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The Impact of Quality Management Methods and Tools on the Profitability of Manufacturing Enterprises: Sectoral Differences across Manufacturing Industries

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ABSTRACT

Research background: Quality management represents a key strategic approach to improving the performance and competitiveness of manufacturing enterprises. Although numerous studies confirm the positive effects of quality management systems and practices on organisational performance, existing research predominantly focuses on selected tools or individual performance indicators, such as productivity, efficiency, or innovation. Considerably less attention has been devoted to examining the comprehensive use of quality management methods and tools (MTQM) in relation to profitability, particularly with regard to sectoral differences across manufacturing industries.

Purpose of the article: The aim of this paper is to evaluate the impact of the application of quality management methods and tools on the profitability of manufacturing enterprises and to identify sectoral differences in their use across industries classified under SK NACE Section C.

Methods: The study adopts a quantitative research approach based on a questionnaire survey supplemented by structured interviews conducted in 2024–2025. The research sample consisted of 405 manufacturing enterprises operating in Slovakia, exceeding the minimum required sample size of 360 determined using the Yamane formula. The MTQM variable was operationalised as the number of quality management methods and tools applied by an enterprise, while profitability was measured using return on sales (ROS), categorised into four groups. To verify the representativeness of the sample and test relationships between variables, the Chi-square goodness-of-fit test and the Chi-square test of independence were applied. Statistical analyses were conducted using STATISTICA 12 at a significance level of $\alpha = 0.05$.

Findings & Value added: The results confirm statistically significant differences in the extent of MTQM utilisation across manufacturing industries ($\chi^2 = 66.98$; $p = 0.001$), indicating that sectoral characteristics, such as technological complexity and regulatory requirements, influence the adoption of quality management practices. Furthermore, a statistically significant association was identified between the extent of MTQM utilisation and enterprise profitability ($\chi^2 = 76.84$; $p = 0.001$), with enterprises applying a broader range of quality management methods and tools being more likely to achieve higher levels of profitability as measured by ROS. The findings provide empirical evidence from the Slovak manufacturing sector and contribute to the existing literature by demonstrating a relationship between the comprehensive application of MTQM and enterprise profitability.

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INTRODUCTION

The current dynamic and rapidly changing business environment places increasing demands on manufacturing enterprises to maintain long-term competitiveness and performance. One of the key approaches to achieving this objective is the effective implementation of quality management principles, methods, and tools. Numerous studies emphasise that quality represents an important strategic instrument enabling enterprises to strengthen their competitiveness and achieve long-term business objectives (Benčiková et al., 2021; Liu et al., 2021). Quality management systems (QMS) are therefore widely recognised as important instruments for improving organisational efficiency and performance; however, certification alone does not automatically guarantee sustained success.

In recent years, research attention has increasingly shifted from the formal implementation of quality systems towards the practical application of quality management methods and tools (MTQM) and their measurable effects on business performance. Previous studies confirm that quality management practices positively contribute to enterprise performance, particularly in manufacturing environments (Kumar et al., 2018; Potjanajaruwit, 2021), while other research highlights their role in improving efficiency, innovation, and overall competitiveness (Gambi et al., 2021).

Despite these findings, existing research frequently focuses on selected quality management approaches or specific industries without providing a comprehensive perspective on the extent of MTQM utilisation across the manufacturing sector. Moreover, studies often assess performance using a variety of indicators, while considerably less attention has been paid specifically to profitability as a key measure of enterprise performance in relation to the broader application of MTQM. Although numerous studies examine the effects of quality management primarily through indicators such as productivity, efficiency, innovation performance, or cost reduction, considerably fewer focus on profitability, particularly return on sales (ROS), which represents a fundamental and directly measurable indicator of the economic performance of manufacturing enterprises. In addition to the limited attention devoted to profitability, another important aspect that remains insufficiently explored is sectoral variation in the adoption of MTQM.

At the same time, the application of quality management methods and tools may vary substantially across manufacturing industries due to differences in technological complexity, production processes, and value-added structures. These sectoral differences arise from varying levels of technological complexity, distinct requirements regarding precision and product quality, different degrees of automation, and diverse competitive pressures across manufacturing industries. The SK NACE Section C classification therefore provides an appropriate and analytically robust framework for examining such variations. Although some studies indicate that structural factors such as firm size and industry characteristics influence quality management adoption, empirical evidence comparing sectoral differences within a unified framework such as the SK NACE classification remains limited.

While a substantial body of literature has confirmed the positive effects of quality management on non-financial performance indicators, including productivity, operational efficiency, innovation performance, customer satisfaction, and process improvement (Kumar et al., 2018; Gambi et al., 2021; Parast & Safari, 2022), considerably fewer studies have examined its direct relationship with financial outcomes, particularly profitability measured by ROS. Existing studies addressing financial performance frequently focus on broader profitability indicators or specific quality management systems rather than on the overall extent of MTQM utilisation across manufacturing enterprises.

Accordingly, a research gap can be identified in assessing both the relationship between the extent of MTQM utilisation and enterprise profitability and the sectoral differences in MTQM application across manufacturing industries.

The aim of this paper is to evaluate the impact of the application of quality management methods and tools on the profitability of manufacturing enterprises and to identify sectoral differences in their utilisation across industries classified under SK NACE Section C.

THEORETICAL BACKGROUND

Quality management in manufacturing enterprises represents a fundamental component of organisational management aimed at optimising processes, improving product quality, and strengthening long-term competitiveness. A central role in this context is played by standardised quality management systems, particularly ISO 9001, which provide a structured framework for process control, customer-oriented management, and continuous improvement. Empirical evidence consistently confirms that the implementation of ISO-based systems contributes to enhanced operational performance, process stability, customer satisfaction, and productivity across various organisational settings. For example, Bakhtiar et al. (2023) demonstrated that ISO 9001 adoption significantly improves operational performance across diverse Indonesian organisations, while Chiarini and Cherrafi (2023) highlighted the relevance of ISO 9001 as a foundation for integrating Industry 4.0 technologies into manufacturing environments. Similarly, Rueda Fierro et al. (2025) found that ISO 9001 certification positively influences productivity in the Ecuadorian manufacturing sector, while Adedeji (2025) confirmed the broader performance benefits of ISO-based management frameworks, including ISO 9001, ISO 45001, ISO 14001, and ISO 31000, in the Nigerian manufacturing industry.

Beyond formalised systems, manufacturing enterprises increasingly rely on a broad portfolio of quality management methods and tools (MTQM), which collectively sup-

port systematic problem-solving, process improvement, and continuous performance enhancement. These approaches include comprehensive management philosophies such as Total Quality Management (TQM), structured improvement methodologies such as Six Sigma, process-oriented approaches, Kaizen practices, the application of ISO standards, and traditional quality management tools. Their relevance for improving operational and strategic outcomes has been widely documented in recent research (Santos et al., 2021; Potkány et al., 2022).

However, recent research continues to focus predominantly on specific quality management approaches rather than providing a comprehensive assessment of the broader portfolio of methods and tools applied across the manufacturing sector. A substantial body of literature concentrates on Lean Six Sigma, emphasising its role in process improvement, waste reduction, and performance enhancement in manufacturing environments (Gomaa, 2023; Kumar et al., 2024). Other studies highlight emerging concepts such as Zero-Defect Manufacturing, which integrates advanced technologies and data-driven quality assurance to eliminate defects and support sustainable production (Psarommatis & Azamfirei, 2024). In parallel, growing attention has been devoted to Quality 4.0 frameworks, which integrate traditional quality management with Industry 4.0 technologies and create new opportunities for digitalised and intelligent quality improvement systems (Baiochi et al., 2025). Despite these valuable contributions, the literature remains fragmented, with limited comparative evidence on how manufacturing enterprises utilise a broader spectrum of quality management methods and tools beyond these dominant approaches.

From a conceptual perspective, individual quality management approaches contribute to enterprise performance through different mechanisms. Six Sigma, for example, relies on the systematic use of data and statistical tools to reduce process variability and eliminate defects, thereby improving efficiency and supporting stronger financial outcomes (Vaidya, 2020; Yadav et al., 2020; Madhani, 2021). By contrast, Total Quality Management (TQM) represents a comprehensive managerial philosophy based on continuous improvement, customer orientation, and the involvement of all employees in quality-related activities (Babu & Thomas, 2021; Sin et al., 2022; Hussain et al., 2023). Similarly, the Kaizen philosophy emphasises incremental and continuous improvements that contribute to higher productivity and more efficient resource utilisation (Singh & Singh, 2018; Berhe, 2022).

A substantial body of research confirms the positive impact of quality management on enterprise performance across different economic contexts and using diverse performance indicators (Kumar et al., 2018; Potjanajaruwit, 2021; Parast & Safari, 2022; Rey Sánchez et al., 2022). The effective application of quality management tools has been shown to reduce costs, improve processes, and enhance financial performance. Quality management methods and tools can contribute to enterprise profitability through several interrelated mechanisms. By reducing process variability, defects, rework, and production waste, MTQM can lower operating costs and improve process efficiency. At the same time, greater process stability and higher product quality may improve customer satisfaction and market performance, ultimately contributing to higher profitability as measured by ROS.

Despite these findings, the practical use of MTQM varies considerably across enterprises and industries. Studies indicate that the adoption of quality management methods is influenced by factors such as technological complexity, firm size, and industry-specific characteristics (Kim-Soon et al., 2020; Antony et al., 2022). Consequently, existing research has largely focused on individual tools or their effects on selected performance indicators, while less attention has been devoted to examining the broader scope of MTQM utilisation in relation to enterprise profitability. At the same time, empirical studies systematically comparing MTQM utilisation across manufacturing industries within a unified classification framework remain scarce.

In the Slovak manufacturing environment, sectoral differences in MTQM adoption may partly reflect disparities in digitalisation levels, technological maturity, production complexity, and organisational readiness. Manufacturing industries differ substantially in their requirements for process standardisation, automation, quality assurance, and regulatory compliance, which may influence both the perceived benefits and the feasibility of implementing advanced quality management methods and tools. Evidence from Slovak manufacturing firms indicates that stronger financial and organisational capacities facilitate the implementation of advanced managerial initiatives (Musa et al., 2026), while the diffusion of such practices also depends on broader organisational and institutional conditions (Liaqat et al., 2026). Furthermore, recent Quality 4.0 research emphasises that the successful transformation of quality management increasingly depends on organisations' readiness to adopt digital technologies, develop new competencies, and adapt existing quality systems to rapidly evolving industrial environments (Oliveira et al., 2025). Consequently, industries characterised by lower investment capacity, limited digitalisation, or slower technological modernisation may face greater challenges in adopting MTQM more broadly.

AIM, METHODOLOGY, AND DATA

The objective of the research is to examine the relationship between the use of quality management methods and tools (MTQM) and the profitability of manufacturing enterprises, with a specific focus on identifying sectoral differences in their application across industries classified under SK NACE Section C.

The empirical research is based on a quantitative approach, using a questionnaire survey supplemented by structured interviews with managers of manufacturing enterprises. The data collection was carried out between November 2024 and December 2025. During this period, manufacturing enterprises were contacted through avai-

lable e-mail and telephone contacts and invited to participate in the research. The questionnaire included identification variables (such as company size, industry classification, and duration of operation) as well as key questions focused on the extent of the application of quality management methods and tools and the achieved level of profitability.

In operational terms, the variable MTQM (methods and tools of quality management) was defined as the number of quality management methods and tools applied by an enterprise. These included commonly used approaches such as ISO-based systems, Total Quality Management (TQM), Six Sigma, Kaizen, and other quality improvement tools. Based on the reported number of applied methods and tools, enterprises were subsequently classified into two categories: enterprises with a lower level of MTQM utilization (application of none or one method/tool) and enterprises with a higher level of MTQM utilization (application of two or more methods/tools).

The profitability of enterprises was measured using return on sales (ROS), which represents the ratio of operating profit to total sales. For the purposes of the analysis, ROS was operationalized as a categorical variable, with enterprises classified into four groups: negative ROS, ROS up to 2.5%, ROS between 2.6% and 5%, and ROS above 5%.

The research sample consisted of manufacturing enterprises classified according to the NACE system (Section C – Manufacturing). According to the Statistical Office of the Slovak Republic, the population included 3,585 enterprises. From this population, 3,000 enterprises were approached and invited to participate in the survey. Given the population size (N = 3,585) and a maximum acceptable sampling error of 0.05 (E), the minimum sample size (n = 360 enterprises) was determined using the Yamane formula (1) (Lind, 2020):

$$n = \frac{N}{1 + NE^2}$$

A total of 405 valid responses were obtained, corresponding to a response rate of 13.5%. Although participation was voluntary and the study therefore relied on a non-probability sampling procedure, the final research sample exceeded the minimum required sample size and provided an adequate basis for statistical analysis. The representativeness of the sample with respect to the sectoral structure of the population was subsequently verified using the Chi-square goodness-of-fit test. Furthermore, the Chi-square test of independence was used to examine the relationships between categorical variables, particularly the association between the extent of the use of quality management methods and tools and selected classification variables. In addition, Cramér's V was calculated as a measure of effect size to assess the practical significance of statistically significant associations identified by the Chi-square test. The chi-square statistic is expressed as (Labudová et al., 2021):

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

where: f_o represents observed frequencies and f_e expected frequencies.

The statistical analysis was carried out using STATISTICA 12 software A significance level of α = 0.05 was applied as the decision criterion for hypothesis testing.

Based on the theoretical background and the research focus, the following research question (RQ) was formulated:

RQ: Are there significant differences in the use of quality management methods and tools across manufacturing industries within SK NACE Section C?

In addition, the following hypothesis (H1) was developed in line with the aim of the study:

H1: Manufacturing enterprises that use a wider range of quality management methods and tools achieve higher levels of profitability measured by return on sales (ROS).

RESULTS & DISCUSSION

The main aim of the study was to evaluate the impact of the application of quality management methods and tools on the profitability of manufacturing enterprises and to identify sectoral differences in their use across industries classified under SK NACE Section C. In this analysis, quality management methods and tools are understood as a comprehensive set of methods, tools, models, approaches, and managerial philosophies aimed at improving process quality, product and service quality, customer satisfaction, and overall enterprise performance. Particular attention is also devoted to sectoral differences in the adoption and application of quality management practices within the manufacturing sector.

The first step of the statistical analysis was to verify the representativeness of the research sample with respect to the sectoral structure of manufacturing enterprises. The proportional distribution of individual industries included in the sample is shown in the column “Observed (Oi)”. The research sample included 405 enterprises from various industrial sectors. The results of the Chi-square goodness-of-fit test are presented in Table 1. At the significance level α = 0.05, the test did not indicate any statistically significant difference between the observed and expected frequencies (χ^2 = 19.336, p = 0.199). These results confirm that the research sample corresponds to the structure of the target population and can therefore be considered representative.

Table 1: Distribution of manufacturing enterprises in the sample and results of the Chi-Square Goodness-of-Fit Test.

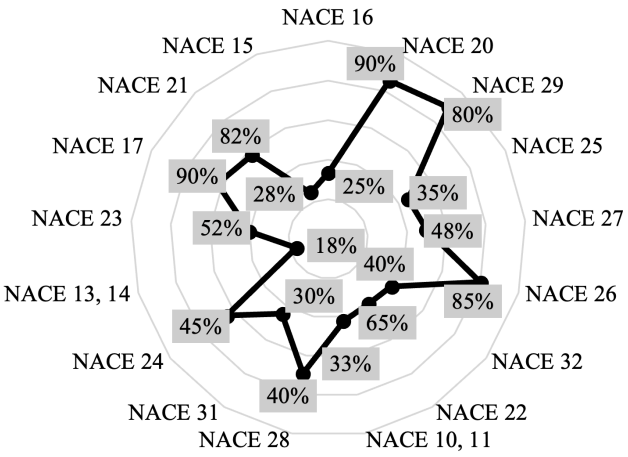
Industry sector (SK NACE)	Observed (Oi)	(E-O)2 /(O)
10+11 Manufacture of food products and manufacture of beverages	68	0.486
13+14 Manufacture of textiles and manufacture of wearing apparel	19	0.409
15 Manufacture of leather and related products	7	0.800
16 Manufacture of wood	27	0.516
17 Manufacture of paper and paper products	9	0.571
20 Manufacture of chemicals	11	1.125
21 Manufacture of basic pharmaceutical products	6	8.000
22 Manufacture of rubber products	26	0.806
23 Manufacture of other non-metallic mineral products	17	0.210
24+25 Manufacture of basic metals and fabricated metal products	102	0.258
26 Manufacture of computer products	14	0.818
27 Manufacture of electrical equipment	17	0.762
28 Manufacture of machinery and equipment n.e.c.	32	0.257
29+30 Manufacture of motor vehicles and other transport equipment	20	0.047
31 Manufacture of furniture	20	3.769
32 Other manufacturing	10	0.500
Total	405	19.336

Source: own research

The research question (RQ) focused on determining whether statistically significant differences exist in the use of quality management methods and tools across manufacturing industries within SK NACE Section C in Slovakia. For the purposes of the analysis, the dataset was adjusted to allow the classification of enterprises according to the extent of MTQM utilization. In this study, enterprises applying two or more quality management methods or tools were categorized as having a higher level of MTQM adoption, whereas those using one or none were classified as having a lower level of adoption. The results related to RQ, based on descriptive statistical analysis, are visualized in Figure 1. This visualization provides an overview of the extent of MTQM utilization across individual manufacturing industries within SK NACE Section C and serves as a basis for subsequent statistical testing of the significance of sectoral differences.

As illustrated in Figure 1, the extent of MTQM utilization varies considerably across manufacturing industries. The highest proportion of enterprises with a broader application of quality management methods and tools was observed in industries such as SK NACE 17, SK NACE 20, SK NACE 26, SK NACE 28, SK NACE 29, and SK NACE 23. In these sectors, more than 50% of enterprises apply two or more MTQM techniques, indicating a more systematic approach to quality management. This pattern may reflect higher requirements for standardization, certification, technological precision, or process stability typical for these industries.

Figure 1: Extent of MTQM utilization across manufacturing industries (SK NACE Section C)



Source: own research

Conversely, a lower extent of MTQM utilization was identified in sectors such as SK NACE 13+14, SK NACE 16, and SK NACE 31, where the share of enterprises applying a broader range of quality management techniques does not exceed 30%. This may be associated with lower levels of automation, smaller average firm size, or less stringent regulatory or technological requirements within these industries. In addition, these industries are often characterized by lower capital intensity, slower rates of digital transformation, and a greater reliance on labour-intensive production processes, which may reduce both the incentives and the organizational capacity for implementing more sophisticated MTQM practices. At the same time, it can be expected that in several of these sectors the degree of automation, digitalization, and technological innovation will increase in the coming years. Such developments are likely to be accompanied by a more intensive adoption of MTQM practices, which will become essential for ensuring standardization, efficiency, and competitiveness in an evolving technological environment.

To assess the statistical significance of differences in the extent of MTQM utilization across manufacturing industries, Pearson's Chi-square test of independence was

applied (Table 2). The results indicate that the null hypothesis of independence can be rejected at the 5% significance level. The obtained p-value (p = 0.001) confirms the existence of a statistically significant association between industry classification and the extent of MTQM adoption. The strength of this association, expressed by the contingency coefficient 0.37 and Cramér's V (0.35), indicates a moderate relationship and suggests that industry affiliation has a practically relevant influence on the extent of MTQM utilization.

From an industry perspective, the sectors with the highest levels of MTQM utilization tend to be those characterized by high technological complexity, stringent regulatory and normative requirements, strong emphasis on product safety and reliability, and intense competition in global markets. In such industries, a systematic and continuous approach to quality management is not only beneficial but often essential for maintaining operational stability and competitiveness. This is reflected in the more intensive implementation of quality management methods and tools.

A binomial test was subsequently used to identify industries in which the proportion of enterprises with a higher extent of MTQM utilization exceeds the expected value under a uniform distribution. With the exception of SK NACE 23, the results confirmed at the 5% significance level that the share of enterprises applying a broader range of MTQM techniques is significantly higher than 50% in all tested industries.

These findings provide empirical support for the assumptions underlying RQ and demonstrate that significant differences exist in the extent of MTQM utilization across manufacturing industries in Slovakia.

Table 2: Results of Pearson's Chi-Square test for research question RQ

Association between the extent of MTQM utilization and manufacturing industry (SK NACE Section C)				
Pearson's Chi-square test	**DF**	**p - value**	**Contingency coefficient**	**Cramér's V**
66.98	16	0.001	0.37	0.35

Source: own research

The results of the study confirm that the extent of MTQM utilization differs significantly across manufacturing industries, which is consistent with previous research emphasizing the influence of structural and contextual factors on the adoption of quality management practices. Several authors have shown that industry characteristics, technological intensity, and production complexity shape the degree to which enterprises implement quality tools and methods (Kim-Soon et al., 2020; Gambi et al., 2021; Antony et al., 2022). The present findings support these conclusions by demonstrating that industries with higher technological and regulatory demands tend to adopt MTQM more systematically, whereas sectors with lower automation or fewer normative requirements show more limited adoption.

These results also align with studies highlighting the importance of organizational and managerial factors in quality management implementation. Garza-Reyes et al. (2015) and Attia (2016) emphasize that managerial commitment and organizational culture play a decisive role in the adoption of quality practices, suggesting that technical requirements alone cannot fully explain sectoral differences. Sectoral differences in MTQM adoption may also reflect variations in organizational and technological readiness. Recent studies suggest that the successful implementation of advanced quality management practices increasingly depends on the integration of Industry 4.0 technologies, digital quality management systems, and Quality 4.0 capabilities, while resource constraints and lower levels of digitalization may create additional barriers to their adoption (Oliveira et al., 2025; Aichouni et al., 2024). These findings further support the argument that the adoption of quality management practices is shaped by a combination of technical, organizational, and strategic factors. Similarly, Tarí et al. (2020) argue that successful implementation depends on the interplay of technical, strategic, and human factors, which may contribute to the variability observed across industries.

By situating MTQM adoption within the SK NACE classification, the study provides empirical evidence that complements existing research, which has often examined individual tools or isolated industries. The findings thus contribute to a more comprehensive understanding of how sector-specific conditions shape the practical application of quality management methods and tools.

Hypothesis H1 examines whether statistically significant differences exist in the extent of MTQM utilization among manufacturing enterprises in Slovakia depending on their performance measured by return on sales (ROS). ROS was selected as the primary performance indicator due to its availability, comparability across firms, and its relevance as a direct measure of profitability. For the purposes of the analysis, enterprises were classified into four ROS categories: firms with negative ROS, firms with ROS up to 2.5%, firms with ROS between 2.6% and 5%, and firms with ROS above 5%. Within these categories, notable differences emerged in the distribution of enterprises according to the extent of MTQM utilization. In the negative ROS category, 12 enterprises with a higher extent of MTQM utilization (3.0% of the total sample) were identified, compared with 68 enterprises characterized by a lower or no extent of MTQM utilization (16.8%). In the ROS up to 2.5% category, 85 enterprises exhibited a higher extent of MTQM utilization (20.9%), whereas 127 enterprises were classified as having a lower or no extent of MTQM utilization (31.4%). In the ROS 2.6–5% category, 66 enterprises were classified as having a higher extent of MTQM utilization (16.3%), compared with 16 enterprises characterized by a lower or no extent of MTQM utilization (3.9%). Similarly, in the ROS above 5% category, 20 enterprises with a higher extent of MTQM utilization (4.9%) were identified compared with

11 enterprises characterized by a lower or no extent of MTQM utilization (2.7%). These differences suggested a potential relationship between the extent of MTQM utilization and enterprise performance, which was subsequently verified through statistical testing.

To statistically verify this relationship, Pearson's Chi-square test of independence was applied. The results (Table 3) show that the null hypothesis of independence can be rejected at the 5% significance level. The test statistic ($\chi^2 = 76.84$, df = 3) and the corresponding p-value (p = 0.001) provide strong evidence of a statistically significant association between MTQM utilization and enterprise profitability. The contingency coefficient reached a value of 0.39, while Cramér's V reached 0.36, indicating a moderate effect size. Although the relationship is statistically significant, these values suggest that MTQM utilization represents an important, but not the sole, determinant of enterprise profitability.

These findings suggest that enterprises applying a broader range of MTQM techniques are more likely to achieve higher profitability levels. Conversely, firms with limited or no use of MTQM were more frequently represented in categories with lower or negative ROS values. This pattern supports the assumption that systematic implementation of quality management methods and tools contributes to improved financial performance. Overall, the results provide empirical support for Hypothesis H1 and confirm that the extent of MTQM utilization is significantly related to the profitability of manufacturing enterprises in Slovakia.

Results of Pearson's Chi-Square test for hypothesis H1

Association between the extent of MTQM utilization and enterprise profitability (ROS)				
Pearson's Chi-square test	DF	p - value	Contingency coefficient	Cramér's V
76.84	3	0.001	0.39	0.36

Source: own research

The findings related to Hypothesis H1 are consistent with a broad body of international research demonstrating that the implementation of quality management systems and tools contributes positively to enterprise performance. Several recent studies confirm that systematic application of MTQM practices enhances operational efficiency, process stability, and financial outcomes across different industrial contexts (Gorondutse, 2021; Olaleye et al., 2021; Potjanajaruwit, 2021). Kumar et al. (2018) similarly report that the adoption of quality management systems in the UK manufacturing sector leads to measurable improvements in both operational and financial performance.

More recent research further highlights the strategic dimension of quality management. Cai et al. (2023) show that Quality 4.0 initiative, integrating digital technologies with traditional quality management, significantly strengthen innovation performance in manufacturing firms. Likewise, Cződörová & Gnap (2023) provide evidence that ISO 9001 implementation has a statistically significant positive effect on profitability indicators such as ROA and ROS, which aligns directly with the present study's findings. This interpretation is further supported by recent studies suggesting that organizational performance increasingly depends on the effective integration of governance mechanisms, risk management practices, and structured managerial approaches that strengthen long-term organizational stability and performance (Musa et al., 2026).

Taken together, these insights reinforce the conclusion that enterprises applying a broader range of MTQM techniques tend to achieve superior financial outcomes. The statistically significant association between MTQM utilization and ROS observed in this study thus extends existing knowledge by providing empirical evidence from the context of Slovak manufacturing. The results suggest that systematic and consistent use of quality management tools may represent an important performance-enhancing mechanism even in smaller economies.

CONCLUSION

The results of the research confirmed that the extent of the use of quality management methods and tools varies significantly among manufacturing enterprises in Slovakia and that these differences are statistically associated with enterprise performance measured by ROS. This empirical evidence indicates that systematic and broader application of MTQM may represent an important factor in increasing the profitability of manufacturing companies, with this relationship observable across different industries.

The study also identified sector-specific patterns in MTQM implementation, suggesting that technological complexity, regulatory requirements, and competitive pressures significantly influence how enterprises approach quality management. The findings also provide several practical implications for economic policy and business support programs. Since enterprises applying a broader range of quality management methods and tools were more likely to achieve higher profitability levels, policy measures aimed at supporting the adoption of quality management practices may contribute to improving the competitiveness and financial performance of manufacturing enterprises, particularly SMEs. Public support initiatives could focus on training, advisory services, and the promotion of quality management systems and continuous improvement practices that facilitate the broader implementation of MTQM. From a managerial perspective, the results suggest that SMEs should favour a comprehensive and systematic approach to quality management based on combining multiple methods and tools, as a broader scope of MTQM utilization was associated with a higher likelihood of achieving superior profitability levels. Although the present study did not compa-

re the effectiveness of individual MTQM techniques, the findings allow the formulation of a gradual implementation framework for SMEs. Such an approach may begin with the adoption of widely used practices, such as ISO-based quality management systems and continuous improvement methods, and subsequently progress towards the integration of more advanced quality management tools in line with firms' organizational capabilities, technological readiness, and strategic objectives.

However, the research also has its limitations. The analysis was based on cross-sectional data, which do not allow capturing changes over time, and enterprise performance was assessed using a single financial indicator. Another limitation of the study is that firm-specific characteristics, such as company size, age, or export orientation, were not included as control variables in the statistical analysis. These factors may influence both the adoption of MTQM and enterprise performance and therefore represent a promising direction for future research. Future research could therefore employ longitudinal data, broaden performance evaluation to include additional economic and non-economic indicators, and examine qualitative factors influencing enterprises' decisions to implement MTQM. Another promising direction is the analysis of the impact of digitalization and Quality 4.0 concepts on the effectiveness and extent of quality tool utilization across industries.

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AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, P.G., M.P., K.K. and N.N.; methodology, P.G. and M.P.; software, M.P.; validation, P.G., M.P., K.K. and N.N.; formal analysis, P.G., M.P., K.K. and N.N.; investigation, P.G., M.P., K.K. and N.N.; resources, P.G. and M.P.; data curation, P.G., M.P., K.K. and N.N.; writing-original draft preparation, P.G., M.P., K.K. and N.N.; writing-review and editing, P.G., M.P., K.K. and N.N.; visualization, P.G., M.P.; supervision, P.G. and M.P. All authors have read and agreed to the published version of the manuscript.

DATA AVAILABILITY STATEMENT

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AI DISCLOSURE

During the preparation of this work, the authors used an AI tool (ChatGPT) to enhance the manuscript's language, readability, and stylistic consistency.

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