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Article

Quality management in the context of performance and agility of manufacturing enterprises

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Abstract: The application of quality management methods and tools is an important prerequisite for the success and performance increase of manufacturing enterprises. The paper deals with the application of methods and tools of quality management (MTQM) in manufacturing enterprises. The paper aims to analyze whether there is a relationship between the application of MTQM and the size of enterprises, the use of MTQM, and the performance of enterprises measured through the achieved profit. It also analyzes the impact of MTQM on the agility of manufacturing enterprises measured through the decrease in sales expressed in revenues during the pandemic period. The paper presents the results of the research which was conducted between 2020–2022. Several statistical tools such as the Chi-square goodness-of-fit test, Pearson's chi-square test, and contingency analysis were used to evaluate the different analyses as well as the representativeness of the sample. Based on the results, it can be concluded that there are differences in the use of MTQM and the size of the enterprise as well as the performance of the enterprises. At the same time, the hypothesis that enterprises using a wider range of quality management methods and tools have a higher potential to adapt to unexpected market changes was also confirmed.

Keywords: quality; methods and tools of quality management system; performance; agility; manufacturing enterprises

1. Introduction

The current dynamically developing and extremely fast-changing economic environment challenges enterprises to ensure their long-term competitiveness. The way to address this challenge is to create an environment that is agile and can adapt flexibly to changing conditions. A critical success factor for enterprises is the establishment of an effective quality management system (QMS). Several authors point to the importance of quality and its positive effects on the performance of enterprises (Parast and Safari, 2022; Potjanajaruwit, 2021). Nowadays, quality management is defined as a situation where more and more enterprises have implemented a quality management system. However, the QMS certification boom has confirmed that the certification process itself in many cases does not guarantee that the expectations of top managers or employees are met, and it is hardly possible to talk about the long-term success of enterprises in challenging markets. That is why many enterprises are questioning what they need to do to be at least as efficient as their competitors on a long-term basis. The answer to this question is to embark on the path to excellence, i.e. to make full use of the principles, methods, and tools of quality

management systems supporting the sustainable development of the enterprise and continuous improvement. The complexity of quality management approaches is influenced by various factors, including the industry, capital structure, know-how, and the size of companies. The relationship between the use of quality management methods and tools and the size of enterprises has been a subject of interest in recent studies. The results of study (Udofia et al., 2021) highlights that medium-scale firms often show a distinct pattern of quality management adoption compared to small-scale enterprises. Other studies, such as Kim-Soon et al. (2020) and Kiseľáková et al. (2020) have also addressed similar issues. However, there is a research gap in this field. The impact of quality management on company performance, as measured by various metrics, is a traditional topic. Quality management plays a crucial role in enhancing performance in manufacturing enterprises across different regions. Studies by Kumar et al. (2018), Olaleye et al. (2022), Potjanajaruwit (2021), Zeng et al. (2017), and O'Neill et al. (2016), Phan et al. (2011) have explored this issue. Agility is a relatively new topic in connection with quality management. The study (Kumar et al., 2022) investigated the impact of agile manufacturing on overall business performance. The relationship between the use of quality management methods and tools and the ability to adapt to unexpected market changes has been also investigated in a limited number of studies. The following authors emphasize the importance of quality management in fostering adaptability and resilience in dynamic market conditions (Bayo-Moriones and De La Torre, 2021; Drinke, 2021). The above studies have focused on specific tools, methods, and approaches within the concept of quality management without considering their broader application across the industrial sector based on enterprise size. Research that evaluates a wider range of quality management methods and tools on business performance measured by profitability and also the potential of quality management to a higher level of enterprise agility is lacking. Therefore, there is a research gap in this area that needs to be addressed. The paper aims to obtain answers to the following research questions (RQ). RQ1: Is there a difference in the use of MTQM and the size of the manufacturing enterprises? RQ2: Does the use of MTQM affect the agility of manufacturing enterprises? Practical experience demonstrates that certain quality management tools have the potential to enhance decision-making even in altered circumstances. For instance, statistical tools of quality facilitate the measurement, analysis, and evaluation of quality within enterprises. These tools quantify quality by utilizing indicators such as costs, defects, and complaints. The outcomes of these evaluations highlight opportunities for quality enhancement and reveal deviations from the required standards. By utilizing a controlling report (the structure and significance of a controlling report were examined in the study of Šatanová et al. 2015) that also incorporates future dimensions for forecasting development in changed conditions, it can be inferred that companies are better equipped to handle unexpected changes. Furthermore, it can be stated that many approaches and methods of quality management align with the principles of crisis management or are applicable in an unstable environment. Furthermore, the quality management system in accordance with the principles and requirements of the ISO 9001:2015 standards allows organizations a systematic approach to quality and process management, which has a positive impact on the organization's efficiency. The paper shows the impact of the use of quality management methods and tools on

the performance of the enterprises measured by profitability and also quantifies the impact of their use on the agility of manufacturing enterprises. According to the study conducted by Potkany et al. (2022), it is evident that slovak manufacturing enterprises primarily use these quality management methods, tools, and concepts, which are collectively referred to as MTQM: TQM, Six Sigma method, Process Management approach, Kaizen philosophy, ISO 9000 standards, basic quality management tools, and preventive methods of quality control. For the study, two or more methods or tools are considered as a wider range of MTQM use. These quality management methods and tools have been selected for the reason of their simple implementation and especially the complexity of their use in the conditions of manufacturing enterprises. The contribution of this research is to point out in particular the impact of quality management on the ability of the enterprise to respond flexibly to unforeseen changes, which are occurring nowadays to a much greater extent and it is therefore essential for enterprises to be able to respond adequately, quickly and satisfactorily to these changes.

2. Materials and methods

Six Sigma is a methodology developed by Motorola. Six Sigma provides companies with options to reduce errors or other variability in their operations. Vaidya (2018) states that the solution is based on a systematic approach that primarily uses data and facts. Yadav et al. (2020) argue that Six Sigma focuses on the continuous improvement (innovation) of an organization by understanding customer needs, through process analysis and standardization of measurement methods. According to Ahmed et al. (2022), it is a comprehensive, flexible management system that is based on understanding customer needs and expectations and disciplined use of information and data for management and decision-making. Innovation in Six Sigma is based on the DMAIC improvement cycle, which focuses on finding weaknesses and eliminating them and is one of the building blocks of Six Sigma. Several authors (Al-Otaibi, 2021; Madhani, 2021; Uluskan, 2022; Veena and Prabhushankar, 2020) state that Six Sigma is an effective problem-solving method as its application reduces the number of defective products or services, thus increasing not only revenues but also customer satisfaction. The goal of Six Sigma is to manage processes in such a way that there are no more than 3.4 errors per million opportunities. It seeks to reduce process variability as much as possible and looks for the factors that cause it. According to Achibat et al. (2023), Six Sigma is a comprehensive system for achieving, maintaining, and maximizing business success.

According to Hussain et al. (2023), Total Quality Management (TQM) is a system management approach that aims to continuously increase value to the customer by designing and continuously improving organizational processes and systems. TQM focuses on managing the whole system, not just some subsystems, isolated processes or functional departments. Abdi and Singh (2021) say that TQM is a way of thinking about goals, organizations, processes, and people to ensure that the right things are done. This thought process can change attitudes, and behaviors and improve results. TQM is a philosophy for managing and organizing in a way that enables the needs of stakeholders and their expectations to be met efficiently and effectively without compromise and with ethical values in mind (Babu and Thomas, 2021). According to

ISO 9000:2015, TQM is a management approach designed for an organization, focused on quality, based on the involvement of all its members, and aimed at long-term success achieved through customer satisfaction and benefits for all members of the organization and society. TQM is a very comprehensive management method that emphasizes quality management in all dimensions of an organization's life. It goes beyond quality management and becomes both a method of strategic management and a management philosophy for the entire conduct of the organization. Olayiwola et al. (2024) claim that TQM is a comprehensive management approach that can help an organization from any industry to ensure long-term success through increasing customer satisfaction. Sin et al. (2022) state that TQM is a managerial strategy for managing and continuously improving the level of quality. According to Alhamd and Yahya (2021), the TQM can be summarized as a management system for a customer-focused organization that involves all employees in continuous improvement. TQM is the continual process of detecting and reducing or eliminating errors. Alawag et al. (2020) state that Total quality management aims to hold all parties involved in the production process accountable for the overall quality of the final product or service.

The ISO 9001 quality management system is a globally accepted form of quality management system that is expected to increase customer satisfaction by meeting customer expectations, needs, and regulatory requirements (Fatima, 2014). It specifies the terms of the quality management system at many points from organizational structure to customer satisfaction, effective management of processes, audits, etc. ISO 9001 is mainly a control mechanism to reduce, eliminate, or prevent errors. The standard is not directly related to the quality of products and services but to the quality of the management system. According to Ribeiro et al. (2019), the basic presumption is that if an effective quality management system is developed and implemented, quality products and services will be produced to meet customer needs. Kakouris and Sfakianaki (2018) say that the implementation of a quality management system according to the requirements of ISO 9001 influences the specific objectives of the organization, brings the various processes used in daily life under control, the quality of the product, increases the efficiency of employees and the performance of the organization itself. According to Youssef M. A. and Youssef E. M. (2018), the implementation of ISO 9001 provides the company with higher efficiency and profitability, reduction of unnecessary costs, increasing employee trust and customer satisfaction. Numerous researchers, including Elwardi et al. (2021) and Dahar and Roudies (2021), focused their investigations on the implementation of quality management systems in line with ISO 9001 standards. According to Su et al. (2020), implementation of the quality management system encourages organizations to assess customer needs, establish processes that help in creating a product that meets customer expectations, and maintain control over these processes.

The term Kaizen is composed of two words KAI - change and ZEN - good, better, which means a change for the better. The goal of this philosophy and method is to continuously and gradually improve processes, products, or services. The basic idea of Kaizen is that continuous improvement should be an integral part of corporate culture and should not be seen as a temporary project. Berhe (2022) argues that Kaizen is a simple tool to accelerate the pace of continuous process improvement through small changes. Small and continuous changes targeted at process improvement are

more effective than large and disruptive leaps; moreover, small changes eliminate the risk of making the wrong decision, and these changes can be implemented quickly and at a significantly lower cost than radical changes that are difficult to manage. Habidin et al. (2018) state that Kaizen is a system of continuous improvement in personal, social, and professional life, involving both workers and managers. According to Shojaei et al. (2019), Kaizen can also be described as a life and work philosophy that seeks to systematically identify and implement suggestions for improvement to break the current standard. Shan et al. (2016) and Janjić et al. (2019) say that management plays a critical role in the introduction and implementation of Kaizen in a company as it involves setting clear goals, allocating resources and supporting employees in applying Kaizen principles. Managers shall facilitate open communication and create an environment in which employees are encouraged to develop creative solutions and come up with innovative ideas. According to Singh J. and Singh H. (2018), the principles of Kaizen emphasize the importance of involving all employees in the improvement process, from top management to those at the lowest positions. Such an inclusive approach supports team spirit and creates an environment where every team member feels responsible for improving operations and processes. As a result, the business can effectively identify and solve problems, reducing waste of resources and increasing overall efficiency.

The procedure for completing the paper can be summarized in the following steps. In the first step, a review of scientific contributions from various experts dealing with the subject was carried out. In the second step, a questionnaire was designed that included several questions about the enterprise, including its size, economic performance, capital, and issues related to the implementation of quality management systems. In particular, it was focused on obtaining responses regarding the use of quality management methods, tools, and approaches, as well as the reasons for implementing these systems and the associated benefits, but also potential barriers hindering higher-level utilization of MTQM. Key questions involved assessing performance levels quantified by revenue, profitability, and also the decline in revenue due to the pandemic period. In the third step, the questionnaire was sent out by e-mail to different sectors of manufacturing enterprises in Slovakia , and later the sample selection to meet representativeness criteria was supplemented with structured interviews with quality managers or top managers of the surveyed companies who have been working in those positions for a long time. The specific job positions were meant to ensure a high level of data relevance and the credibility of this study. Subsequently, in the further stage, the working hypotheses were formulated and the questionnaire responses were evaluated using selected statistical methods. Afterward, the results were compared with the research of other authors who investigated the same issue. This comparison provided valuable insights and helped to put the findings into context. In the last step, conclusions were formulated and directions for future research were outlined.

The Statistical Office of the Slovak Republic provided an essential database for determining the size of the population of the basic sample of manufacturing companies and also served as a communication base for contacting these companies. During the completion phase of the sample selection, the Statistical Office of the Slovak Republic indicated a population size of 2504 companies. The criteria for inclusion in the basic

sample were the classification of companies according to the European Industry-standard classification system (Section C - Manufacturing), geographical localization, and business operations within the territory of the Slovak Republic, with a minimum of 10 employees. To ensure the representativeness of the research sample in terms of enterprise size, stratified random sampling was applied.

With a population size of 2504 and a required margin of error of 0.05, a minimum sample size of 345 manufacturing enterprises was determined based on the Yamane Taro formula (Richterová et al. 2007):

$$n = \frac{N}{1 + N \times E^2} \tag{1}$$

Based on the experience of the low questionnaire return from previous studies, the given questionnaire was distributed to more than 2000 Slovak manufacturing enterprises. Data completion for the survey was carried out between 2020 and 2022. Subsequently, in 2023, structured telephone interviews with quality managers and top managers from selected industrial companies in Slovakia were used to expand the sample.

Stratified sampling was applied to ensure the representativeness of the sample according to the size of the enterprises. The return rate of questionnaires reached 16.42%. After summarizing the correctly completed questionnaires, 371 were processed for the study.

The sample data from the survey were at the nominal level of measurement, therefore all input data for the analyses had the nature of frequencies which also influenced the choice of appropriate statistical methods.

The upper and lower limits of confidence intervals for the population proportion were constructed using the normal distribution, where P is the actual sample proportion, z is the critical value for the selected 95% confidence level, and σ_p is the standard deviation (Kohler, 1988).

$$\pi = P \pm (z \times \sigma_P) \tag{2}$$

Contingency analysis involving the Pearson chi-squared test was applied to test the relationship between two investigated categorical variables. The Pearson chi-square test is a valuable tool for enterprise research, enabling insights from categorical data (Keller, 2018; Walsh and Prendergast, 2014). The chi-square statistic allows to measure the degree of disagreement between the frequencies observed (O) and those that would be theoretically expected (E) when the two variables are independent. Based on the sample data, chi-square test statistic χ^2 is computed as follows (Box et al. 2005):

$$\chi^2 = \sum \frac{(O - E)^2}{E} \tag{3}$$

The α-level of 0.05 was used for testing. Significant relationships were quantified by the contingency coefficient with values from 0 to 1. The chi-square goodness-of-fit test was also applied to test the representativeness of the research sample according to the size of the enterprises at the beginning of data processing.

Statistical software STATISTICA 12 was used for all statistical analyses. The output tables were subsequently edited for better readability in MS Excel Office 365.

H1: The use of quality management methods and tools increases proportionally

to the size of the enterprise.

H2: Manufacturing enterprises that use a wider scope of quality management methods and tools are likely to be more profitable.

H3: Manufacturing companies that use a wider scope of quality management methods and tools have a higher potential to adapt to unexpected market changes.

3. Results

The first step of statistical data processing was testing the representativeness of the sample concerning the representation of enterprises by size. The results of the Chi-square goodness-of-fit test are presented in **Table 1**. At an α-level of 0.05, there is no evidence of a significant difference (p = 0.313) between the sample and target population.

Table 1. Results of representativeness test of sample according to the size of the enterprises.

χ^2 = 2.32 df =2 p = 0.313				
Enterprise Size	**Observed (O)**	**Expected (E)**	**E-O**	**(E-O)²/(O)**
Small	184	181.5	2.5	0.034
Medium	135	145.64	−10.64	0.777
Large	52	43.86	8.14	1.511
Total	371	371	0	2.322

Within all 371 surveyed manufacturing enterprises, 181 use a wider range of quality management methods and tools, which represents a share of 48.79 %. The overview by individual industries denoted by NACE codes is illustrated in **Figure 1**.

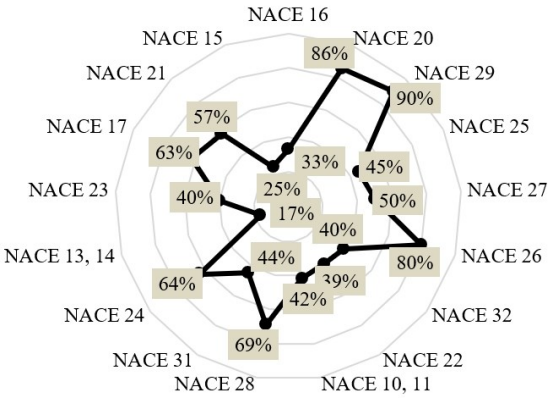

Figure 1. The proportion of manufacturing enterprises in the research sample using a wider range of MTQM.

From the results of the sample survey, confidence intervals for the proportion of enterprises using a wider range of MTQM in the target population for individual size categories were calculated with a confidence of 95%. The number of enterprises, point, and interval estimates of the proportions in individual size categories are shown in **Table 2**.

Table 2. The proportion of enterprises using a wider range of MTQM in individual size categories and interval estimates of population proportions.

Enterprise size	Sample size	Point estimate	95% Interval Estimate	
			Lower Limit	Upper Limit
Small	184	24.46%	18%	31%
Medium-sized	135	68.15%	60%	76%
Large	52	84.62%	75%	94%

Based on a 95% interval estimate only from 18% to 31% of small Slovak manufacturing enterprises use a wider range of MTQM. In the category of medium-sized enterprises, it is from 60% to 76%. Large enterprises use MTQM to the greatest extent. Confidence interval limits for the population proportion are 75% and 94%.

The distribution of manufacturing enterprises according to the level of profit in the group of enterprises using a smaller and wider range of MTQM tools varies considerably in the research sample. The results of this two-dimensional classification are shown in **Figure 2**. The proportion of enterprises with a loss was twice as high in the group that uses a smaller range of MTQM. On the contrary, the share of enterprises with the highest level of profit, i.e. above €500,000, was only 3.16% compared to 14.36% in the group of enterprises using a wider range of MTQM.

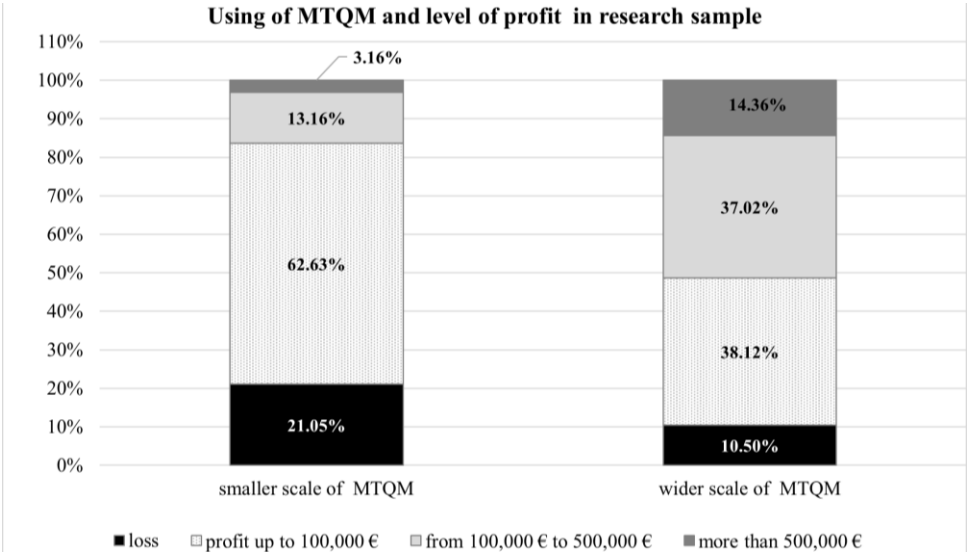

Figure 2. Distribution of manufacturing enterprises in the research sample according to the range of MTQM and profit.

Based on the test results presented in **Table 3**, a significant dependence of the level of profit on the extent of use of MTQM was confirmed (p = 0.000). According to the value of the contingency coefficient of 0.35, the strength of dependence was determined to be moderately strong.

Table 3. Analysis of contingency: Chi-square test of the dependence between the use of MTQM tools and the level of profit.

Usage of MTQM versus Profit	Chi-square test	Degree of freedom	*p*-level	Contingency coefficient
	52.26	3	**0.000**	0.35

A more detailed look at the nature of the tested dependence can be seen in the table of residual frequencies (**Table 4**). Slovak manufacturing enterprises that use MTQM to a smaller range show a loss or profit of up to €100,000. On the other hand, enterprises with a wider range of MTQM tools report profits at levels above €100,000 or €500,000.

Table 4. Contingency table of residual frequencies: The use of MTQM versus the level of profit.

Usage of MTQM	Profit in EUR thousands			
	<0	0–100	100–500	>500
smaller range	**9.78**	**22.72**	−22.12	−10.39
wider range	−9.78	−22.72	**22.12**	**10.39**

As part of the second research hypothesis, a decrease in sales in two groups of enterprises according to the use of MTQM tools has been observed. A detailed overview of the distribution of enterprises in the research sample is presented in **Figure 3**. In the case of enterprises using a wider range of MTQM, 50% reported no decrease in sales compared to 17.89% of enterprises with a smaller range of MTQM. Concerning the decrease in sales of up to 5%, the observed ratio of enterprises is 22.11% to 12.15%. A gradual decrease in sales is shown in the figure up to a level of decrease of more than 20%, where the proportions of 17.89% and 7.73% were recorded for enterprises using MTQM to a wider and smaller range.

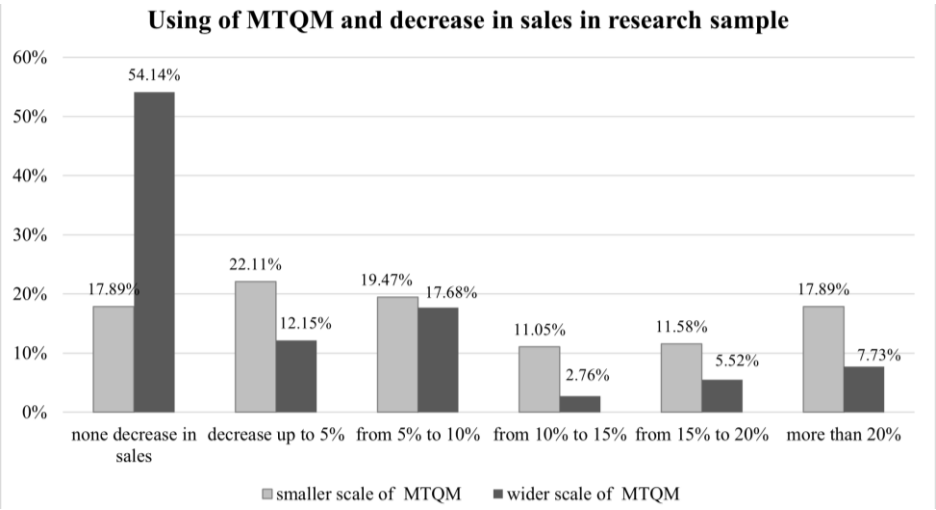

Figure 3. Distribution of manufacturing enterprises in the research sample according to the range of MTQM and decrease in sales.

The results of testing the dependence between the use of MTQM tools and the

decrease in sales are presented in **Table 5**. Based on the corresponding *p*-value 0.000 a significant dependence was tested. The value of the contingency coefficient 0.37 informs about the medium strength of dependence.

Table 5. Analysis of contingency: Chi-square test of the dependence between the use of MTQM tools and a decrease in sales.

Usage of MTQM versus Decrease in Sales	**Chi-square test**	**Degree of freedom**	***p*-level**	**Contingency coefficient**
	60.14	5	**0.000**	0.37

Based on the residual frequencies shown in **Table 6**, it is possible to derive a closer nature of the tested dependence. Slovak manufacturing enterprises using a wider range of MTQM do not show a decline in sales. A decrease in sales characterizes the enterprises that use MTQM tools to a smaller extent.

Table 6. Contingency table of residual frequencies: The use of MTQM versus the level of decrease in sales.

Usage of MTQM	**Decrease in Sales**					
	none	up to 5%	5%–10%	10%–15%	15%–20%	>20%
smaller range	−33.60	**9.22**	1.66	**7.68**	5.61	**9.42**
wider range	**33.60**	−9.22	−1.66	−7.68	−5.61	−9.42

4. Discussion and conclusion

Quality management is a very dynamic area, which is gaining new importance in the context of current social development and changing conditions. Modern management of top organizations prefers a strategic approach to the quality of all outputs and activities. A strategy aimed at increasing customer satisfaction brings improvements in productivity, efficiency, and quality, which ultimately increases the competitiveness and success of the organization. The goal is to achieve maximum customer satisfaction at optimum cost, i.e. where quality is not compromised by reducing costs. To achieve this goal, it is necessary to improve quality and efficiency continuously.

The paper aimed to analyze the methods and tools of quality management in the conditions of Slovak manufacturing enterprises. The applied statistical tools confirmed the hypothesis that the size of the enterprise would have an impact on the use of quality management methods and tools. Recent studies have shown a keen interest in the correlation between the adoption of quality management methods and tools and the size of businesses. Findings from a study by Udofia et al. (2021) underscore that medium-sized companies often exhibit a unique trend in the implementation of quality management, which stands out when compared to smaller enterprises. The study (Kiselakova et al., 2020) examined the impact of TQM on enterprise performance, highlighting that the size of the enterprise significantly influences the use of TQM. The research (Kim-Soon et al., 2020) investigated the implementation of quality management practices among small, medium, and large

food manufacturing companies in Malaysia. The results indicates that larger enterprises have a higher and more effective level of quality management. In this context, it is also possible to answer the research question RQ1. These studies collectively indicate that the size of an enterprise plays a significant role in the implementation and effectiveness of quality management practices.

In the further part of the paper, the impact of using MTQM on business performance was examined. The established hypothesis H2 was also confirmed because manufacturing enterprises that used a wider range of MTQM achieved better performance than enterprises that used MTQM to a lesser extent. The results of the research also confirmed the results of other authors' research on the impact of quality management on business performance (Gorondutse, 2021; Olaleye et al., 2022; Potjanajaruwit, 2021). Another example is the results of the study (Kumar et al., 2018) highlighted the importance of quality management systems (QMS) in enhancing operational efficiency and financial performance in the UK manufacturing sector. In the study (Power et al., 2011) was presented that the effectiveness of QMS in German, Finland, Italy and Sweden enterprises has been shown to significantly impact quality performance and address global quality management challenges (Power et al., 2011). Interesting are the results of the study (Cai et al., 2023), which declares that quality management in the era of Industry 4.0 (Quality 4.0) significantly enhances innovation performance in Chinese manufacturing enterprises. Quality management approaches also positively impact the financial performance of Australian manufacturing firms, emphasizing the role of strategic QM orientations (O'Neill et al., 2016). Other authors Lamine and Lakhal (2018) in their research stated that the implementation of Six Sigma and TQM has a positive impact on business performance. The research results presented in this study follow up on previous studies and complement them with a comprehensive view of the utilization of QMPs in the manufacturing sector. Research reveals the need for further empirical studies to identify key performance indicators and standardize performance measures.

Following the results that confirm the validity of hypothesis H3, which assumed that manufacturing companies that use a wider scope of quality management methods and tools have a higher potential to adapt to unexpected market changes it is possible to discuss the answers and support them with findings from other studies. RQ2 addressed whether the use of MTQM has an impact on the agility of manufacturing enterprises. In this part, a decline in sales declared by manufacturing enterprises during the crisis was analyzed and it was confirmed that enterprises that used a wider range of MTQM were much more resilient and did not experience a decline in sales or a smaller decline in sales compared to enterprises that used MTQM to a lesser extent. The study (Drinke, 2021) highlights that Quality Management Systems can significantly enhance a company´s ability to remain sustainable and competitive in a globalized economy by enabling swift adaptation to market changes. The research (Bayo-Moriones and De La Torre, 2021) explores the multifaceted relationship between quality management practices, performance appraisal, and pay for performance. It finds that effective use of quality tools and a focus on customer and supplier collaboration significantly enhance the ability of firms to adapt to market changes. The study (Klochkov and Tveryakov, 2020) suggests that high adaptability of quality management methods is crucial for addressing new technological processes

and evolving market demands, thereby ensuring continuous improvement and competitiveness. In the context of RQ2, it can be stated that the MTQM scale is partially applicable in stable market conditions, but numerous quality management approaches and methods align with crisis management principles and can thus be utilized in unstable environments. For instance, the ISO 9001:2015 standards oblige companies to identify risks and propose measures to eliminate them, thereby offering significant potential for application even in fluctuating market conditions. Another example is the indices of readiness for changed conditions, encompassing various aspects and quality management indicators. The potential for reporting and analyzing deviations within the controlling report at the level of monitoring quality costs was previously highlighted in the study by Šatanová et al. (2015). Other arguments are the results of a study by authors Siddiqui and Iqbal (2021), which state that the integration of Six Sigma and TQM contributes to the agility of manufacturing enterprises by improving processes, reducing costs, and eliminating waste. According to the authors Bulto and Kant (2023), the implementation of Six Sigma and TQM has a positive impact on the performance and agility of enterprises, contributing to quality improvement, cost reduction, and increased overall process efficiency. Combining these methods with other approaches can further improve business results. According to Potkany et al. (2022), quality alone would not solve the problems of pandemic impact in the industrial sector, but by its very nature, it can contribute to a higher degree of adaptation and anticipation concerning competitiveness and greater management flexibility in times of crisis. It can be concluded that enterprises that use quality management methods and tools are more agile, i.e. they have been able to adapt more quickly and flexibly to changes, new challenges, and trends.

The research revealed differences in the use of MTQM across different industries, yet in many sectors, there are still enterprises that refuse to implement quality management systems. This suggests that there is still considerable space and potential for wider and more intensive use and implementation of these systems. A further benefit is that the results provide an informative basis for comparison with other research projects in different countries. Certain limiting factors of the study include the fact that the research in question examined the relationship between MTQM and performance as a whole and not partially, meaning the possible dependence on the use of individual tools, methods, and approaches of quality management. This is precisely the area for potential future research direction. Future research could also focus on identifying the reasons for the lower implementation rates of MTQM, especially in micro and small enterprises, or on examining the benefits enterprises gain from their implementation. In addition, future research should be extended to other countries, both within Europe and worldwide. During the implementation of the research activities, another problems were also noted, which can also be called barriers to research. These barriers include problems in obtaining relevant data stemming from the low interest of manufacturing enterprises to share these data, as well as the pandemic period, which is characterized by the volatility of market conditions. The possibility of extending research to other countries carry additional challenges, as it will be very difficult to obtain information from multiple countries and will require increased collaboration with foreign partners. Cooperation and expansion of research to other countries may bring new knowledge and information that shall support the

development of the business environment in Slovakia and increase awareness of the nature and effects of MTQM implementation.

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References

Abdi, M., & Singh, A. P. (2021). Effect of total quality management practices on nonfinancial performance: an empirical analysis of automotive engineering industry in Ethiopia. The TQM Journal, 34(5), 1116–1144. https://doi.org/10.1108/tqm-03-2021-0069

Achibat, F. E., Lebkiri, A., Aouane, E. M, et al. (2023). Analysis of the Impact of Six Sigma and Lean Manufacturing on the Performance of Companies. Management Systems in Production Engineering, 31(2), 191–196. https://doi.org/10.2478/mspe-2023-0020

Ahmed, A., Olsen, J., & Page, J. (2022). Integration of Six Sigma and simulations in real production factory to improve performance – a case study analysis. International Journal of Lean Six Sigma, 14(2), 451–482. https://doi.org/10.1108/ijlss-06-2021-0104

Alawag, A. M., Salah Alaloul, W., Liew, M. S., et al. (2020). Total Quality Management Practices and Adoption in Construction Industry Organizations: A Review. IEEE. https://doi.org/10.1109/ieeeconf51154.2020.9319992

Alhamd1, A. E., & Bin Yahya, M. Y. (2021). Relationship between Total Quality Management and Organizational Performance: Evidence from the UAE. In: Proceedings of the International Conference on Industrial Engineering and Operations Management. https://doi.org/10.46254/an11.20211102

Al-Otaibi, S. A. (2021). Implementation of Six-Sigma methodology to achieve a competitive edge in Saudi universities. Studies of Applied Economics, 39(10). https://doi.org/10.25115/eea.v39i10.5956

Babu, F., & Thomas, S. (2021). Quality management practices as a driver of employee satisfaction: exploring the mediating role of organizational image. International Journal of Quality and Service Sciences, 13(1), 157–174. https://doi.org/10.1108/ijqss-10-2019-0124

Bayo-Moriones, A., & de la Torre, R. (2021). Analysing the relationship between QM, performance appraisal and pay for performance. Total Quality Management & Business Excellence, 33(9–10), 1056–1083. https://doi.org/10.1080/14783363.2021.1933422

Berhe, H. H. (2022). Application of Kaizen philosophy for enhancing manufacturing industries' performance: exploratory study of Ethiopian chemical industries. International Journal of Quality & Reliability Management, 39(1), 204–235. https://doi.org/10.1108/ijqrm-09-2020-0328

Box, G. E. P., Hunter, J. S., Hunter, W. G. (2005). Statistics for Experimenters: Design, Innovation, and Discovery. Wiley-Blackwell, 664.

Bulto, L., & Kant, S. (2023). Total Quality Management integration with Six Sigma for Operational Success of a Project. Journal of Management and Service Science (JMSS), 3(1), 1–12. https://doi.org/10.54060/jmss.v3i1.35

Cai, C., Wang, H., & Deng, Y. (2023). Based on Regression Analysis Assessing the Impact of Quality 4.0 on Enterprises Innovation Performance. In: Proceedings of the 2023 9th International Conference on Industrial and Business Engineering. https://doi.org/10.1145/3629378.3629456

Dahar, H., & Roudies, O. (2021). Co-deployment of quality standards: a systematic literature review. International Journal of Productivity and Quality Management, 32(1), 1. https://doi.org/10.1504/ijpqm.2021.111983

Drinke, Z. (2021). Impact of adopted Quality Management on a business model in globalized economy. SHS Web of Conferences, 92, 02013. https://doi.org/10.1051/shsconf/20219202013

Elwardi, B., Meddaoui, A., Mouchtachi, A., et al. (2021). Towards a new maturity model of industrial performance improvement based on ISO 9001: version 2015 and VDA6.3: version 2016. International Journal of Process Management and Benchmarking, 11(3), 367. https://doi.org/10.1504/ijpmb.2021.115013

Fatima, M. (2014). Impact of ISO 9000 on Business Performance in Pakistan: Implications for Quality in Developing Countries. Quality Management Journal, 21(1), 16–24. https://doi.org/10.1080/10686967.2014.11918373

Gorondutse, A. H., Ali, G. A., & Hilman, H. (2021). Developing rightly culture on TQM - evidence from SMEs in the context of emerging economy. RAUSP Management Journal, 56(4), 465–481. https://doi.org/10.1108/rausp-11-2020-0264

Habidin, N. F., Hashim, S., Fuzi, N. M., et al. (2018). Total productive maintenance, kaizen event, and performance. International Journal of Quality & Reliability Management, 35(9), 1853–1867. https://doi.org/10.1108/ijqrm-11-2017-0234

Hussain, S., Alsmairat, M. A. K., Al-Ma'aitah, N., et al. (2023). Assessing quality performance through seven total quality management practices. Uncertain Supply Chain Management, 11(1), 41–52. https://doi.org/10.5267/j.uscm.2022.12.002

Janjić, V., Todorović, M., & Jovanović, D. (2019). Key Success Factors and Benefits of Kaizen Implementation. Engineering Management Journal, 32(2), 98–106. https://doi.org/10.1080/10429247.2019.1664274

Kakouris, A. P., & Sfakianaki, E. (2018). Impacts of ISO 9000 on Greek SMEs business performance. International Journal of Quality & Reliability Management, 35(10), 2248–2271. https://doi.org/10.1108/ijqrm-10-2017-0204

Keller G. (2018). Statistics for management and economics. Cengage Learning, 800.

Kim-Soon, N., Mostafa, S. A., Nurunnabi, M., et al. (2020). Quality Management Practices of Food Manufacturers: A Comparative Study between Small, Medium and Large Companies in Malaysia. Sustainability, 12(18), 7725. https://doi.org/10.3390/su12187725

Kiseľáková, D., Gallo, P., Čabinová, V., et al. (2020). Total quality management as managerial tool of competitiveness in enterprises worlwide. Polish Journal of Management Studies, 21(2), 195–209. https://doi.org/10.17512/pjms.2020.21.2.14

Klochkov, Y. S., & Tveryakov, A. M. (2020). Approaches to the improvement of quality management methods. International Journal of System Assurance Engineering and Management, 11(S2), 163–172. https://doi.org/10.1007/s13198-019-00939-x

Kohler, H. (1988). Statistics for Business and Economics. Scott Foresman, Wesley, 153.

Kumar, P., Maiti, J., & Gunasekaran, A. (2018). Impact of quality management systems on firm performance. International Journal of Quality & Reliability Management, 35(5), 1034–1059. https://doi.org/10.1108/ijqrm-02-2017-0030

Kumar, R., Singh, K., & Jain, S. K. (2022). Assessment of Agile manufacturing impact on business performance of Indian manufacturing industry: A PLS-SEM approach. Sustainable Manufacturing and Service Economics, 1, 100001. https://doi.org/10.1016/j.smse.2022.100001

Lamine, K., & Lakhal, L. (2018). Impact of TQM/Six Sigma practices on company's performance: Tunisian context. International Journal of Quality & Reliability Management, 35(9), 1881–1906. https://doi.org/10.1108/ijqrm-05-2017-0097

Madhani, P. M. (2021). Lean Six Sigma in Finance and Accounting Services for Enhancing Business Performance. International Journal of Service Science, Management, Engineering, and Technology, 12(6), 141–165. https://doi.org/10.4018/ijssmet.2021110109

O'Neill, P., Sohal, A., & Teng, C. W. (2016). Quality management approaches and their impact on firms financial performance – An Australian study. International Journal of Production Economics, 171, 381–393. https://doi.org/10.1016/j.ijpe.2015.07.015

Olaleye, B. R., Ali-Momoh, B. O., Herzallah, A., et al. (2022). Dimensional Context of Total Quality Management Practices and Organizational Performance of SMEs in Nigeria: Evidence from Mediating Role of Entrepreneurial Orientation. International Journal of Operations and Quantitative Management, 27(4), 399. https://doi.org/10.46970/2021.27.4.6

Olayiwola, R. K., Tuomi, V., Strid, J., et al. (2024). Impact of Total quality management on cleaning companies in Finland: A Focus on organisational performance and customer satisfaction. Cleaner Logistics and Supply Chain, 10, 100139. https://doi.org/10.1016/j.clscn.2024.100139

Parast, M. M., & Safari, A. (2022). Enhancing the quality and competitiveness of small businesses: A pooled cross-sectional analysis. International Journal of Production Economics, 246, 108410. https://doi.org/10.1016/j.ijpe.2022.108410

Permana, A., Purba, H. H., & Rizkiyah, N. D. (2021). A systematic literature review of Total Quality Management (TQM) implementation in the organization. International Journal of Production Management and Engineering, 9(1), 25. https://doi.org/10.4995/ijpme.2021.13765

Phan, A. C., Abdallah, A. B., & Matsui, Y. (2011). Quality management practices and competitive performance: Empirical evidence from Japanese manufacturing companies. International Journal of Production Economics, 133(2), 518–529. https://doi.org/10.1016/j.ijpe.2011.01.024

Potjanajaruwit, P. (2021). TQM knowledge management and analysis of smes in thailand. Polish Journal of Management Studies, 24(2), 386–397. https://doi.org/10.17512/pjms.2021.24.2.24

Potkany, M., Zavadsky, J., Hlawiczka, R., et al. (2022). Quality Management Practices in Manufacturing Enterprises in the Context of Their Performance. Journal of Competitiveness, 14(2), 97–115. https://doi.org/10.7441/joc.2022.02.06

Power, D., Schoenherr, T., & Samson, D. (2011). Assessing the Effectiveness of Quality Management in a Global Context. IEEE Transactions on Engineering Management, 58(2), 307–322. https://doi.org/10.1109/tem.2010.2081992

Ribeiro, L. H. M. S., Beijo, L. A., Salgado, E. G., et al. (2019). Modelling of ISO 9001 certifications for the American countries: a Bayesian approach. Total Quality Management & Business Excellence, 32(11–12), 1290–1315. https://doi.org/10.1080/14783363.2019.1696672

Richterová K, Labská H, Klepochová D, et al. (2007). Marketing Research (Slovak). Bratislava: Ekonóm, 407.

Šatanová, A., Závadský, J., Sedliačiková, M., et al. (2015). How Slovak small and medium manufacturing enterprises maintain quality costs: an empirical study and proposal for a suitable model. Total Quality Management & Business Excellence, 26(11–12), 1146–1160. https://doi.org/10.1080/14783363.2014.916477

Shan, A. W., Ahmad, M. F., & Nor, N. H. M. (2016). The Mediating Effect of Kaizen between Total Quality Management (TQM) and Business Performance. IOP Conference Series: Materials Science and Engineering, 160, 012012. https://doi.org/10.1088/1757-899x/160/1/012012

Shojaei, M., Ahmadi, A., & Shojaei, P. (2019). Implementation productivity management cycle with operational kaizen approach to improve production performance (Case study: pars khodro company). International Journal for Quality Research, 13(2), 349–360. https://doi.org/10.24874/ijqr13.02-07

Siddiqui, T., & Iqbal, M. A. (2021). Six Sigma Practices on The Perceived Betterment of Organization Performance. Journal of Entrepreneurship, Management, and Innovation, 3(1), 77–96. https://doi.org/10.52633/jemi.v3i1.52

Sin, K. Y., Jusoh, M. S., & Sim, C. L. (2022). The effects of total quality management practices on sustainable performance: perspective from Malaysia. International Journal of Services and Operations Management, 42(1), 1. https://doi.org/10.1504/ijsom.2022.123067

Singh, J., & Singh, H. (2018). Enigma of Kaizen approach in manufacturing industry of Northern India – a case study. International Journal of Quality & Reliability Management, 35(1), 187–207. https://doi.org/10.1108/ijqrm-12-2016-0220

Su, H.-C., Kao, T.-W., & Linderman, K. (2020). Where in the supply chain network does ISO 9001 improve firm productivity? European Journal of Operational Research, 283(2), 530–540. https://doi.org/10.1016/j.ejor.2019.11.042

Udofia, E. E., Adejare, B. O., Olaore, G. O., et al. (2021). Direct and indirect impact of quality management on the integrated performance of medium-scale manufacturers. The TQM Journal, 33(6), 1589–1609. https://doi.org/10.1108/tqm-08-2020-0174

Uluskan, M. (2022). Enhancing Six Sigma Understanding: Insights into Various Dimensions and Aspects of Six Sigma. Engineering Management Journal, 34(1), 99–128. https://doi.org/10.1080/10429247.2020.1852806

Vaidya, O. S. (2018). A six sigma based approach to evaluate the on time performance of Indian railways. International Journal of Quality & Reliability Management, 35(10), 2212–2226. https://doi.org/10.1108/ijqrm-07-2017-0128

Veena, T. R., & Prabhushankar, G. V. (2020). Identification of Critical Success Factors for implementing Six Sigma methodology and grouping the factors based on ISO 9001: 2015 QMS. International Journal of Six Sigma and Competitive Advantage, 12(1), 1. https://doi.org/10.1504/ijssca.2020.107463

Walsh DC, Prendergast G. (2014). Using chi-squared tests to examine categorical data in marketing R research. Journal of Marketing Analytics, 2(2), 102-108.

Yadav, N., Shankar, R., & Singh, S. P. (2020). Impact of Industry4.0/ICTs, Lean Six Sigma and quality management systems on organisational performance. The TQM Journal, 32(4), 815–835. https://doi.org/10.1108/tqm-10-2019-0251

Youssef, M. A., & Youssef, E. M. (2018). The synergistic impact of ISO 9000 and TQM on operational performance and competitiveness. International Journal of Quality & Reliability Management, 35(3), 614–634. https://doi.org/10.1108/ijqrm-02-2016-0024

Zeng, J., Zhang, W., Matsui, Y., et al. (2017). The impact of organizational context on hard and soft quality management and innovation performance. International Journal of Production Economics, 185, 240–251. https://doi.org/10.1016/j.ijpe.2016.12.031