countries.

The implementation of Quality 4.0 could significantly contribute to the economic development of the Western Balkans and its competitiveness in the global market. However, despite this potential, there are still no signs of successful implementation, nor is there existing literature reporting similar research.

The questionnaire was sent to over 1,500 email addresses of certified companies. The sample was formed based on publicly available data on certified companies, ensuring valid generalization of the results to the entire population and reducing the likelihood of bias.

4. Methodology

4.1 Research questions

The research questions guiding this study were related to the identification of readiness factors and the analysis of their relationships. The first and fundamental step in creating a theoretical model for assessing organizational readiness and subsequently developing a questionnaire for conducting the research concerns the identification of readiness factors. Based on this, the first research question was as follows:

RQ1. What are the readiness factors for the implementation of Quality 4.0 in companies?
To determine the validity of the readiness factors for the implementation of Quality 4.0, it was necessary to examine their relationship and determine the correlation among them. For this reason, the second research question was as follows:

RQ2. What is the relationship between the readiness factors for the implementation of Quality 4.0 in companies?

Through identifying the factors with the greatest and least impact within a specific geographical framework, a more comprehensive understanding of the organization's readiness assessment for the implementation of Quality 4.0 would be achieved. Therefore, the third research question was as follows:

RQ3. Which factors have the greatest/least impact on a company's readiness for Quality 4.0 implementation in the context of Serbia as a representative region of the Western Balkans?

4.2 Research design

A systematic literature review (according to Page et al., 2020) was conducted to identify key factors influencing Quality 4.0 readiness. Studies were selected based on relevance, accessibility, design quality, and outcome measures, with only those passing a qualitative analysis included. A theoretical model was then developed based on the identified factors.

The research employed a structured questionnaire featuring general questions, subjective statements, and factor-based items. Responses were analyzed using a five-point Likert scale to evaluate relationships between factors. Pearson correlation analysis ranked the factors by impact. Descriptive statistics and specialized software tools were used for data processing. In terms of sampling, the target population comprised all ISO 9001:2015-certified companies in Serbia listed in national and certification bodies' registers. Using these registers, a list-based email frame was created and the questionnaire was sent to more than 1,500 companies, which corresponds to a census-type approach within the available population frame. A total of 184 fully completed questionnaires were returned, giving an estimated response rate of around 12%. Only one response per company was retained, and all respondents reported that their work was directly related to quality management.

Data analysis was carried out in several steps. First, the reliability of each multi-item factor was evaluated using Cronbach's alpha. Second, descriptive statistics (mean, standard deviation, skewness, kurtosis, and coefficient of variation) were computed for all readiness factors and for the overall readiness score. Third, Pearson correlation coefficients were calculated to examine the relationships between the readiness factors and overall readiness. Finally, independent-samples t-tests and one-way ANOVA were used to test differences in readiness perceptions across groups defined by familiarity with Quality 4.0, job position, work experience, and company size, with a significance level of 0.05. All analyses were performed using standard statistical software.

The study aimed to identify and categorize readiness factors, develop a theoretical model, and analyze interrelations between factors affecting Quality 4.0 implementation. Key tasks included factor identification, justification, and interrelation analysis, as well as the creation of a questionnaire for ISO 9001:2015 certified companies in Serbia. The collected data provided insights into readiness levels, highlighting key correlations and the impact of different factors on the implementation process.

5. Research findings

5.1 Identification of readiness factors

The study identified key readiness factors for Quality 4.0 by analyzing 15 selected sources from an initial pool of 1,560. The identified factors were categorized into 3 dimensions: people, technology, and processes, following Aichouni and Alshamari (2022).

The people dimension includes factors significant for organizational transformation. Top management support is essential for driving innovation, removing obstacles, and achieving comprehensive quality. Leadership plays a key role in motivating and empowering employees, which is vital for successful Quality 4.0 implementation (Yadav et al., 2021a). A clear vision and strategy help guide companies in adopting this concept, while organizational culture must embrace change to support necessary transformations. Additionally, managers need knowledge and competencies beyond leadership skills, including modern technology expertise and quality management best practices (Tadic et al., 2021). Continuous employee training is also necessary due to the growing presence of technological innovations (Zavadska & Zavadsky, 2020).

The technology dimension highlights the importance of modern tools in Quality 4.0 adoption. The use of modern technology is fundamental, as it improves quality and ensures consistency in operations (Bowers & Pickerel, 2019; Illes et al., 2017; Sader et al., 2019; Sommerhoof, 2021). Big data and analytics enable

companies to process vast amounts of data efficiently (Balouei Jamkhaneh et al., 2022; Gudivada et al., 2021; Haltenburg, 2019; Shamim et al., 2019), offering real-time reporting (Bousdekis & Mentzas, 2021) and visualization capabilities (Faheem et al., 2021). The use of applications facilitates real-time data transfer, supporting engagement and collaboration. Scalability is also a significant factor, ensuring the adaptability of business systems to changing demands.

The processes dimension focuses on system integration and strategic orientation. Process and system integration is essential for interconnected manufacturing environments and value chain optimization (Joo, 2017). Customer focus, while not the primary driver, plays a role in personalization, profitability, and sustainability (Haleem & Javaid, 2019; Li et al., 2021; Tadic Stanic, 2023; Villalba-Diez et al., 2019). Finally, supplier orientation is improved through modern technology, simplifying and strengthening relationships between companies and suppliers.

Table 1 presents the dimensions, factors, and items of company readiness for the implementation of Quality 4.0; it briefly explains the importance of each factor and lists the sources of the studies where the data were found.

Table 1: Dimensions, Factors, and Items of Readiness for the Implementation of Quality 4.0

Dimensions:	Factors:	Items:	The importance of the readiness factor:	Sources:
People	Top management support	Commitment to quality – F1Q1	The understanding of the importance of implementing the concept by top management is significant for the successful implementation of Quality 4.0. The allocation of resources will influence the intensity of investments in modern technology, employee training, and motivation.	(Antony et al., 2023; Antony et al., 2023a; Ali & Johl 2022; Dias, 2021; Jbeily, 2022; Maganga & Taifa, 2022; Mtotywa, 2022; Schneider, 2021; Sony et al., 2020; Sony et al., 2021; Yadav et al., 2021; Zhao et al., 2023)
		Support for quality improvement – F1Q2		
		Emphasizing the importance of quality – F1Q3		
		Provision of resources – F1Q4		
		Collaboration with consultants – F1Q5		
	Leadership	Commitment to quality - F2Q1	Resistance to change and employee dissatisfaction are common occurrences when implementing something new. The role of a leader is to motivate, inspire, and guide employees to bridge the gap between the current and desired ways of performing business processes.	(Alzahrani et al., 2021; Armani et al., 2021; Arsic et al., 2022; Nenadal et al., 2022; Schneider, 2021; Seo et al., 2021; Sony et al., 2021; Thekkoote, 2022; Yadav et al., 2021; Zulfiqar et al., 2023; Zulqarnain et al., 2022)
		Encouraging teamwork – F2Q2		
		Managing the pace of change – F2Q3		
		Motivation and empowerment – F2Q4		
		Inspiring employees – F2Q5		
	Vision and strategy	Targeted quality application – F3Q1	It is significant for the company's vision and strategy to be infused with the concept of Quality 4.0. In this way, it will be defined what kind of quality the company aims to achieve in the future and how it will accomplish its goal.	(Antony et al., 2020; Antony et al., 2023a; Alzahrani et al., 2021; Maganga & Taifa, 2022; Mtotywa, 2022; Nenadal et al., 2022; Schneider 2021; Sony et al., 2020; Sony et al., 2021)
		Alignment with quality – F3Q2		
		Clear communication of strategy – F3Q3		
		Integration with methodologies – F3Q4		
		Understanding of vision and strategy - F3Q5		

Dimensions:	Factors:	Items:	The importance of the readiness factor:	Sources:
	Organizational culture	Clear communication – F4Q1	The application of modern technology in quality involves new work methods, innovative knowledge and skills, as well as an adaptable organizational culture. Embracing change is significant for the future success of the company.	(Antony et al., 2023; Alzahrani et al., 2021; Maganga & Taifa, 2022; Jacob et al., 2017; Juran, 2019; Schneider, 2021; Seo et al., 2021; Sony et al., 2020; Thekkoote, 2022; Zulfiqar et al., 2023; Zulqarnain et al., 2022)
		Planned resolution of uncertainties – F4Q2		
		Encouragement of change – F4Q3		
		Involvement of change catalysts – F4Q4		
		An environment conducive to change – F4Q5		
	Knowledge and competencies of managers	Awareness of the importance of quality – F5Q1	The role of quality experts will become increasingly dynamic, challenging, and versatile. Managing Quality 4.0 involves addressing complex problems, the need for extensive knowledge, emotional competence, and more.	(Antony et al., 2020; Dias, 2021; Jacob et al., 2017; Juran, 2019; Kupper et al., 2019; Santos et al., 2021; Sony et al., 2021; Yadav et al., 2021)
		Knowledge of quality tools – F5Q2		
		Daily quality management – F5Q3		
		Attending relevant training – F5Q4		
		Emotional competence – F5Q5		
	Employee training	Conducting training – F6Q1	Organizing various types of training for employees promotes their professional development. In this way, employees are prepared for new roles related to creating quality products or services, i.e., implementing Quality 4.0.	(Ali & Johl, 2022; Babatunde, 2021; Barsalou, 2023; Breque et al., 2021; Cudney & Keim, 2017; Frey & Osborne, 2017; Kendirli & Berksun, 2020; Kupper et al., 2019; Santos et al., 2021; Schneider, 2021)
		Assessment of training needs – F6Q2		
		Rewards and recognition - F6Q3		
		Incentive programs – F6Q4		
		Knowledge testing – F6Q5		
Technology	Use of modern technology	Familiarity with modern technologies – F7Q1	Innovative technology improves the functionality of the quality system, improves the interaction of people focused on achieving quality, and ensures optimal decision-making, transparency, traceability, and repeatability.	(Antony et al., 2022; Antony et al., 2023a; Chatterjee & Chaudhuri, 2021; Maganga & Taifa, 2022; Mtotywa & Dube, 2023; Mtotywa et al., 2022; Nenadal et al., 2022; Johnson, 2019; Juran, 2019; Kupper et al., 2019)
		Automation – F7Q2		
		Digitalization – F7Q3		
		Remote monitoring devices – F7Q4		
		Intelligent devices – F7Q5		
	Big data and analytics	Access to information – F8Q1	The digitized approach to data processing ensures reliable, timely, and relevant information. Quality Management 4.0, based on Big Data, involves making data-driven decisions.	(Ali & Johl, 2022; Carvalho et al., 2020; Dogan & Gurcan, 2018; Support & Gardner, 2022; Juran, 2019; Mittal et al., 2023; Mtotywa & Dube, 2023; Nenadal et al., 2022; Schneider, 2021; Zonnenshain i Kenett, 2020)
		Data for decision-making – F8Q2		
		Data management – F8Q3		
		Advanced analytics – F8Q4		
		AI-based analyses – F8Q5		

Dimensions:	Factors:	Items:	The importance of the readiness factor:	Sources:
	Application implementation	Paperless system – F9Q1	The application of software refers to the technological integration of the organization with its employees. The significance of using applications lies in the real-time data transfer.	(Alzahrani et al., 2021; Jacob, 2017; Juran, 2019; Thekkoote, 2022; Villarroel Ordenes & Zhang, 2019; Zheng et al., 2018; Zulqarnain et al., 2022)
		Application usage – F9Q2		
		Ease of use – F9Q3		
		Frequent updates of applications – F9Q4		
		Automatic data feed – F9Q5		
	Scalability	Adaptability and scalability – F10Q1	Scalability is important due to the growth in the number of users, operations, or data. It refers to the ability of a system, process, or technology to adapt to changes in workload, market demands, and other factors.	(Alzarani et al., 2021; Jacob, 2017; Juran, 2019; Khourshed & Gohar, 2023; Thekkootee, 2022; Xu & Duan, 2019; Zulqarnain et al., 2022)
		Easy data processing – F10Q2		
		Data availability – F10Q3		
		Efficient data search – F10Q4		
		Multiple users simultaneously – F10Q5		
Processes	Integration of processes and systems	Remote inventory monitoring – F11Q1	Process and system integration ensures the forecasting of future needs, such as required inventory, repairs, maintenance, and similar aspects.	(Mtotywa, 2022; Mtotywa & Dube, 2023; Seo et al., 2021)
		Remote product tracking – F11Q2		
		PVC management software – F11Q3		
		Machine communication – F11Q4		
		Intelligent control/inspection – F11Q5		
	Customer focus	Understanding customer preferences – F12Q1	One of the key characteristics of Quality 4.0 is personalized production. The focus on customers enables personalized manufacturing, strengthens market competitiveness, and increases revenue.	(Ali & Johl, 2022; Efimova & Briš, 2021; Maganga & Taifa, 2022; Mtotywa, 2022; Khourshed & Gohar, 2023; Osakwe, 2020; Schneider, 2021; Sony et al., 2021; Wechsler & Schweitzer, 2019)
		Customer feedback – F12Q2		
		Customer involvement in creation – F12Q3		
		Observing future requirements – F12Q4		
		Complaint collection system – F12Q5		
	Supplier orientation	Supplier management system – F13Q1	Supplier orientation enables optimal procurement of raw materials or goods, with the expected quality. A good selection of suppliers contributes to better product quality at more affordable prices.	(Ali & Johl, 2022; Efimova & Briš, 2021; Maganga & Taifa, 2022; Mtotywa, 2022; Khourshed & Gohar, 2023; Osakwe, 2020; Schneider, 2021; Sony et al., 2021; Wechsler & Schweitzer, 2019)
		Supplier performance evaluation – F13Q2		
		Quality assurance – F13Q3		
		Cooperation and commitment – F13Q4		
		Transmission of customer suggestions – F13Q5		

5.2 Theoretical model and hypothesis

The descriptive analysis of the factors and their items, which could indicate the readiness of companies for the implementation of Quality 4.0, in accordance with the set objectives and research tasks, led to the establishment of the theoretical model (Figure 1). Following the example of the "Impuls-Industry 4.0 Readiness" model (Lichtblau et al., 2015), considered one of the most comprehensive and well-founded models (Rahamaddulla et al., 2021), a theoretical model was created to demonstrate the validity of the existence, analysis, and examination of the relationships between readiness factors. Ultimately, it serves to assess overall readiness for the implementation of Quality 4.0, based on which the hypothesis H0 was set:

(H0): It is possible to create a model for assessing readiness for the implementation of Quality 4.0 based on identified factors.

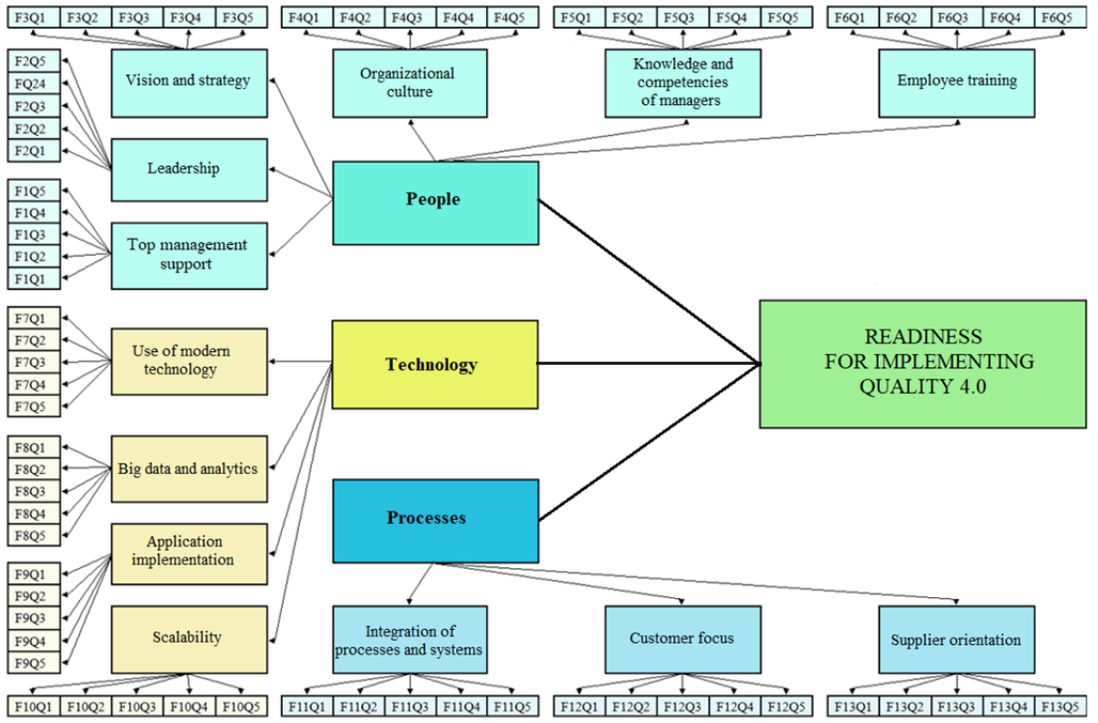

Figure 1: Theoretical model of company readiness for implementing Quality 4.0

After identifying the factors and creating the readiness model, using appropriate software tools, the relationships between the factors were determined and their correlation with readiness for implementing Quality 4.0 was measured. The obtained results can contribute to a better understanding of the interdependent relationships between the factors and their impact on company's readiness. Based on the previous, the first auxiliary hypothesis was:

(H1): It is possible to determine the interrelationships between factors and their correlation with readiness for Quality 4.0.

Through measuring the correlation of factors with the company's readiness, it is possible to identify those with the greatest and least impact. Such insights are significant for a complete understanding of the company's readiness, as well as for later creating a plan to achieve full readiness. Based on this, the second auxiliary hypothesis is formulated as follows:

(H2): It is possible to identify the factors that most/least affect the company's readiness for implementing Quality 4.0.

5.3 Presentation of statistical data processing results

The sample selection for the research and respondents was made with consideration for representativeness, ensuring the results could be generalized to the Serbian economy and, implicitly, the Western Balkans. The study included 184 respondents, with those in the quality sector occupying positions such as: quality directors (15%), quality managers (36%), and quality engineers (7%). The remaining 42% consisted of employees in other roles, such as company directors or professional associates, but whose activities were related to quality.

The respondents were categorized based on their work experience: up to 5 years (29%), 5–15 years (45%), and over 15 years (26%), in order to examine the differences in responses based on experience in the field of quality.

The companies were categorized based on size into micro (up to 10 employees, 9.8%), small (10–49 employees, 29.3%), medium (50–249 employees, 33.7%), and large (250+ employees, 27.2%) in order to analyze readiness in relation to the number of employees.

The majority of the sample consisted of indigenous companies, established and predominantly operating in Serbia (83.1%), while 74% of the surveyed companies had a market focus on Serbia. The aim of these divisions was to identify key factors and potential differences in the readiness of companies, considering the respondents' work experience, company size, domestic nature, and market focus. For clarity and transparency, the general characteristics of the respondents and their companies are summarized in Table 2. The table presents the distribution of respondents by job position, work experience, and the size, origin, and market focus of their companies. This overview provides a clear context for the interpretation of subsequent statistical analyses and supports the representativeness of the sample.

Table 2: Respondents' general information

Category	Sub-category	Percentage (%)	Number of respondents
Respondent position	Quality directors	15.0	28
Respondent position	Quality managers	36.0	66
Respondent position	Quality engineers	7.0	13
Respondent position	Other positions connected to quality (e.g., company directors, professional associates)	42.0	77
Work experience	Up to 5 years	29.0	53
Work experience	5–15 years	45.0	83
Work experience	Over 15 years	26.0	48
Company size	Micro (up to 10 employees)	9.8	18
Company size	Small (10–49 employees)	29.3	54
Company size	Medium (50–249 employees)	33.7	62
Company size	Large (250+ employees)	27.2	50
Company origin	Domestic companies	83.1	153
Company origin	Foreign or mixed ownership	16.9	31
Market focus	Domestic market (Serbia)	74.0	136

The internal consistency of the scale was demonstrated by the statistical coefficient values - Cronbach's alpha for each readiness factor. The obtained values range from 0.79 to 0.96, indicating the interconnection of items, consistency of responses, and high reliability of the questionnaire. The obtained values are shown in Table 3.

Table 3: Cronbach's Alpha values for readiness factors for implementing Quality 4.0

Factors of enterprise readiness for the implementation of Quality 4.0	Cronbach's alpha
Top management support	0.88
Leadership	0.96
Vision and strategy	0.89
Organizational culture	0.91
Knowledge and competencies of managers	0.93
Employee training	0.91
Use of modern technology	0.79
Big data and analytics	0.81
Application implementation	0.9
Scalability	0.93
Integration of processes and systems	0.84
Focus on customers	0.81
Orientation to suppliers	0.82

The readiness of the factors was determined using the arithmetic mean of respondents' answers. In addition to the arithmetic mean, values for standard deviation, skewness, kurtosis, and coefficient of variation were also determined (Table 4).

Table 4: Readiness factors for implementing Quality 4.0 and descriptive statistical indicators

Factors:	M:	SD:	Sk:	Ku:	CV:
Top management support	**4.05**	0.93	-1.19	1.09	0.23
Leadership	3.98	1.02	-0.91	0.09	0.26
Vision and strategy	3.79	0.94	-0.91	0.66	0.25
Organizational culture	3.60	1.03	-0.52	-0.31	0.29
Knowledge and compet. of managers	3.83	0.99	-0.86	0.41	0.26
Employee training	3.35	1.11	-0.27	-0.70	0.30
Use of modern technology	**2.85**	1.00	0.43	-0.53	0.33
Big data and analytics	3.40	0.90	-0.38	0.003	0.26
Application implementation	3.39	1.04	-0.45	-0.46	0.31
Scalability	3.74	0.99	-0.6	-0.21	0.27
Integration of processes and systems	**2.31**	1.04	0.66	-0.24	0.45
Focus on customers	3.66	0.95	-0.71	0.20	0.26
Orientation to suppliers	3.60	0.93	-0.59	-0.03	0.26

The impact of general characteristics (of respondents and companies) on the ratings of readiness factors was determined using statistical tests. The results of the t-tests indicate that familiarity with the Quality 4.0 concept influenced the assessment of the following factors: use of modern technology ($t=3.944$; $p<0.001$), big data and analytics ($t=3$; $p<0.01$), employee training ($t=2.28$; $p<0.05$), application usage ($t=2.124$; $p<0.05$), integration of processes and systems ($t=2.663$, $p<0.009$), customer focus ($t=2.773$; $p<0.01$), and supplier orientation ($t=2.822$; $p=0.005$). Respondents were asked to provide their subjective assessment of the readiness of the three dimensions (people, technology, and processes), based on which the overall company readiness (mean value) was calculated from their perspective. The assessment was influenced by the time spent in their current job position (ANOVA, $F(2.136) = 3.266$, $p = 0.041$) and their familiarity with the concept of Quality 4.0 (t-test, $t = 1.973$, $p < 0.01$). On the other hand, based on the ratings of individual readiness factors, an objective assessment of the dimensions and the overall company readiness was conducted. The difference between the respondents' subjective evaluations and the objective perspective is presented in Table 5.

Table 5: Subjective perception and objective assessment of company Readiness for Quality 4.0 implementation

Dimensions of readiness:	Subjective perception:	Objective assessment:
People:	2.9	3.8
Technology:	3.1	3.3
Processes:	3.1	3.2
Overall readiness:	**3.0**	**3.4**

The linear relationship between the readiness factors for the implementation of Quality 4.0 was determined using Pearson's correlation. The results of the correlation between readiness factors and company readiness for the implementation of Quality 4.0 are presented in Table 6.

Table 6: Pearson correlation (relationship between readiness factors and company readiness for the implementation of Quality 4.0)

Factors of readiness for the introduction of Quality 4.0	Company readiness for the implementation of Quality 4.0
Top management support	.460
Leadership	.490
Vision and strategy	.533
Organizational culture	.537
Knowledge and compet. of managers	.488
Employee training	.528
Use of modern technology	.623
Big data and analytics	.468
Application implementation	.434
Scalability	.456
Integration of processes and systems	.501
Focus on customers	.303
Orientation to suppliers	.506

All observed correlations are statistically significant at the 1% level, which implies a high degree of relevance, meaning that there is a low probability that the obtained results are due to chance.

6. Discussion

Based on the systematic review of the literature and analysis of the selected papers, the factors of readiness for the implementation of Quality 4.0 in enterprises have been identified. These factors are concentrated around three main dimensions: people (top management support, leadership, vision and strategy, organizational culture, knowledge and competencies of employees, and employee training), technology (use of modern technology, big data and analytics, application usage, and scalability), and processes (integration of processes and systems, focus on customers, and supplier orientation). Each factor consists of 5 items. Using this set, a model was created to assess the readiness of companies. In line with this, the main hypothesis was confirmed, which stated: It is possible to create a model to assess readiness for the implementation of Quality 4.0 based on the identified factors. The research was conducted using an online questionnaire which, in addition to general questions, included items that enabled the assessment of both subjective perceptions and objective readiness. The results revealed that company readiness, according to the subjective views of respondents, was lower (M=3.0) compared to the objective assessment (M=3.4). The highest-rated factor in terms of readiness was top management support (4.05), while the lowest-rated factor was the integration of processes and systems (2.31). In addition to this, the only other factor rated below 3 was the use of modern technology (2.84). The medium level of readiness observed in Serbian ISO 9001:2015-certified companies is comparable with previous findings from other developing and transition economies, where many organisations are still in the early stages of Quality 4.0 adoption (Maganga & Taifa, 2022; Mtotywa, 2022; Nenadal et al., 2022; Salimbeni et al., 2023; Zulfiqar et al., 2023). Similar to these studies, our results show that companies have started to develop leadership commitment and basic digital initiatives, but that large-scale integration of technologies and processes is still limited. The relatively high scores for top management support and leadership confirm earlier observations that senior commitment is often one of the first elements to develop in Quality 4.0 projects, even when technological capabilities and process integration remain at an intermediate level (Antony et al., 2023; Sony et al., 2021; Rico et al., 2024).

The fact that the use of modern technology has both the lowest mean score and the strongest correlation with overall readiness underscores the central role of digital capabilities in Quality 4.0 (Bousdekis et al., 2023; Carvalho et al., 2024; Liu et al., 2023; Oliveira et al., 2024). This pattern suggests that many companies in the sample are aware of the importance of digital tools but still lack sufficient investments in automation, connectivity, and analytics. The low rating of integration of processes and systems indicates that digital solutions are often applied in isolated areas rather than being embedded in an integrated value chain, which is consistent with maturity studies in manufacturing and mining organisations that report similar gaps

between pilot projects and system-level integration (Khourshed & Gohar, 2023; Mtotywa & Dube, 2023; Salimbeni et al., 2023).

In comparison with previous work that places strong emphasis on customer focus as a driver of Quality 4.0, our results show a more modest role of customer-related practices in explaining readiness in the Serbian context. Studies on Quality 4.0 often link the concept to customer-centric strategies, data-driven personalisation, and service quality (Broday, 2022; Osakwe, 2020; Sader et al., 2022; Sureshchandar, 2023), while our findings point to a stronger concern with internal digital infrastructure and process integration. One possible explanation is that companies in the Western Balkans are still building basic technological and organisational capabilities, so they may prioritise internal improvements before fully exploiting advanced customer analytics and personalised services. Future research could examine whether the role of customer focus increases as organisations move to higher levels of Quality 4.0 maturity.

The standard deviation was on average 1. Skewness was negative for every factor except for the one with the lowest rating. Kurtosis ranged from -0.70 (employee training) to 1.09 (top management support). The coefficients of variation were approximately equal, with the highest deviation recorded for the use of modern technology (0.33) and the lowest for top management support (0.23). Through applying appropriate software tools, the correlation between factors in relation to readiness for the implementation of Quality 4.0 was measured. All obtained values were statistically significant at the 1% level, positive, and greater than 0.3 (except for the use of modern technologies (.296) and the integration of processes and systems (.280), with support from top management).

Support from top management has a very strong correlation with leadership (.883), but a weak correlation with the integration of processes and systems (.280). This means that greater support from top management will positively influence the leadership style, and vice versa. On the other hand, stronger support from top management will not significantly contribute to the development of process and system integration. The factor of process and system integration shows a strong correlation with the use of modern technology (.773). This means that the use of modern technology will positively impact the integration of processes and systems, and vice versa. Similar correlations can be observed between other factors of readiness, which contribute to a better understanding of the relationships and influences. Based on this, the first auxiliary hypothesis can be confirmed: It is possible to determine the interrelationships between factors, as well as their correlation with readiness for Quality 4.0.

Through observing the correlation of factors with readiness for implementing Quality 4.0, the factors that have the greatest and least impact on readiness were identified. The greatest impact is achieved using modern technology (.623), while the least impact comes from the customer focus (.303). The concept of Quality 4.0 is based on the application of modern technologies, and its implementation is not possible without them, unlike customer focus, which is not a primary concern for the implementation process. Based on this, the second auxiliary hypothesis can be confirmed: It is possible to identify factors that have the greatest and least impact on a company's readiness for implementing Quality 4.0.

The research findings indicate a moderate level of readiness among Serbian companies for the implementation of Quality 4.0. This highlights the necessity for education and technological adaptation to enable successful adoption. A key finding is the discrepancy between subjective perceptions and objective assessments, which justifies the need for further investigation into a more in-depth and objective analytical model. The most influential factor use of modern technology received the lowest rating, suggesting that insufficient technological adoption remains the primary barrier. Customer focus was found to have the least impact, although its importance may increase over time.

A major limitation of this study lies in the limited familiarity with the concept of Quality 4.0 and the scarcity of successful implementation cases. A higher level of awareness could potentially yield different results. Future research should extend beyond the Western Balkans in order to compare data across regions and identify best practices. Such research could assist in developing tailored strategies for companies with lower levels of readiness and facilitate the broader adoption of Quality 4.0 through customized solutions and evidence-based examples from other contexts.

Conclusion

A systematic review of the literature related to the factors of readiness for implementing Quality 4.0 has provided a significant insight into this topic. The goal was to identify factors, create a model for assessing readiness, determine the relationships between the factors, and identify the factors that have the greatest and the least impacts on a company's readiness. Based on 3 dimensions, 13 factors, and 65 items, a model for assessing company readiness was created, confirming the first hypothesis. The research was conducted in the Republic of Serbia, with implications for the Western Balkans, among certified companies (ISO 9001:2015), and included 184 respondents. The objective assessment indicates a medium level of readiness, while the subjective assessment is somewhat lower. This suggests that the importance of digitalization and automation in quality management is recognized, but companies are still not fully ready to implement advanced technologies and improved processes. The analysis of the relationships between the readiness factors and the readiness for the implementation of Quality 4.0 was performed using Pearson's correlation. The statistical significance of the correlations at the 1% level indicates a high degree of relevance.

The use of modern technology has the greatest impact on the readiness of companies, while customer focus is not a primary factor for successful implementation. This suggests that the adoption of advanced technologies plays a significant role in preparing companies for Quality 4.0, while customer orientation, although important, may not be as immediately essential in this context. From a theoretical perspective, the study contributes by empirically validating a readiness model that combines people, technology, and process factors and by showing how these factors connect to both objective and subjective readiness measures in a developing economy. The results extend the existing Quality 4.0 frameworks by confirming the importance of leadership and culture, but also by quantifying the strong link between digital technology factors and overall readiness (Carvalho et al., 2024; Liu et al., 2023; Oliveira et al., 2024). From a practical perspective, the model and the associated questionnaire can be used by managers and consultants as a diagnostic tool to identify strengths and weaknesses in Quality 4.0 readiness and to set priorities for investment in training, digital infrastructure, and process integration (Antony et al., 2023; Khourshed & Gohar, 2023; Sariyer et al., 2021; Silva et al., 2022).

Finally, several limitations of this study should be acknowledged. First, the research focuses only on ISO 9001:2015-certified companies in Serbia, which limits the generalizability of the findings to other types of organisations and to other Western Balkan or international contexts. Second, the study is cross-sectional and relies on self-reported data from single respondents in each company, which may introduce common method bias and does not allow for analysis of changes in readiness over time. Third, the estimated response rate of about 12% suggests that non-response bias cannot be completely excluded, even though the sample structure is consistent with the known characteristics of certified companies in Serbia.

These limitations open up several directions for future research. Comparative studies across different countries and sectors could examine how institutional, cultural, and technological conditions shape Quality 4.0 readiness profiles (Maganga & Taifa, 2022; Nenadal et al., 2022; Zulfiqar et al., 2023). Longitudinal designs and multi-respondent surveys within the same organisation would make it possible to track readiness over time and to link it more directly to project outcomes and performance indicators (Antony et al., 2023; Liu et al., 2023; Oliveira et al., 2024). In addition, more advanced statistical techniques, such as structural equation modelling or fuzzy-set qualitative comparative analysis, could be used to test causal paths and necessary or sufficient configurations among readiness factors (Rico et al., 2024; Sureshchandar, 2023).

In recent years, the discussion has started to move from Quality 4.0 toward the concept of Quality 5.0, which connects quality management with the broader Industry 5.0 agenda of human-centricity, sustainability, and resilience (Arsovski, 2019; Breque et al., 2021; Frick & Grudowski, 2023; Fialkowska-Filipek & Dobrowolska, 2024; Maljugic et al., 2024). Quality 5.0 stresses the joint role of humans and smart technologies, the well-being and development of employees, and the contribution of quality to social and environmental goals (Antomarioni et al., 2025; Tadic Stanic, 2023). Future studies could extend the readiness model developed here by including Quality 5.0 elements, such as human-centric design, employee well-being, and sustainability-related capabilities, and by examining how these elements are perceived and prioritised in different organisational and regional settings.

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