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COMPARISON OF THE ATTRIBUTES OF THE WOOD PROCESSING INDUSTRY AND AUTOMOTIVE AND ENGINEERING INDUSTRIES IN THE CONTEXT OF QUALITY MANAGEMENT SYSTEMS

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ABSTRACT

The aim of the paper is to compare the effect of implementing a more extensive scope of methods and quality management approaches of the enterprises in wood processing, automotive and engineering industries in Slovakia. The automotive and engineering industries have been selected for comparison because there is a significant difference in the approach of the state support and incentives of these industries as well as they are important manufacturing industries with a significant GDP share and export rate in Slovakia. At the same time, there is a presumption of several common determinants of implementing quality management systems and the circular economy potential in comparison with the wood-processing industry. The results of performed analyses revealed the existence of significant relations among capital structure and the complexity of using the quality management methods, tools and approaches.

Keywords: quality; quality management methods tools and approaches; wood processing industry; automotive and engineering industry.

INTRODUCTION

Quality management is a dynamic category and takes on new significance in the context of the current development of society in changing conditions. Modern management of top organizations currently prefers a strategic approach to the quality of all outputs and corporate activities. The main goal is to achieve maximum customer satisfaction at optimal costs. The strategy of increasing customer satisfaction leads to the improvement in productivity, efficiency and quality, which brings an increase in competitiveness, i.e., the overall success of the organization. Several studies (Ondra, 2021, Mizanbekova *et al.*, 2017) present that the application of quality management principles leads to an increase in the competitiveness of companies, customer satisfaction and improvement of the quality parameters of products, which ultimately contributes to increasing the performance and efficiency of the company. In the paper, we want to get answers to the following research questions (RQ). RQ1: Does the capital structure of the enterprise influence the use of quality management methods, tools and techniques? RQ2: Are there differences in the application of quality management methods, tools and techniques among industries of the national economy?

The paper deals with comparing selected industries of the national economy in the context of implementing quality management systems. The following sectors have been chosen for comparison: the wood-processing industry as an industry based on the processing of available domestic renewable raw material, where there is a high potential for its development, and the automotive and engineering sectors, which are traditional in our economy, have good support by the state and significantly contribute to the export of the Slovak Republic. In this paper, ISO 9000 standards and TQM philosophy are considered quality management approaches, while quality management procedures are represented by Six Sigma methodology. These approaches and techniques have been selected for their intensity of utilization, suitability and complexity. The contribution of the research is the comparison of selected industries of the national economy concerning the implementation of quality management approaches as well as verification of the most common reasons for the use and implementation of quality management approaches in these enterprises.

According to (Elwardi *et al.*, 2021) and (Ribeiro *et al.*, 2019), the ISO 9001 standard specifies the requirements for a quality management system in organizations that want and need to demonstrate their ability to consistently provide products in accordance with relevant regulations and customer requirements, and that strive to increase customer satisfaction. (Nenadal *et al.*, 2018) states that the positive aspect of ISO 9001 standards is the pressure to establish order in organizations by determining responsibilities and competences, process descriptions, etc. According to (Sarb *et al.*, 2019) and (Knop, 2021), the implementation of the quality management system according to ISO 9001 is a strategic decision for an organization that can help improve its overall performance and provide a sound basic for sustainable development. This International Standard promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system. This approach enables the organization to control the interrelationships and interdependencies among the process of the system, so that the overall performance of the organization can be enhanced (Su *et al.*, 2020).

According to (Al Robaaiy and Al-Husseini, 2022) the Six Sigma is one of the tools of the modern quality management system, which is concerned with diagnosing and treating deviations to improve the performance of the processes, an attempt to manage cost through the use of accounting and statistical concepts. Six Sigma is one of the management philosophies required to achieve improved quality and process performance in systems (U-Dominic *et al.*, 2021). (Al-Otaibi, 2021) claims that Six Sigma is a process improvement method that aims to discover and eliminate the causes of defects, mistakes, and errors. According to several authors (Uluskan, 2020; Lande *et al.*, 2016; Antony *et al.*, 2017), Six Sigma emphasizes the financial advantages (reduced production costs and higher profitability) of reducing waste and increasing quality. According to some authors (Pande *et al.*, 2002), the Six Sigma is the quality management system in enterprises. Other authors (Yadav *et al.*, 2019) designate Six Sigma as a tool or methodology enabling one to reach business excellence.

TQM is a system approach towards management that aims to continuously increase customer values by designing and continually improving organizational processes and systems. Total Quality Management (TQM) is a universally applied management strategy to improve organizational performance and thereby to achieve competitiveness (Babu and Thomas, 2021). TQM can be summarized as a management system for a customer-focused organization that involves all employees in continual improvement. (Alawag *et al.*, 2020) states that a core definition of TQM describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate

in improving processes, products, services, and the culture in which they work. According to (Alhamd and Yahya, 2021), Total quality management is a structured approach to overall organizational management. (Kisel'akova *et al.,* 2020) states that the focus of the process is to improve the quality of an organization's outputs, including goods and services, through the continual improvement of internal practices.

The aim of the paper is to compare the effect of implementing a broader scope of methods and quality management approaches (a broader scope means the use of two or more methods) of the enterprises in wood processing, automotive and engineering sectors in Slovakia.

MATERIALS AND METHODS

The procedure for preparing an article can be summarized in the following steps. In the first step, we reviewed scientific papers authored by various experts dealing with the issue at hand. In the second step, we created a questionnaire comprising several questions about the company, including its size, economic performance, capital, and inquiries related to the introduction of quality management systems. Our particular focus was on obtaining answers regarding the use of quality management methods, tools, and approaches, as well as the reasons for implementing these systems and the benefits associated with them. Moving on to the third step, we distributed the questionnaire to various branches of industrial enterprises in Slovakia via email. Subsequently, in the next phase, we formulated working hypotheses and evaluated the questionnaire responses using selected statistical methods. Following this, we compared our results with the research of other authors investigating the same issue. This comparison provided valuable insights and helped contextualize our findings. In the final step, we formulated conclusions and outlined the future direction of our research.

The research was conducted using a survey method involving the distribution of a questionnaire. The questionnaire was addressed to Slovak manufacturing enterprises of different industries divided according to NACE classification (European Industry-standard classification system, section C Manufacturing). The survey was conducted in the last two years 2020 and 2021, through the platform docs.google.form.

The current questionnaire link is as follows: https://docs.google.com/forms/d/e/1FAIpQLSfp0H8V5dEf1UTZlF2YjK_wDjLTH9lZ8U0qgd-dPZd4H6HClQ/viewform.

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

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

To determine the minimum sample size, a formula for the finite population according to Yamane Taro was applied. With a target population size of 2,504 units and the selected error e=0.05 the minimum sample size was derived as:

Because the target population was divided into subgroups according to different industries, stratified sampling was applied to ensure that the sample was representative. The questionnaire was distributed to Slovak manufacturing enterprises by e-mail contacts, repeatedly in several rounds. In the end, 364 correctly filled and usable questionnaires were obtained for the research. The minimum sample size condition was met. In terms of

representativeness, Fig. 1 shows how the distribution of the research sample by individual industry replicates the population. The Chi-square goodness-of-fit test was applied for testing (Tab.1).

Tab. 1 Results of the test of representativeness.

χ^2 goodness-of-fit test criterion	Degree of freedom	p-level
5.89	15	0.981

Several methods of inductive statistics, suitable for working with categorical data and frequencies, were used to test the research hypotheses. The Pearson chi-square test was applied to test the significance of the relationship between two categorical variables. The measure is based on the observed and expected frequencies – frequencies that we would expect if there was no relationship between the variables (Box *et al.*, 2005):

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

The test statistic allows researchers to measure the degree of disagreement between the frequencies observed (*O*) and theoretically expected (*E*) – when the two variables are independent. The chi-square test becomes increasingly significant as the numbers deviate further from this expected pattern. The only assumption underlying the Chi-square statistics is that the expected frequencies are not very small (below five). The coefficient of contingency measures the relation between two categorical variables with a scale from 0 to 1, where 0 means complete independence.

95% confidence intervals were calculated for the estimation of population proportions according to the formula (Lind, 2020), where p represents a point estimate of a given proportion, n is the sample size, and z is the critical value of standardized normal distribution:

$$p - z_{\frac{\alpha}{2}} \cdot \sqrt{\frac{p\,(1 - p)}{n}} < \pi < p + z_{\frac{\alpha}{2}} \cdot \sqrt{\frac{p\,(1 - p)}{n}} \tag{3}$$

A test criterion based on the z statistics was used to test the difference between two population proportions (Box et al. 2005):

$$|z| = \sqrt{\frac{n_1\, n_2}{n_1 + n_2}} \cdot \frac{|p_1 - p_2|}{\sqrt{p\,(1 - p)}} \tag{4}$$

Parameter $p=(p_1.n_1+p_2.n_2)/(n_1+n_2)$, p_1 and p_2 are the sample proportions, and n_1, n_2 are the sample sizes.

All statistical analyses were carried out using the software STATISTICA 12. In hypothesis testing an alpha level of 0.05 was traditionally used as the decision rule. The output tables were edited in the Microsoft Excel spreadsheet editor.

Many studies assert that quality and its associated approaches serve as essential tools for companies to align with their strategies and enhance their performance (Sahoo, 2021; Gambi *et al*., 2021; Liu et al., 2021). Supporting evidence for Hypothesis H1 can also be found in publicly available data from comparisons of industrial sector performance in the national economy, sourced from the Statistical Office of the Slovak Republic and the Finstat database. Over several years, these sources have consistently indicated that the automotive and engineering industries outperform the wood-processing industry. The connection between improved performance and the utilization of quality approaches is further

substantiated in the study conducted by Kafetzopoulos *et al.* (2021). Consequently, Hypothesis H1 was formulated as follows:
H1: It is assumed that enterprises of automotive and engineering industries use a wider range of quality management methods, tools and approaches (QMMTA) than the wood-processing industry.

Regarding the interplay between capital structure, performance, and the quality of business management, a potential relationship was explored in the study by Zandi *et al.* (2020). It is widely acknowledged that industrial enterprises in Slovakia with foreign capital structures exhibit greater competitiveness and flexibility in responding to various changes compared to enterprises with domestic capital structures. The question that arises is whether this argument extends to the complexity of Quality Management Methods and Tools Application (QMMTA). Therefore, Hypothesis H2 was established as follows:
H2: It is assumed that there is a dependence of the capital structure of selected manufacturing industries and the complexity of QMMTA use.

Some authors (Abdi and Singh, 2022; Neves *et al.*, 2021; Nenadál *et al.*, 2018) enumerate a wide range of reasons for implementing quality management, but they do not delineate the order of priority among these reasons. Consequently, Hypothesis H3 was formulated as follows:
H3: It is assumed that in the practice of automotive, engineering and wood-processing industries, the theoretical assumptions of the reasons for the implementation of quality management systems will be confirmed, namely the product quality improvements and customer satisfaction increase.

RESULTS AND DISCUSSION

To determine the minimum sample size, a formula for the finite population was applied. With a target population size of 2,504 units and the selected error e=0.05 the minimum sample size was derived as:

$$n = \frac{2\,504}{1 + 2\,504 \cdot 0.05^{\,2}} = 345 \tag{5}$$

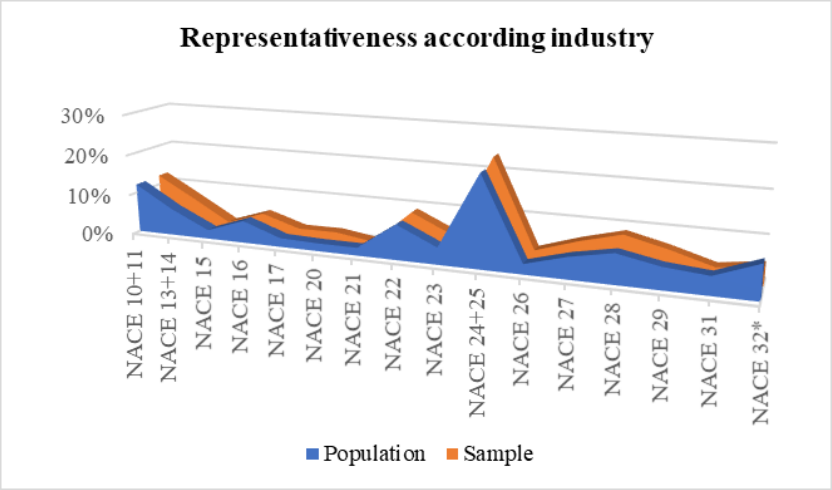

Fig. 1 Proportions of different industries in the target population according to NACE codes; * NACE 32 includes NACE 5, 7, 8, 9, 18, 19 (European Industry-standard classification system, section C Manufacturing).

NACE 24+25 were represented with the highest percentage in the research population but afterwards in research, about the using of QMMTA's (Fig. 2), those two NACE 24+25 were not considered because the aim of the paper was to compare selected industries according to the reasons that were written in the introduction.

In the context of the first hypothesis the proportions of enterprises which use a wider scale of quality management techniques and approaches are illustrated in Fig 2. The highest share 89.47% of enterprises is observed in the automotive industry. Within the enterprises of the engineering industry, it was 51.85%. As for the enterprises of the wood processing industry, the share of those that use a wider scale of QMMTA was 43.18%.

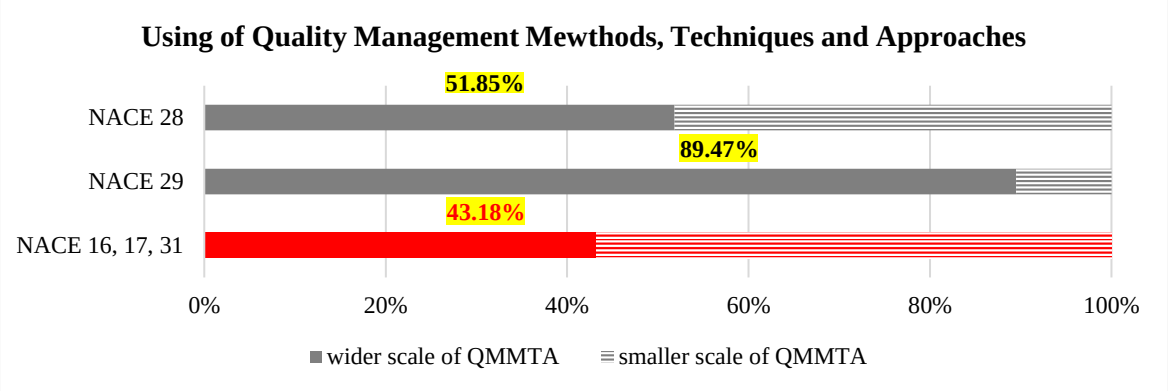

Fig. 2 Use of QMMTA in surveyed enterprises of automotive, engineering and wood processing industry.

*NACE 16 Manufacture of wood and of products of wood and cork, NACE 17 Manufacture of paper products, NACE 31 Manufacture of furniture, NACE 28 Manufacture of machinery and equipment, NACE 29 Manufacture of motor vehicles, trailers, and semi-trailers

Subsequently, the observed differences were tested using a two-sample z-test for proportions. The results of the testing are presented in Tab. 2. A significant difference (p=0.000) was confirmed in the case of the automotive and wood processing industry. No significant difference in the use of wider scale of QMMTA was confirmed between the engineering and wood processing industries (p=0.177).

Tab. 2 Results of two-sample z-test for the difference in the proportion of enterprises using a wider scale of QMMTA.

Industry type 1	n_1	p_1	Industry type 2	n_2	p_2	z-test	p-level
Wood processing	44	43.18%	Automotive	19	89.47%	3.41	0.000
			Engineering	81	51.85%	0.93	0.177

As part of the second hypothesis, the distribution of investigated companies based on two variables – capital structure versus the using of QMMTA is shown in Fig. 3. Wider scale of QMMTA was applied in 92.31 % of the manufacturing enterprises with foreign capital structure. In the group of enterprises with mixed capital structure, it was 61.90%. As for enterprises with domestic capital, 34.52% of them stated that the wider scale of QMMTA was applied.

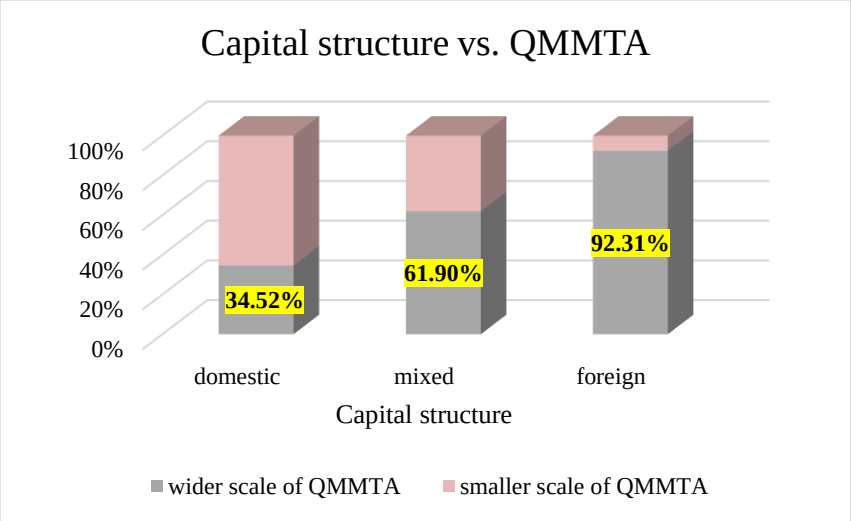

Fig. 3 Two-dimensional distribution of the investigated manufacturing enterprises according to capital structure and using QMMTA.

The chi-square test was used to test the dependence between the capital structure of enterprises and the use of QMMTA. A significant dependence was determined based on the corresponding p-value of the Chi-square test statistic (p=0.000). The contingency coefficient value of 0.45 indicates a moderately strong dependence.

Tab. 3 Results of Pearson chi-square test of contingency – capital structure of manufacturing enterprises versus use of QMMTA.

Capital structure vs. QMMTA	Chi-square test	Degree of freedom	p-level	Contingency coefficient
	36.41	2	0.000	0.45

A more detailed look at the nature of the dependence is given based on the residual frequencies shown in Tab. 4. The confirmed support is manifested mainly by manufacturing enterprises with a domestic capital structure using QMMTA tools on a smaller scale. In comparison, enterprises with a foreign design apply a broader scale of QMMTA.

Tab. 4 Contingency table of residual frequencies – structure of manufacturing enterprises versus the use of QMMTA.

Capital structure	wider scale of QMMTA	smaller scale of QMMTA
domestic	-16.5	**16.5**
mixed	1.6	-1,6
foreign	**14.9**	-14.9

In the third hypothesis focused on the reasons for the implementation of QMMTA, point estimates of proportions (Tab. 5) formed the starting point for the next calculations. Within wood processing enterprises, the most frequent reasons for implementing QMMTA competitiveness, product quality, and customer satisfaction are almost in the same share: 40.91%, 36.36%, and 36.36%. The given reasons were the most frequent also in the sample of automobile enterprises, but in shares 73.68% competitiveness, 84.21% product quality, and 73.68% customer satisfaction. The investigated enterprises of the engineering industry,

in addition to the mentioned three reasons (39.51%, 44.44%,40.47), indicated to a considerable extent, namely 44.44%, also customer requirement as a guarantee of quality.

Tab. 5 The reasons for the implementation of QMMTA and the shares of surveyed manufacturing enterprises that spoke in their favour.

Reason for implementation of QMMTA	Manufacturing enterprises		
	Wood processing	Automotive	Engineering
Improving market position	31.82%	42.11%	27.16%
Competitiveness	**40.91%**	**73.68%**	**39.51%**
Product quality	**36.36%**	**84.21%**	**44.44%**
Customer satisfaction	**36.36%**	**73.68%**	**40.47%**
Customer requirement as a guarantee of quality	22.73%	52.63%	**44.44%**
Participation in tenders	9.09%	10.53%	8.64%
Positive references	6.82%	10.53%	6.17%
Getting better orders	27.27%	15.79%	14.81%

With a reliability of 95%, confidence intervals for the most frequent reasons for implementation of QMMTA in Slovak wood processing enterprises were calculated (Tab. 6).

Tab. 6 Interval estimate of the proportion of wood processing enterprises that implement QMMTA for the following reasons.

Reasons for implementation of QMMTA	95-% Confidence Intervals
competitiveness	(26%; 55%)
product quality	(22%; 51%)
customer satisfaction	(22%; 51%)

The most common reasons for the implementation of OMMTA in enterprises of the wood processing industry in Slovakia are competitiveness, product quality, and customer satisfaction. For all three mentioned reasons, a 50% share was reached as the upper limit of the interval estimate.

Some of the findings in this paper are in line with other research studies. The authors agree that methods, tools and approaches to quality are important factors influencing the performance and competitiveness of enterprises. These claims are also confirmed by research studies published by Marcysiak (2021), Liu *et al*. (2021), Shafiq *et al*. (2019), Jimoh *et al*. (2019), Ghicajanu (2019). Therefore, the application of QMMTA in manufacturing enterprises has been addressed by several authors, including Gambi *et al*. (2021), Bera & Mukherjee (2018), Agarwal *et. al*. (2013). The research results presented in this study follow up on previous studies and complement them with a comprehensive view of the utilization of QMMTA in the manufacturing sector. Through a scale of approaches, methods and tools related to quality management, it evaluates their synergistic effect on the consequence factor which is business performance. The synergistic effect was also confirmed using a wider scale of QMMTA (Wu, 2020, Sader *et al*. 2019). The potential impact of the synergistic effect is given by the assumption of simultaneously applying several quality management approaches. Other authors also confirmed these research results (Abdi and Singh, 2022; Neves *et al.,* 2021; Bravi and Murmura, 2021; Nenadál *et al.,* 2018).

CONCLUSION

Quality management is an important part of the management, which aims to optimize work or production processes with the respect of the resulting product quality. Modern quality management currently prefers a strategic approach to quality. The main goal is to achieve maximum customer satisfaction at an optimal cost level. The aim of the paper was to analyze the use of quality management approaches and techniques in the wood processing industry and its comparison with the automotive industry and engineering industry. Using statistical tools, the established hypothesis H2 was confirmed that there is a dependence on the capital structure of selected manufacturing industries and the complexity of QMMTA use. H1 was confirmed. Although there is a significant difference between the wood-processing industry and the automotive industry in the use of QMMTA, no significant difference was confirmed in the use of a broader scale of QMMTA between the engineering and wood-processing industries.

In the second part of the paper, the reasons why wood processing enterprises, automotive enterprises and engineering enterprises decided to implement quality management approaches and procedures were examined. The establishment of the hypothesis was based on theoretical assumptions. The hypothesis assumed that the main reasons for the implementation of selected approaches are the improvement of product quality and the increased customer satisfaction. The results indicated that the established hypothesis was again confirmed.

In terms of answers to the research questions, the following can be stated: RQ1 addressed, whether there is an influence of the capital structure of the enterprises on the use of quality management methods, tools and techniques. Based on the results of the research, it can be concluded that there is such an influence. Enterprises with predominantly domestic capital use QMMTA much less than those with foreign capital. RQ2 addressed whether there are differences in the application of quality management methods, tools and techniques among industries of the national economy. Based on the results, it can be concluded that there are such differences. The difference was mainly in the automotive industry, where the use of QMMTA was more extensive than in the engineering industry. QMMTA in the wood-processing industry is applied to the least of the examined industries. The research contributed to the identification of differences in the use of QMMTAs within the individual examined industries, where there is still a group of enterprises within different sectors that reject the implementation of quality management systems. Therefore, there is still a relatively wide space and potential for more intensive use and implementation of quality management systems. A certain limiting factor of the present research is that the results are obtained by the questionnaire survey in the manufacturing enterprises in one country only. However, the intention was to initiate research of current issues in a more comprehensive sense. The presented results could become an information base for comparison with related research studies in the European business environment. Identification of the causes of the relatively low level of use of QMMTA, especially in wood processing enterprises, but also determining the real benefits of their implementation are becoming the future orientation of research. Future research should include a more extensive comparative survey of selected central European countries. At the same time, certain research barriers have been identified, which include data collection and especially the reluctance of many manufacturing enterprises to provide information and data necessary for research assessment.

In conclusion, it can be stated that the industries with a significant support from the state use a wider range of QMMTA, which leads to higher performance, competitiveness, flexibility and so on. The wood-processing industry is an industry of the national economy that deserves more significant attention and support from the state, especially because it processes domestic renewable raw material with significant potential to apply the principles of the circular economy, which, in addition to a stable economy, shall increase the quality of the environment and human life by increasing the efficiency of production.

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