

## **BENCHMARKING OF ENTERPRISES IN THE WOOD- PROCESSING SECTOR WITH OTHER SECTORS OF THE NATIONAL ECONOMY IN THE CONTEXT OF IMPROVING THEIR PERFORMANCE THROUGH QUALITY MANAGEMENT SYSTEMS**

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### **ABSTRACT**

The aim of this paper is to analyze the performance of enterprises operating in the wood-processing sector relative to those in other sectors of the national economy, with particular emphasis on the role of quality management systems in enhancing efficiency, competitiveness, and sustainability. The research is based on a quantitative analysis of selected performance indicators, such as revenues from own production, economic results, labor productivity, and sales profitability. Significant differences in the implementation of quality management systems across sectors of the national economy and within the wood-processing industry are revealed by the findings. Moreover, the positive impact of these systems on enterprise performance is confirmed by the results. Key factors for the successful implementation of quality management systems are identified and recommendations for strategic decision-making in the field of performance improvement are provided in the paper.

**Keywords:** performance; quality; quality management system; wood processing industry.

### **INTRODUCTION**

Currently, the business environment is facing increasing pressure to enhance efficiency, competitiveness, and sustainability. In this context, quality management systems are becoming a key tool for achieving strategic goals across various sectors of the national economy. Several authors (Ali and Rahmat, 2010; Lin and Jang, 2008) argue that quality management systems have the potential not only to increase an organization's competitiveness and efficiency, but also to improve product quality and overall organizational performance. Petrick (2017) states that the goal of implementing quality management systems is to reduce costs, deliver outstanding-quality services, achieve customer satisfaction, and enhance competitiveness. The focus of the research on industrial enterprises stems from their key role in the Slovak Republic's economic structure and their significant potential for implementing quality management techniques. An argument in favor of this targeted focus on industrial enterprises is the particular attention given to companies in the wood-processing industry, which have historically formed an important segment of Slovak industry. These enterprises utilize the only domestic renewable natural resource – wood-, making them a strategically important sector not only from an economic perspective but also from a sustainability perspective. Their specific position and environmental linkage

also create space for applying quality management techniques to increase competitiveness and reduce negative environmental impacts.

According to Gambi *et al.* (2021), benchmarking is an effective method for comparing enterprise performance, enabling the identification of best practices and areas with potential for improvement. The use of benchmarking, combined with an analysis of the implementation of quality management systems, provides a comprehensive view of how these systems influence the performance of enterprises in the wood-processing sector compared to other industries.

The aim of this paper is to examine the differences in performance between enterprises in the wood-processing industry and those in other sectors of the national economy, with particular attention given to the role of quality management systems and their relationship to improving business performance. The research is based on a quantitative analysis of selected performance indicators, which enables an objective assessment of the impact of management quality on business outcomes.

To verify our assumption, the following research questions (RQ) were formulated: RQ1: Do companies in the wood-processing industry rank among the most profitable sectors within industrial enterprises in Slovakia? RQ2: Do companies in the wood-processing industry rank among the sectors with the highest labor productivity within industrial enterprises in Slovakia? RQ3: Are there differences in the use of the quality management techniques among industrial enterprises across various sectors in Slovakia?

In this analysis, quality management techniques are understood as a set of methods, tools, models, approaches, and philosophies aimed at improving the quality of processes, products, and services, enhancing customer satisfaction, and thereby contributing to the overall performance improvement of the enterprise.

The quality management system, often referred to as QMS, is a set of internal rules defined by a collection of policies, processes, documented procedures, and records (ISO 9001:2015). The international ISO standard requires that the adoption of a quality management system be a strategic decision of the organization. The design and implementation of the organization's quality management system are influenced by various factors, including its objectives, the products it provides, the processes it uses, and its size and structure (Fonseca *et al.*, 2022). As noted by Elwardi *et al.* (2021) and Ribeiro *et al.* (2019), the ISO 9001 standard outlines the criteria for a quality management system in organizations that aim to consistently deliver products that meet applicable regulations and customer expectations, while also seeking to enhance customer satisfaction. ISO 9000 is the most well-known and widely used quality management system (Ilkay and Aslan, 2017). It can be used by any institution, company, or organization, regardless of its size or field of activity (Bekele and Zewedie, 2017). This international standard encourages organizations to apply a process-based approach when designing, implementing, and enhancing the performance of a quality management system. By doing so, organizations can effectively manage the connections and dependencies between system processes, leading to improved overall organizational performance (Su *et al.*, 2020). The main objective of ISO 9001 is to identify a set of requirements and practices that can be applied to organizations and institutions, regardless of the products or services they provide.

The roots of Total Quality Management (TQM) can be traced back to the early 1920s, when statistical theory was first applied to product quality control in manufacturing (Chen *et al.*, 2022). This concept further evolved in the late 1940s and early 1950s, largely thanks to American engineers working in post-war Japan, especially W. Edwards Deming, Joseph M. Juran, and Armand V. Feigenbaum. Interest in TQM peaked in the early 1990s, but by the mid-1990s, its popularity began to decline in many developed countries as it was

gradually replaced by the ISO 9000 standard. In recent years, however, many companies have returned to TQM principles in search of effective models for achieving competitive success (Zaidi & Ahmad 2020). TQM is a management philosophy that focuses on continual improvement of customer value by systematically designing and refining organizational processes and systems. It has been widely adopted as a strategic approach to enhance organizational performance and achieve competitive advantage (Babu and Thomas, 2021). Mehralian *et al.* (2017) state that TQM is a management approach that enables organizations to effectively and efficiently meet the needs and expectations of stakeholders without compromising ethical values. TQM can be described as a management system centered on customer satisfaction, involving the active participation of all employees in ongoing improvement efforts. According to Alawag *et al.* (2020), a fundamental definition of TQM highlights it as a long-term management strategy aimed at achieving success through consistently meeting customer needs. It focuses on improving quality through the involvement of all members of the organization, aiming for long-term success through customer satisfaction and benefits for all organizational members (Fadera, 2020). According to Kisel'akova *et al.* (2020), the primary aim of the process is to enhance the quality of an organization's output continuously improving its internal operations.

Sales are a key quantitative indicator of a company's production performance. Its amount, especially from sales of own outputs and goods, serves as a fundamental indicator of the company's efficiency and market success (Zalai *et al.*, 2013). The economic result is an integral indicator of a company's overall economic performance, reflecting the difference between revenues and expenses. Its value is crucial for the return on investment for entities that participate in the company's share capital (Kotulič *et al.*, 2018). Labor productivity is the most effective indicator of how efficiently human resources are utilized within a company. Based on the level of labor productivity, it is possible to assess the technological and organizational maturity of the enterprise (Lisý *et al.*, 2011). Among the basic indicators of a company's profitability are returns.

A preferred metric is Return on Sales (ROS), which expresses the efficiency of converting sales into profit (Zalai *et al.*, 2013). This indicator provides insight into the cost-effectiveness of a company's operations and is defined as the ratio between economic result and sales (Kráľovič and Vlachynský, 2011).

Quality management systems have a significant and complex impact on business performance, which is reflected in key economic indicators such as sales, labor productivity, and profitability. By implementing systematic, standardized procedures, a company improves the coordination of its processes, thereby achieving a more stable, higher-quality product or service (Lamine and Lakhali, 2018). Higher quality leads to more satisfied customers, a reduction in the number of complaints, and the strengthening of market trust, which subsequently translates into sales growth (Attia, 2016). In addition to their direct impact on revenues, quality management systems also increase labor productivity. Clearly defined responsibilities, work procedures, and control points eliminate unnecessary downtime, duplicate activities, and the disorder that often arises in non-standardized work environments. At the same time, rising sales and higher productivity strengthen profitability and enable the company to achieve sustainable long-term economic results (Kumar *et al.*, 2018). Profitability therefore increases not only from higher sales but also from consistent cost savings and the more efficient use of financial, material, and human resources.

The main contribution of the work is benchmarking and examining performance differences between companies in the wood-processing industry and its individual subsectors, namely the furniture industry, the pulp and paper industry, and the woodworking industry, and companies in other sectors of the national economy, with special emphasis on

the role of quality management systems and their relationship to improving corporate performance.

## MATERIALS AND METHODS

The paper preparation process was carried out in several stages. Initially, a literature review was performed of scholarly papers written by experts who have explored the relevant topic. For the actual data collection in quantitative research, a standardized questionnaire survey was used. It was conducted from the end of April to the beginning of June 2025 via the Google Forms online platform. The questionnaire was distributed to industrial enterprises in Slovakia, classified according to NACE, through individual email contacts. The link to the questionnaire is as follows: <https://docs.google.com/forms/d/e/1FAIpQLSe01NVN7mLnMjC7Lw8b2bpzBhtriSTz4HurZKUJLWckULrvA/viewform?usp=header>. A total of 3.585 companies were contacted, and the response rate was 11%. A questionnaire was developed containing various questions about the company, such as its size, financial performance, capital structure, and aspects related to the implementation of quality management systems - for example, why companies implement QMS, which methods and tools they use, what benefits they are able to identify from using QMS, what problems have they identified in connection with the implementation of the QMS and similar aspects. Our primary aim was to gather information on the application of quality management techniques as well as the motivations for adopting these systems and the benefits they bring. Following this, research questions were formulated and analysed the collected responses using selected statistical techniques. The research questions were formulated based on theoretical assumptions grounded in the idea that companies with high demands on the technologies they use, as well as sophisticated and automated management systems, including quality management systems will achieve better performance as measured by indicators such as return on sales and labor productivity. At the same time, our intention was to compare the subsectors of the wood-processing industry with other sectors of the national economy and to confirm the assumption that there are differences in the use of quality management techniques among industrial enterprises across various sectors in Slovakia. Our findings were compared with those of other researchers studying the same issue, which allowed us to gain deeper insights and place our results in a broader context. Finally, conclusions were drawn and future directions for our research was proposed.

To determine the necessary sample size, a formula for a population of the finite size according to Yamane Taro (Lind, 2020) was followed.

$$n = \frac{N}{1+N \cdot E^2} \quad (1)$$

To determine the population size of manufacturing enterprises, the information database of the Statistical Office of the Slovak Republic for the year 2025 was used as the reference source. To evaluate the representativeness of the research sample in terms of industry affiliation and enterprise size category, the Chi-square goodness-of-fit test and Pearson's Chi-square test of independence were used. To determine the Chi-square level ( $\chi^2$ ), the following formula was used:

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

To evaluate the economic indicators, the theory of time series was applied. A time series is understood as a chronologically ordered sequence of data that are comparable in terms of content and location, referring to any quantitative random variable. For the decomposition of the time series, only the trend component will be applied, using a linear function with time  $t = 1, 2, \dots n$ . Such a function of the form:

$$Tr_t = \beta_0 + \beta_1 t \quad (3)$$

The parameter  $\beta_0$  in the linear model is called the intercept constant, indicating the point where the regression line intersects the y-axis. The parameter  $\beta_1$  is called the regression coefficient and represents the slope of the regression line. It shows the change in the mean value of the dependent variable Y corresponding to a one-unit increase in the independent variable t.

All statistical analyses were carried out using software STATISTICA 14. In hypothesis testing, an alpha level of 0.05 has traditionally been used as the decision rule. The output tables were edited in Microsoft Excel.

For the purposes of a comparative analysis of the performance of industrial enterprises, data from the Statistical Yearbooks of Industry of the Slovak Republic published by the Statistical Office of the Slovak Republic for the period 2014–2023 were analyzed. The selection of indicators was based on their availability, informative value, and relevance for evaluating performance within the SK NACE classification – Section C: Manufacturing.

To determine the minimum sample size, a formula for the finite population according to Yamane Taro (Lind, 2020) was applied. With a target population size of 3585 units and the selected error  $e = 0.05$  was the minimum sample size derived as:

$$n = \frac{3585}{1 + 3585 \cdot 0.05^2} = 360 \quad (4)$$

Since the target population was segmented by industry, a stratified sampling method was used to maintain the sample's representativeness. Ultimately, 405 questionnaires were completed correctly and deemed suitable for analysis. To verify representativeness, the chi-square goodness-of-fit test was used. This test determines whether the distribution of observed frequencies in the sample significantly differs from the expected distribution in the population. The testing was based on the null hypothesis that there is no statistically significant difference between the observed frequencies (the structure of the sample) and the expected frequencies (the structure of the entire population). The results of the representativeness testing based on the industry structure of manufacturing enterprises (categorized according to the SK NACE classification) confirmed that the research sample represents and corresponds to the structure of the entire population and can therefore be considered representative (Tab. 1).

**Tab. 1 Results of the representativeness testing according to the SK NACE classification.**

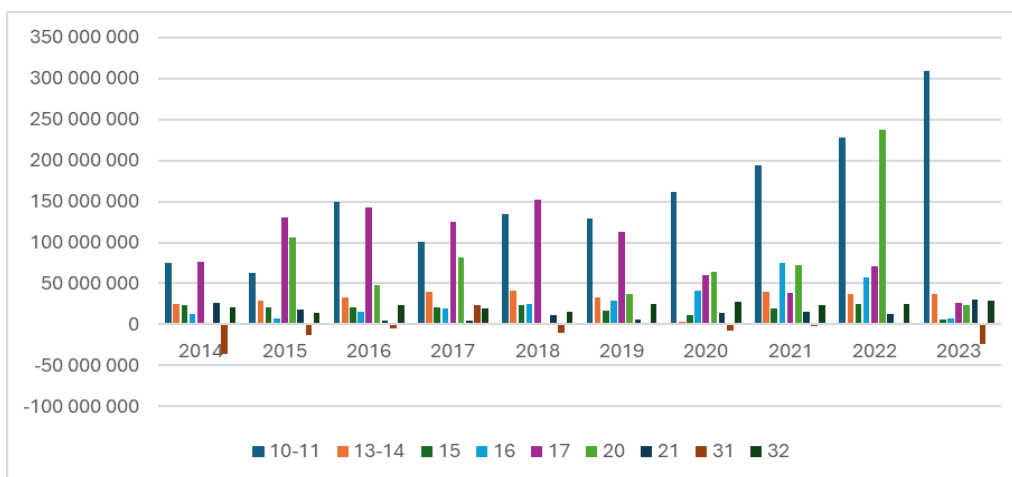
Industry sector	$\chi^2 = 19.34$ $sv = 15$ $p = 0.199$			
	Observed frequencies (O <sub>i</sub> )	Expected frequencies (E <sub>i</sub> )	E - O	(E-O) <sup>2</sup> (/O)
SK NACE 10+11	68	74	-6	0.500
SK NACE 13+14	19	22	-3	3.769
SK NACE 15	7	5	2	0.048
SK NACE 16	27	31	-4	0.257
SK NACE 17	9	7	2	0.762
SK NACE 20	11	8	3	0.819
SK NACE 21	6	2	4	0.258
SK NACE 22	26	31	-5	0.211
SK NACE 23	17	19	-2	0.806
SK NACE 24+25	102	97	5	8.000
SK NACE 26	14	11	3	1.125
SK NACE 27	17	21	-4	0.571
SK NACE 28	32	35	-3	0.516
SK NACE 29	20	21	-1	0.800
SK NACE 31	20	13	7	0.409
SK NACE 32	10	8	2	0.486
Spolu	405	405	0.00	19.337

## RESULTS AND DISCUSSION

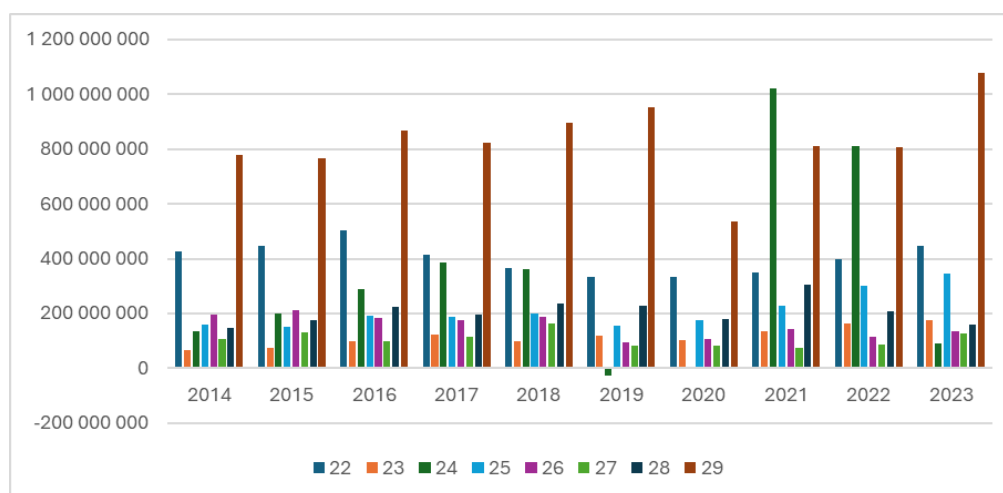
The results of time series analysis and the performance of industrial enterprises in Slovakia are presented in the next part. Tab.2 presents revenues from own performance and goods, categorized according to the SK NACE classification. As shown in the table, the automotive industry sector clearly dominates this indicator. The lowest revenues among the sectors are generated by the pharmaceutical industry, clothing and textile manufacturing, leather production, wood processing, and furniture manufacturing. A very similar pattern is observed in the indicator of profit before tax (Fig. 1 and Fig. 2), where the automotive sector, metal processing, and the production of rubber and plastic products again dominate. Furniture manufacturing recorded a loss throughout the observed period, while the pharmaceutical industry, textile and clothing manufacturing, leather production, and wood processing sectors showed slight profits.

**Tab. 2 Sales from own performance and goods in thousands of euros (€) according to SK NACE.**

SK NACE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
10-11	3139988	3100425	3701302	3981675	4038396	4266634	4284461	4538184	5725822	6389603
13-14	551526	577482	588959	619652	630743	600795	520152	518294	610041	644015
15	579662	581359	586945	633748	646141	570803	506725	515471	663599	441864
16	498621	501899	588790	639148	673974	692425	679394	900029	1101086	853202
17	1230330	1305472	1299458	1313570	1398983	1355851	1271727	1509358	2037397	1797089
20	1676215	1643398	1567931	1668701	1601584	1531482	1431876	2007869	2896399	2086955
21	191213	203439	174515	186960	181732	177409	183447	187082	207947	271908
22	3818450	4109853	4421526	4683291	4618572	4637916	4097189	4526113	5238565	5076065
23	1350228	1429433	1530233	1581968	1733060	1922839	1897146	2121566	2575287	2482847
24	4023996	3950741	3778768	4726021	5034092	4533750	3945812	6786667	8284977	6313015
25	3508186	3769917	3882500	4399701	4838051	4524186	4092638	4733225	5746080	5925479
26	5941963	5837274	5771175	5232585	4604050	4072560	3558439	3862813	3952098	3523090
27	3286856	3441365	3457081	3651042	3780655	3845998	3448418	4108309	4923034	6007963
28	3825629	4132982	4464258	4845859	5150126	5240128	4828791	5824561	6921218	6939282
29	21228361	24590242	25816878	26629037	30434400	31411895	28562838	30551126	34345260	39680172
31	704425	803305	784209	838292	906588	848501	763813	818144	940042	824428
32	351048	347065	330243	324439	355767	395463	392875	432918	513483	517923



**Fig. 1 Profit before tax by industry sectors according to SK NACE\*, in €.**



**Fig. 2 Profit before tax by industry sectors according to SK NACE\*, in €.**

\*SK NACE 10-11 - Food and beverage production, SK NACE 13-14 - Manufacture of textiles and wearing apparel, SK NACE 15 - Manufacture of leather and related products, SK NACE 16 - Manufacture of wood and of products of wood and cork, except furniture, SK NACE 17 - Manufacture of paper and paper products, SK NACE 20 - Manufacture of chemicals and chemical products, SK NACE 21 - Manufacture of basic pharmaceutical products, SK NACE 22 - Manufacture of rubber and plastic products, SK NACE 23 - Manufacture of other non-metallic mineral products, SK NACE 24 - Manufacture of basic metals, SK NACE 25 - Manufacture of fabricated metal products, SK NACE 26 - Manufacture of computer, electronic and optical products, SK NACE 27 - Manufacture of electrical equipment, SK NACE 28 - Manufacture of machinery and equipment, SK NACE 29 - Manufacture of motor vehicles, trailers and semi-trailers, SK NACE 31 - Manufacture of furniture, SK NACE 32 - Other manufacturing

The first research question examined whether the wood-processing industry sector belongs among the most profitable sectors within industrial enterprises in Slovakia. From the data analysis (Tab. 3), we can conclude that, based on the Return on Sales indicator, the most profitable industrial sector in the Slovak Republic is the manufacture of rubber and plastic products (SK NACE 22). Above-average performance is also achieved by the manufacture of metal structures (SK NACE 25), other manufacturing (SK NACE 32), and the manufacture of textiles and apparel (SK NACE 13 and 14). Within the specific characteristics of the wood-processing industry (NACE 16, 17, and 31), the paper and paper products sector is among the higher-performing sectors. However, performance has not yet reached levels from the pre-COVID period. On the other hand, the worst-performing sector

based on the Return on Sales indicator is the manufacture of furniture (SK NACE 31), which in the observed period shows negative values or values very close to zero.

**Tab. 3 Indicator Return on Sales in % by SK NACE.**

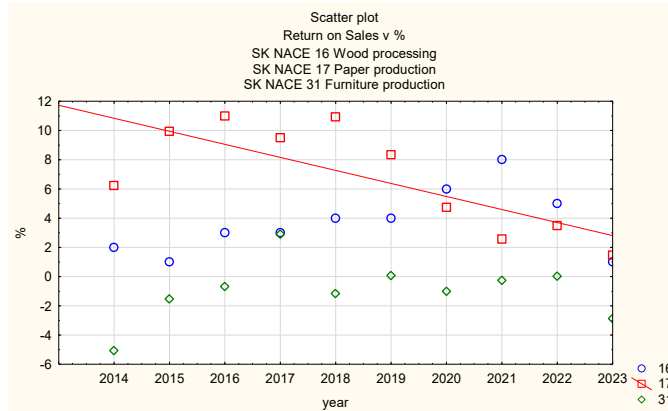
SK NACE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
10-11	2,40%	2,01%	4,05%	2,54%	3,34%	3,02%	3,77%	4,27%	3,98%	4,85%
13-14	4,58%	5,05%	5,52%	6,35%	6,51%	5,52%	0,71%	7,63%	6,14%	5,68%
15	4,03%	3,54%	3,67%	3,24%	3,59%	2,85%	2,26%	3,66%	3,69%	1,31%
16	2,43%	1,48%	2,65%	3,02%	3,67%	4,17%	6,11%	8,29%	5,26%	0,91%
17	6,24%	9,95%	11,00%	9,50%	10,92%	8,35%	4,73%	2,57%	3,49%	1,47%
20	0,05%	6,50%	3,07%	4,89%	-0,05%	2,45%	4,53%	3,62%	8,18%	1,10%
21	13,40%	8,68%	2,99%	2,73%	6,19%	3,61%	7,49%	8,18%	5,94%	11,06%
22	11,13%	10,88%	11,37%	8,86%	7,95%	7,15%	8,14%	7,72%	7,59%	8,79%
23	5,04%	5,32%	6,48%	7,82%	5,58%	6,24%	5,48%	6,30%	6,27%	7,02%
24	3,33%	5,00%	7,65%	8,15%	7,22%	-0,59%	-0,05%	15,05%	9,81%	1,41%
25	4,56%	4,04%	4,96%	4,25%	4,16%	3,45%	4,26%	4,79%	5,27%	5,84%
26	3,29%	3,61%	3,17%	3,34%	4,09%	2,34%	2,97%	3,65%	2,93%	3,80%
27	3,23%	3,76%	2,82%	3,14%	4,31%	2,16%	2,40%	1,78%	1,73%	2,09%
28	3,83%	4,26%	4,99%	4,06%	4,59%	4,37%	3,73%	5,21%	3,02%	2,27%
29	3,66%	3,12%	3,36%	3,09%	2,94%	3,04%	1,87%	2,65%	2,35%	2,72%
31	-5,06%	-1,54%	-0,68%	2,89%	-1,16%	0,07%	-1,00%	-0,27%	0,02%	-2,88%
32	5,83%	3,89%	7,04%	5,83%	4,17%	6,22%	6,89%	5,50%	4,78%	5,67%

**Tab. 4 Results of the statistical significance testing of the trend by individual industry sectors according to SK NACE for the indicator “Return on Sales”.**

Sector	n	Average	Standard deviation	Intercept constant $b_0$	Regression coefficient $b_1$	t-test	p-value
SK NACE 10+11	10	3.42%	0.91	2.07	0.24	3.85	0.005
SK NACE 13+14	10	5.37%	1.84	5.03	0.06	0.28	0.780
SK NACE 15	10	3.18%	0.83	4.08	-0.16	-2.12	0.066
SK NACE 16	10	3.70%	2.21	1.93	0.32	1.38	0.204
SK NACE 17	10	6.82%	3.59	11.72	-0.89	-3.22	0.012
SK NACE 20	10	3.43%	2.69	2.58	0.15	0.49	0.633
SK NACE 21	10	7.03%	3.48	7.11	-0.01	-0.038	0.970
SK NACE 22	10	8.96%	1.58	11.13	-0.39	-3.26	0.011
SK NACE 23	10	6.16%	0.84	5.58	0.10	1.14	0.287
SK NACE 24	10	5.70%	4.87	4.99	0.12	0.22	0.828
SK NACE 25	10	4.56%	0.68	3.93	0.11	1.63	0.141
SK NACE 26	10	3.32%	0.50	3.34	-0.00	-0.06	0.949
SK NACE 27	10	2.74%	0.86	3.87	-0.20	-2.95	0.018
SK NACE 28	10	4.03%	0.88	4.79	-0.13	-1.52	0.166
SK NACE 29	10	2.88%	0.51	3.57	-0.12	-3.23	0.012
SK NACE 31	10	-0.96%	2.06	-1.69	0.13	0.56	0.58
SK NACE 32	10	5.58%	1.04	5.50	0.014	0.11	0.911

The time series analysis used the indicator Return on Sales. Based on the results of the time series analysis (Tab. 4), it can be stated that the parameters of the linear trend model for the indicator “Return on Sales” are statistically significant at the 5% significance level in the following sectors: food and beverage production ( $p = 0.005$ ), paper and paper products manufacturing ( $p = 0.012$ ), rubber and plastic products manufacturing ( $p = 0.011$ ), electrical equipment manufacturing ( $p = 0.018$ ), and motor vehicles, trailers, and semi-trailers manufacturing ( $p = 0.012$ ). In the remaining analyzed sectors, the parameters of the linear model are not statistically significant, indicating that modeling sales profitability with a straight line is not appropriate.

Fig. 2 illustrates the linear trend model ( $y=11.73-0.89t$ ) of the development of the “Return on Sales” indicator in the wood-processing industry sectors in Slovakia. Based on the value of the regression coefficient  $b_1$ , it can be stated that in the paper manufacturing sector, sales profitability decreases on average by 0.89% per year. In the other sectors, the parameters are not statistically significant, which means that modeling sales profitability using a linear trend is not appropriate.



**Fig.2 Linear trend model of the development for SK NACE 16. 17. and 31 for the indicator “Return on Sales”.**

The second research question examined whether the wood-processing industry sector belongs among the sectors with the highest Labor Productivity within industrial enterprises in Slovakia. For the labor productivity indicator, the manufacture of motor vehicles trailers, and semi-trailers (SK NACE 29) and the manufacture of computer, electronic and optical products (SK NACE 26) clearly dominate. From the perspective of labor productivity, the worst-rated sectors include the manufacture of textiles and apparel (SK NACE 13 and 14), which, compared to the most productive sector in this indicator, achieves approximately seven times lower values (Tab. 5). The wood-processing industry sectors are among the stable ones in this indicator. showing a growth trend. Among these analyzed sectors, the pulp and paper industry again stands out as the most productive, achieving approximately 1.5 times the performance of wood processing and about twice that of the furniture manufacturing sector.

**Tab. 5 Indicator Labor Productivity per Employee in € by SK NACE.**

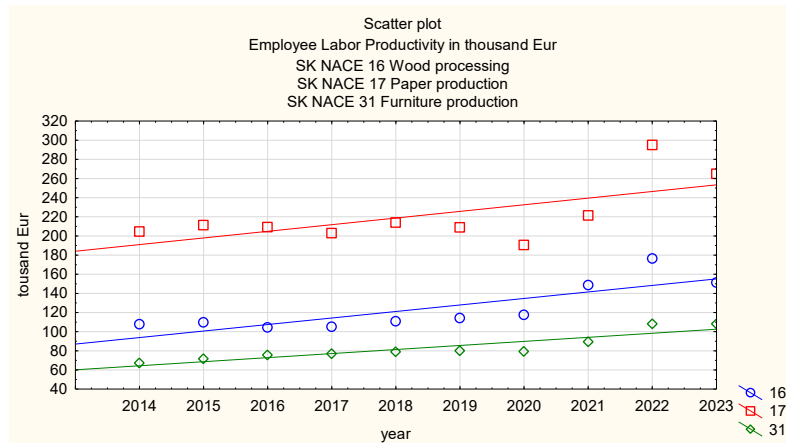
SK NACE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
10-11	130 207	125 438	145 495	148 108	155 139	160 502	161 103	166 247	201 811	228 743
13-14	43 018	45 252	44 574	45 694	49 760	50 818	51 240	54 581	63 737	71 857
15	61 509	61 550	60 147	61 724	65 789	69 010	6 7613	70 159	87 698	59 611
16	107 570	109 628	104 420	105 026	110 682	114 177	117 301	148 662	176 394	151 315
17	204 561	211 310	209 219	202 690	213 964	209 056	190 484	221 323	294 775	264 726
20	203 783	213 620	196 586	211 054	213 093	215 111	207 458	282 739	410 924	299 420
21	89 633	93 449	80 596	83 921	84 315	83 569	84 733	79 015	89 114	113 850
22	146 610	146 579	145 008	142 474	141 283	141 701	133 372	152 781	182 927	186 814
23	110 392	121 185	122 654	127 534	133 002	138 673	137 086	156 158	189 042	190 916
24	174 724	178 966	171 054	206 079	219 505	197 735	181 961	308 510	382 314	301 431
25	117 295	120 329	112 339	120 271	125 403	121 073	120 153	139 390	166 985	174 503
26	423 914	444 497	449 542	385 540	332 204	321 779	307 284	405 464	403 683	376 266
27	113 109	114 379	110 194	113 085	113 440	118 102	112 060	128 062	150 814	176 337
28	103 954	109 970	111 259	117 148	120 872	124 177	120 290	140 847	162 246	168 842
29	350 554	373 722	365 879	349 249	380 225	387 774	367 490	401 249	461 855	528 417
31	67 274	71 573	75 579	77 079	78 859	79 875	79 311	89 237	108 078	108 173
32	77 334	73 221	74 179	72 345	76 081	82 111	79 410	86 705	99 808	104 834

For the indicator Labor Productivity, the time-series analysis (Tab. 6) revealed a statistically significant trend in most observed sectors. Significance at the 5% level was confirmed, for example, in the food and beverage manufacturing sector ( $p = 0.000$ ), textile and clothing manufacturing ( $p = 0.000$ ), furniture manufacturing ( $p = 0.003$ ), as well as in other sectors such as paper manufacturing, chemical products, rubber and plastic products, electrical equipment, machinery and equipment, and motor vehicles. These results indicate a consistent development of labor productivity over time, which can be reliably modeled using a linear trend.

**Tab. 6 Results of the statistical significance testing of the trend by individual industry sectors according to SK NACE for the indicator “Labor Productivity”.**

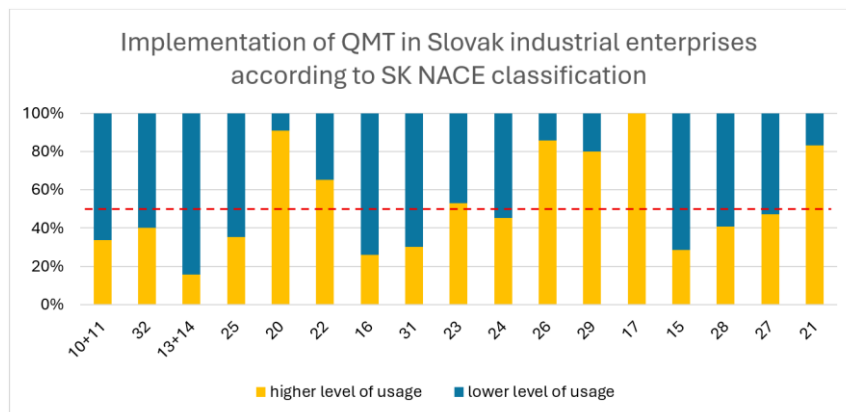
Sector	n	Average	Standard deviation	Intercept constant $b_0$	Regression coefficient $b_1$	t-test	p-value
SK NACE 10+11	10	162,279.3	31,481.74	109,961.2	9,512.38	6.40	0.000
SK NACE 13+14	10	52,053.1	9,230.42	36,830.5	2,767.74	6.12	0.000
SK NACE 15	10	66,481.0	8,372.08	58,584.3	1,435.77	1.71	0.124
SK NACE 16	10	124,517.5	25,023.11	87,097.6	6,803.62	4.10	0.003
SK NACE 17	10	222,210.8	32,148.50	184,053.0	6,937.78	2.44	0.040
SK NACE 20	10	245,378.8	67,836.17	156,583.6	16,144.58	2.93	0.018
SK NACE 21	10	88,219.5	9,985.62	82,173.1	1,099.35	0.99	0.346
SK NACE 22	10	151,954.9	18,058.80	131,013.3	3,807.57	2.34	0.047
SK NACE 23	10	142,664.2	27,756.49	95,945.5	8,494.32	6.96	0.000
SK NACE 24	10	232,227.9	72,710.84	126,996.1	19,133.06	3.72	0.006
SK NACE 25	10	131,774.1	21,767.46	99,372.9	5,891.12	4.04	0.004
SK NACE 26	10	385,017.3	50,429.66	424,354.4	-7,152.20	-1.34	0.215
SK NACE 27	10	124,958.2	27,756.49	94,457.4	5,545.60	3.41	0.009
SK NACE 28	10	127,960.5	21,795.14	90,940.7	6,730.88	6.56	0.000
SK NACE 29	10	396,641.4	56,449.09	314,747.4	14,889.82	3.75	0.006
SK NACE 31	10	83,503.8	14,171.50	60,182.9	4,240.17	6.04	0.000
SK NACE 32	10	82,602.8	11,313.73	6,5154.0	3,172.51	4.54	0.002

Fig. 3 illustrates the linear trend model of the development of the “Labor Productivity” indicator in the wood-processing industry sectors in Slovakia. Based on the values of the regression coefficient  $b_1$  (Fig. 3), it can be stated that in the wood-processing sector, employee labor productivity shows an average annual increase of 6804€ ( $y=87,098+6,804t$ ); in the paper manufacturing sector, an average increase of 6938€ ( $y=184,053+6,938t$ ); and in the furniture manufacturing sector, an average increase of 4240€ ( $y=60,182+4,240t$ ) per year. These values represent the slopes of the trend lines, which quantify the rate of productivity growth in the respective sectors.



**Fig.3 Linear trend model of the development for SK NACE 16. 17. and 31 for the indicator “Labor Productivity”.**

The third research question (RQ3) focused on determining whether there are statistically significant differences in the extent of use of quality management techniques across industrial enterprises operating in different sectors in Slovakia. For the analysis, the data were adjusted to allow classification and selection of enterprises based on the extent of their implementation of quality management techniques (QMT). In the paper, enterprises with a higher level of usage are considered those that apply two or more quality management tools. Conversely, enterprises using only one or none of the tools were classified into the lower-implementation category. As illustrated in Fig. 4, the level of use of quality management techniques varies significantly across industrial sectors. The red dashed line at the 50% level serves as a reference threshold, allowing for quick visual identification of sectors with above-average or below-average implementation of quality management techniques.



**Fig. 4 Implementation of QMT in Slovak industrial enterprises according to SK NACE classification.**

To verify the statistical significance of differences in the extent of using quality management techniques among individual industrial sectors. Pearson's Chi-square test was applied (Tab. 7). The test results showed that the null hypothesis was rejected at the 5% significance level. The p-value = 0.000 confirms that there is a statistically significant relationship between the two examined variables. The degree of dependence expressed by the contingency coefficient reached a value of 0.38, which can be interpreted as a moderate strength of the relationship.

**Tab. 7 Results of Pearson chi-square test of contingency - Using Quality Management Techniques versus Industrial Sector.**

Using QMT vs. Industrial Sector	Chi-square test	Degree of freedom	p-level	Contingency coefficient
	67.61	16	0.000	0.38

From the perspective of sectoral structure, the sectors with the greatest extent of using quality management techniques include those with very high technological complexity, strict legislative and regulatory requirements, a strong emphasis on product safety and reliability, and intense competition in global markets. Therefore, in these industrial sectors, a systematic and continuous approach to quality management is practically a necessity. Quality plays a strategic and existential role here, as reflected in the more intensive implementation of quality techniques.

The first research question examined whether companies operating in the wood-processing industry rank among the most profitable industrial enterprises in Slovakia. The results show that several interconnected factors may be driving the decline in return on sales across many Slovak industrial sectors. First and foremost, the COVID-19 pandemic disrupted supply chains, caused production outages, and led to sharp fluctuations in demand. The second significant factor was the energy crisis, which, following the outbreak of the war in Ukraine, has led to a steep rise in energy prices, especially gas and electricity, as key inputs for a large part of industrial production. Slovakia, as an energy-intensive economy, faced extreme cost pressures, significantly reducing business profitability. In addition to its impact on energy markets, the war in Ukraine also caused raw material shortages, restrictions on exports to eastern markets, and further geopolitical tensions, all of which reduced companies' willingness to invest and expand. These factors resulted in high inflation and tighter monetary policy. Another important factor is the weakening of global demand. Slowing economic growth among Slovakia's main trading partners led to a decrease in orders and demand for Slovak exports. Besides these factors, we can also identify others, such as increasing social and tax burdens on businesses, rising costs, particularly strong pressure to raise wages, and transportation and other expenses, which companies, amid growing competition, cannot always pass on to product prices. Similar conclusions were reached by Sharma (2022), who argued that capital structure and managerial efficiency positively impact profitability. Similarly, Yolanda and Yanti (2022) argue that company size and management efficiency positively affect return on sales. The authors, Sahabuddin and Khan Synthia (2020), in their scientific study, state that wage costs, industry-specific factors (market concentration), and macroeconomic factors (inflation) significantly influence the profitability of manufacturing companies.

The second research question examined whether companies operating in the wood-processing industry rank among the highest labor productivity industrial enterprises in Slovakia. Labor productivity in the Slovak industry shows significant intersectoral differences. Among the sectors with the highest labor productivity are the automotive, metal processing, and chemical industries. These sectors are characterized by a high degree of automation and robotization, as well as strong integration into global supply chains. capital-intensive production with high efficiency. and a strong focus on research, which translates into higher labor efficiency and greater added value per employee.

At the opposite end of the spectrum are sectors with the lowest labor productivity, including the textile and clothing industry, leather goods manufacturing, and wood processing and furniture production. These sectors are characterized by a high share of manual labor, lower levels of technological modernization and automation, lower product

value added, and often a dependence on cheap labor. These differences highlight structural imbalances within the industrial sector and indicate that increasing labor productivity is not merely a matter of individual employee performance but primarily the result of a systemic approach to production modernization, digitalization, and strategic human resource management. According to Kim *et al.* (2019), five main factors influence productivity growth: innovation, education, market efficiency, infrastructure, and institutional factors. They also state that these factors carry different weights depending on regional conditions. A similar study was conducted by Vu and Nguyen (2024) in Vietnamese enterprises, and they found that labor productivity is mainly influenced by technical equipment and wage costs. Ganguly (2024) emphasizes that, in addition to traditional factors (education, skills, wages), the impact on productivity is changing due to labor market flexibilization and production digitalization, while also highlighting the influence of labor market regulation and investment in technology.

The third research question focused on whether there are statistically significant differences in the extent of use of quality management techniques across industrial enterprises operating in different sectors in Slovakia. The analyses' conclusions provide empirical support for the answers and assumptions of RQ3, indicating that there is a significant difference in the extent of use of quality management techniques across industrial enterprises from different sectors in Slovakia. The research also revealed that some sectors systematically implement quality tools, while others continue to exhibit a relatively low level of their utilization. The observed differences may result from several factors, such as the technological complexity of production, regulatory and normative requirements, customer and supply chain pressure, or the level of market competition.

Despite positive trends in certain industries, the research also highlighted that many sectors still include enterprises that refuse to implement quality management systems. This indicates that there remain considerable room and potential within the Slovak industry for broader and more intensive adoption and implementation of these systems, particularly to improve performance and competitiveness. Similar findings have been reported by several authors who examined the use of quality management tools across various manufacturing sectors. Gambi *et al.* (2021) identified sectoral differences in the degree of quality tool implementation, depending on company size and production type. Garza-Reyes *et al.* (2015) and Attia (2016) emphasized the importance of organizational culture and managerial approach in decisions regarding the adoption of quality systems. Tarí *et al.* (2020) stressed that the successful implementation of quality tools depends not only on technical factors but also on strategic and human factors.

## CONCLUSION

Performance disparities between companies in the wood-processing sector and those operating in other sectors of the national economy are analyzed in the paper focusing particularly on how business performance is enhanced by quality management systems.

In conclusion, the findings indicate that enterprises implementing quality management techniques achieve superior performance outcomes, as measured by Return on sales and labor productivity. Significant differences were observed across industries. These disparities are also evident when considering firm size, with a general trend suggesting that smaller enterprises exhibit lower interest in adopting quality management techniques. The wood-processing sector is among the traditional and regionally significant branches of the Slovak economy; however, despite these advantages, enterprises operating in this industry have long

recorded lower performance indicators than those in the most productive sectors of the Slovak economy. One of the fundamental reasons for this lower performance is the sector's structural focus on processing primary raw materials and producing semi-finished goods with low added value. Consequently, the Return on sales in wood-processing enterprises remains lower than in industries characterized by higher technological and innovation intensity. Another significant factor is the relatively low level of technological modernization and automation of production processes. Compared to high-tech industries, enterprises in the wood-processing sector are less likely to implement robotic lines, digital production control systems, or Industry 4.0 principles. The sector also faces the challenge of a fragmented size structure, as it is dominated by small- and medium-sized enterprises with limited capital resources and limited capacity to undertake extensive modernization projects. A closer look at individual subsectors of the wood-processing industry in Slovakia reveals that performance is not uniform across subsectors. The lowest profitability and labor productivity are recorded by enterprises engaged in primary wood processing. Furniture manufacturing companies achieve slightly better results, while the highest performance is observed in the paper production sector. It follows that improving the performance of the wood-processing sector requires a systematic shift from processing primary raw materials to producing final products with higher added value, strengthening investments in automation and digitalization, and enhancing energy and process efficiency. A key prerequisite is also the support of research and development activities and the implementation of modern quality management techniques, which will enable Slovak wood-processing enterprises to increase their competitiveness within the European context.

For future research, it is recommended to expand the sample to include more enterprises or to include companies from other countries to conduct international comparative analyses. It would also be appropriate to monitor long-term developmental trends through longitudinal studies, which would allow for a more precise identification of causal relationships between the implementation of quality management systems and techniques and changes in performance indicators. Further research could focus on a more detailed examination of specific factors influencing business performance, such as the level of digitalization, innovation activity, the quality of human capital, organizational culture, or the degree of integration of sustainability principles into corporate strategies. A promising direction is also the analysis of synergistic effects arising from the combination of various quality management tools and their impact on the long-term competitiveness of enterprises.

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