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GREEN LOGISTICS IN THE WOOD-PROCESSING ENTERPRISES*

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Abstract. Green logistics affects all companies worldwide. Compared to conventional logistics, it has several specificities and differences, especially in relation to the environment. In the context of the wood-processing industry, whose impacts are also reflected in the environment, implementing green logistics in enterprises is more than effective. This study aims to propose measures that could be implemented in wood-processing enterprises and thus increase their sustainability, based on a mapping of the state of green logistics in wood-processing enterprises. The basis of the conducted empirical research is a systematic elaboration of the theoretical foundations of green logistics in the wood-processing industry according to the approaches of domestic and foreign authors. The results of the empirical research in the form of a questionnaire survey, in which 359 wood-processing enterprises participated, revealed the need to pay increased attention to logistics processes in enterprises. In addition to identifying green logistics, the questionnaire survey also focused on identifying potential areas for the future development of wood-processing enterprises. Based on the results and their mathematical-statistical analysis, recommendations within the framework of green logistics in the wood-processing industry were proposed, which have the potential to increase the sustainability of companies in the wood-processing sector. The hypotheses were tested using mathematical-statistical methods. The practical benefits of the study were defined by a detailed treatment of green logistics and proposals for the sustainability of green logistics in the wood-processing industry, which can be systematically followed up in the future.

Keywords: green logistics; wood-processing industry; ecology; sustainability

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1. Introduction and review of literature

As a separate scientific discipline, logistics has been developing in connection with logistics processes since ancient times (Tang, Liu & Hu, 2020). Even in ancient Egypt, they knew that great works such as the pyramids could only be built under systematic organisation, strategic process management and collective effort. The Byzantine emperor Leontos defined the content of logistics as the movement of people and materials so that the given object is in the required place and at the required time.

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Musolino, Rindone, and Vitetta (2019) defined logistics as going through four basic phases during its history. The first phase was dominated by a distribution model with an emphasis on a commercial approach; the second phase brought an expansion to the area of supply. The creation of interconnected logistics chains within integrated logistics characterised the third phase. In the fourth phase, process deficiencies were eliminated, moving the system towards optimised logistics (Zhang, Li & Peng 2020). After World War II, mathematical methods, linear planning and development plans became the basis of logistics (Kokoab et al., 2019). The logistics and production management method JIT (Just in Time) in the field of information and communication technologies, aims to minimise inventories and deliver material exactly when it is needed, not earlier or later.

Ghomi-Avili et al. (2021) characterise logistics as a scientific discipline whose task is to ensure that the right goods or services are delivered at the right time, to the right place, in the required quality and quantity, to the right customer with optimal costs. Logistics plans, organises, optimises and manages material, information and financial flows, and connects them to the timely fulfilment of all required customer needs using information technologies (Taylor & Van Der Velden, 2019; Song et al., 2020). Logistics manages material, information and financial flows and integrates them to fulfil customer needs quickly (Brecka & Korauš, 2016; Gombár et al. 2022; Dai et al., 2025).

The goal of green-oriented logistics is to integrate environmental aspects into all logistics processes in the company. The key to implementing green logistics is available resources, such as human resources, machinery and equipment or energy, as well as the processes and outputs, including products, services, environmental impact or information. The most significant added value of green logistics for a company is building a positive image and reputation.

Green logistics aims to reduce the environmental impact in accordance with the ISO 14 000 certification. Green logistics is an approach oriented towards reducing the environmental burden caused by the company's logistics activities (Alves, Silva & Rodrigues, 2020). The key green logistics activities are considered to be the optimisation of the transport of goods, the preference of land transport over air transport, the ecological design of products and packaging, the processing of returned products, the recycling of used materials, the reduction of the amount of toxic substances and waste, as well as the use of environmentally friendly materials and many others.

Companies are increasing their productivity by expanding the application of logistics from distribution to production and supply (Fan et al., 2020). Green logistics is still dynamically developing, and no unanimously accepted definition exists (Osintsev & Rakhmangulov, 2025). Chepurna et al. (2025) found 55 distinct available definitions of green logistics in scientific literature published between 2000 and 2023.

The authors Mondal, Giri and Maiti (2020); Mihalčová et al. (2021); Šimberová et al. (2022) describe the logistics chain as a set of organisational units, institutions, or agencies within or around the company that perform functions supporting the marketing of a given product. A logistics chain in which logistics companies, or only forwarders or carriers, participate is called a supply chain. Green procurement logistics, production logistics, distribution logistics and reverse logistics form a comprehensive system of green logistics. Sustainable green logistics aims to focus on the impacts of business activities on the environment, that is, to observe the relationship between individual modes of transport and the level of environmental pollution, or to reduce the energy and material intensity of logistics activities. Sustainable products provide environmental, ethical, social and economic benefits in protecting the health of stakeholders and the environment beyond the limits set by legislation, throughout their entire life cycle (from raw material extraction to disposal) (Tayler & Velden, 2019). Sustainable solutions depict changes in products, systems or services that contribute to reducing negative and increasing positive impacts on sustainable development from an economic, ecological, ethical and social perspective in business (Rajnoha et al., 2016; Kolesnichenko, Sokolinskaya & Popova, 2019; Straková et al., 2021; Berberoglu, Kazancoglu & Sagnak, 2023; Asamoah et al., 2024).

The object of our research is wood-processing enterprises in Slovakia, the wood, furniture and pulp and paper industries and their various legal forms (sole proprietorships, small and medium-sized enterprises, joint-stock companies, etc.). Sedliačiková (2005) points out that one of the main problems of wood-processing enterprises

in Slovakia is the low level of added value generated by their products. Wood-processing companies form an industry based on the processing of renewable natural raw materials – wood. The European Union is interested in creating healthy economic areas based on renewable raw materials. From this perspective, it is necessary to ensure the availability of the necessary financial resources to purchase safe, environmentally friendly and energy-efficient input materials, new technologies, production equipment and innovations in the wood processing industry. The issue of green logistics in wood processing companies is a highly topical topic, especially in the context of the deepening environmental crisis, characterised by the deterioration of environmental quality, global warming, increased greenhouse gas emissions and the need to promote the principles of sustainable development.

The main goal of the presented study is, based on the identification and evaluation of the current state of green logistics in the wood-processing industry, to formulate measures to strengthen the sustainability of business processes in the wood-processing industry.

2. Methodology and data

To ensure a clear structure and logical continuity, the methodology of the scientific contribution was divided into three phases. The study focuses on the theoretical and practical analysis of the research issue. To achieve the set scientific goal, a detailed analysis of secondary sources related to the issue of sustainable and socially responsible business and activities within sustainable business was carried out in the first phase. The theoretical analysis drew primarily from foreign scientific sources, which were subsequently supplemented by domestic literature. The main focus was on relevant studies published in renowned electronic databases, such as Web of Science (WoS), Science Direct and ProQuest. The methods of analysis, synthesis, induction, deduction, comparison, description and concretisation were used to process the theoretical part of the study.

After analysing the theoretical information, the survey method was used – a questionnaire form of the survey, which appeared to be the most appropriate method of obtaining the necessary data to achieve the main goal of the presented study. The survey method served as the primary source of information for the research part of the work. Based on the obtained theoretical foundations of the given issue, a questionnaire was compiled, which was anonymous, and the target group of the research was business entities in the wood-processing industry operating in the territory of the Slovak Republic. The questionnaire consisted of 26 purposefully formulated questions focused on the characteristics of wood processing companies, the level of implementation of green logistics principles, and the identification of perceived needs, benefits and barriers associated with its application in practice. The questionnaire survey aimed to obtain relevant data for evaluating the current state and formulating proposals to develop environmentally sustainable logistics processes in this sector. The preparation and distribution of the electronic questionnaire were ensured using the free Google Forms platform.

Calculating the minimum size of a research sample involves assessing the sufficient sample size in terms of the requirements and objectives of a given study. The process involves determining the optimal sample size needed to achieve relevant results. A simple calculation is used to determine the sample size:

$$n = \frac{z^2 \times p \times (1 - p)}{c^2} \quad (1)$$

Where:

z – value, substituted from statistical tables (confidence level 95 %, z = 1.96),

p – proportion of the sign, with unknown total values p = 0.5,

c – permissible margin of error (value 2-10 %), research sets a value of around 5 %.

After collecting, processing, and analysing the obtained data, the questionnaire survey was evaluated statistically, numerically, and graphically, and the results were presented using a descriptive method. All types of tests were performed, and the obtained data were analysed and processed using the statistical program STATISTICA 12. The STATISTICA 12 program is specialised software for collecting, processing, analysing statistical data, and drawing statistical conclusions.

In connection with the primary goal of the presented scientific study, the following hypotheses were formulated, which resulted from the current knowledge of the issue being addressed:

H₁: It was assumed that most wood-processing companies in Slovakia perceive the introduction of green logistics in the company as important.

Logistics processes have an impact in various ways on both the environment and the business environment (Malá, 2017). Therefore, dealing with procurement, production, distribution and reverse logistics in the enterprise remains essential. Green-oriented logistics makes it possible to differentiate the environmental aspects of all enterprise logistics processes, define mistreatment, and minimise errors in logistics processes.

H₂: It was assumed that most enterprises interviewed applied green production strategies and environmental management.

Material flows and their management are an integral part of the overall concept of production management and the philosophy of production logistics. It is a vital process for the company, even if it does not directly affect the end customers. Unless the enterprise can ensure effective and efficient management of input material flow, the production process cannot produce products at the required price and at the time when these products are required for distribution to customers. Incorporating smart logistics into business practice will require long-term preparation and strategic planning support (Kokab et al., 2019).

H₃: It was assumed that most businesses surveyed did not use alternative fuel vehicles for transport.

Transport is one of the key areas in logistics and contributes significantly to environmental pollution. The most significant negative effect of transport on the environment is the emissions themselves; other equally significant externalities of transport are noise and vibration caused by trucks, planes or trains. This trend is already well established in the innovative world, while in Slovakia, it has been used only to a small extent so far.

H₄: It was assumed that most businesses would show interest in the green logistics model and thus contribute to better sustainability.

To incorporate green logistics into companies, a range of innovative technologies and especially green products are needed (Nicoletti & Appolloni, 2024). Sustainable solutions (Kolesnichenko, Sokolinskaya & Popova, 2019) are product changes or innovations, service changes, or systems changes that reduce negative and increase positive sustainability impacts (economic, environmental, ethical, and social).

The research sample should be representative of the baseline population, so it will be validated using Pearsen's Chi-square test. Pearson's Chi-Square test is one of the most well-known goodness-of-fit tests based on the difference between observed (X_i) and expected (Np_i) frequencies. The test characteristic for the Chi-squared test (where k is the number of counts) is:

$$\chi^2 = \sum_{i=1}^k \frac{(X_i - Np_i)^2}{Np_i} \quad (2)$$

Where:

χ^2 – Chi-squared test value,

X_i – observed values,

Np_i – expected values.

The final part of the study is based on the methods of analogy, synthesis, deduction and summarisation, where the summary of conclusions is subsequently strategically supplemented by the use of a systems approach, which allows for the formulation of the future direction of the presented research.

3. Results

The calculation of the minimum scope of the research shows that the size of the sample of enterprises in the questionnaire survey, which ensures sufficient representation and statistical significance, is at least 358 enterprises operating in Slovakia in the wood-processing industry. We contacted a total of 2,549 enterprises through direct communication via email. Of the total group of respondents contacted, 359 enterprises completed the questionnaire, representing a relatively low return rate of 14.08%. The statistical level of the minimum scope of the research sample, i.e. 358 responses from the questionnaire survey, was exceeded, since 359 responses were recorded. It follows from the above that the achieved results can be generalised to the entire basic set.

At this point, it is necessary to clarify again the issue of green logistics in Slovakia with regard to the topic of the thesis. The definition of green logistics is absent in the legislative conditions of the Slovak Republic. Since the object of the thesis in a narrower sense is the wood-processing industry in Slovakia, the theoretical background of the thesis shows that we consider the following, briefly summarised definition of green logistics to be the guiding one.

The first question from the questionnaire served as an important element in the survey conducted, as it is generally expected that sustainability is used more in larger companies. The questionnaire survey results showed that medium-sized enterprises were the most represented, accounting for 69.92 % (251 enterprises). This was followed by small enterprises with 25.07 % (90 enterprises) of the total number of enterprises responding, and the smallest representation was from large enterprises with only 5.01 % (18 enterprises) responding. The answers to the question on which market the company prefers to focus on showed that more than half of the companies supply their products to the national market 57.90 %, 26.05 % to the regional market, 9.95 % to the local market and the remaining 6.10 % of the companies also offer their products or services within the EU market. Of the 359 wood-processing enterprises in Slovakia, 69.92 % (250 enterprises) are involved in wood working, 20.06 % (72 enterprises) in furniture production and 1.95 % (7 enterprises) in pulp and paper production. The remaining 8.07 % of enterprises indicated the other option.

Through the first hypothesis, we verified whether a statistically significant majority of wood-processing enterprises in Slovakia perceive the introduction of green logistics in their enterprise as important. Up to 80 % of companies declared a positive attitude towards ecology, 10 % of companies stated that they have no attitude towards ecology, and the remaining 10 % have a neutral attitude towards ecology - they do not care or cannot comment on this issue. The results of the univariate chi-square goodness-of-fit test (at the $\alpha = 0.05$ level) showed that there is a statistically highly significant difference in the number of enterprises that have a positive attitude towards ecology compared to enterprises that have no or a neutral attitude towards ecology. Based on the nature of the data obtained, a Chi-Square test was used to test the hypotheses. The data obtained for the first hypothesis H_1 are presented in Table 1.

Table 1. Relation of the wood-processing enterprise to ecology

	Chi-square = 128.76; df = 1; p < 0.0001	
The company's relationship to ecology	Observed frequencies	Expected frequencies
Positive attitude	287	179.5
None, neutral attitude	72	179.5

Source: Own research

When asked in the questionnaire survey whether the enterprise carries out at least some environmental activities, 70 % of enterprises answered positively, while the remaining 30 % of enterprises confirmed that they do not carry out any environmental activities. Based on the chi-square test results, we can further conclude that the number of enterprises that carry out these types of activities is significantly higher than the number of enterprises that are not interested in these types of activities and do not practice them in their enterprises ($\chi^2 = 56.691$; df = 1; $p < 0.0001$). Based on the results obtained, **hypothesis H_1 was confirmed.**

To examine the level of environmental responsibility among enterprises, attention was directed to the implementation of green production strategies and environmental management practices. In this context,

Hypothesis H₂ was formulated with the assumption that the majority of the surveyed enterprises incorporate sustainable approaches into their production processes and actively engage in environmental management. The data shows that up to 80 % of all participating enterprises consider ecology when planning and managing material flows, which represents a significant majority ($\chi^2 = 128.76$; $df = 2$; $p < 0.0001$). The second hypothesis was also addressed by a question that addressed whether companies in the wood-processing industry use recyclable and renewable materials in their production (Table 2).

Table 2. Use of recyclable and renewable materials

	Chi-square = 211.845; df = 2; p < 0.0001	
Using recyclable and renewable materials	Observed frequencies	Expected frequencies
Yes	251	119.67
No	72	119.67
Partially	36	119.66

Source: Own research

Table 2 shows that 69.92 % of enterprises use recyclable and renewable materials on a regular basis, 10.03 % of enterprises said they use them only sometimes, and the remaining 20.05 % do not use them at all. The test results confirmed the existence of significant differences in the rate of use of these green materials in wood processing enterprises ($\chi^2 = 211.845$; $df = 2$; $p < 0.0001$), with a significant majority of enterprises using recyclable and renewable materials.

The research analysed the extent to which companies in the wood processing industry take environmental aspects into account in the production of their products. In particular, it was investigated whether the companies strive to produce environmentally friendly products. The results showed that up to 71 % of enterprises consider the environmental friendliness of their products to be important, while 19 % of enterprises do not attach importance to this aspect, and 10 % of the respondents could not comment on this question. The chi-square test confirmed the existence of statistically significant differences between the different groups of enterprises according to their approach to green production ($\chi^2 = 220.687$; $df = 2$; $p < 0.0001$). The findings also build on previous test results, indicating businesses' positive attitude towards environmental issues. Here again, the statistical analysis confirmed that a significant majority of wood processing enterprises pay increased attention to the production of environmentally friendly products, which further strengthens and **confirms the validity of hypothesis H₂**.

Through the third hypothesis H₃ we analysed the distribution process in wood processing enterprises in terms of its impact on the environment – we verified whether a significant majority of wood-processing enterprises use or do not use vehicles powered by alternative fuels for transportation (Table 3).

Table 3. Type of vehicle propulsion in wood-processing enterprises

	Chi-square = 229.440; df = 1; p < 0.0001	
Vehicle drive type	Observed frequencies	Expected frequencies
Diesel	323	179.5
Ecological - electric, LPC or CNG	36	179.5

Source: Own research

In terms of type, 89.97 % of wood-processing companies own diesel vehicles in their plants and only 10.03 % own electric, LPG or CNG vehicles. The chi-square test results confirmed that significantly more enterprises still use cars, trucks and all types of diesel vehicles, which are not environmentally friendly as opposed to eco-friendly vehicles. Based on the results from the questionnaire survey, we conclude that **hypothesis H₃ was confirmed**.

The fourth hypothesis, H₄, tested the difference in opinions of wood-processing enterprises on the concept of green logistics. When asked whether the firm planned to implement some part of green logistics in their

company in the future, 90.25 % (324 enterprises) of the enterprises answered positively, 5.01 % (18 enterprises) of the enterprises could not answer clearly and chose the option "maybe" and about the same number of enterprises (4.74 %) (17 enterprises) answered that they definitely did not. However, we can state with certainty that significantly more enterprises are clearly in favour of introducing green logistics ($\chi^2 = 516.510$; $df = 2$; $p < 0.0001$). To test the fourth hypothesis H_4 , a question focused on the willingness of companies to invest in the implementation of the green logistics model was also assigned (Table 4). This question was intended to complement the view of the environmental strategies of enterprises in terms of their readiness to allocate funds to environmentally oriented logistics solutions.

Table 3. Type of vehicle propulsion in wood-processing enterprises

	Chi-square = 243.682; df = 2; p < 0.0001	
Investing in a green logistics model	Observed frequencies	Expected frequencies
Yes	256	119.67
Depends on the financial requirements	25	119.67
No	78	119.66

Source: Own research

71,31 % (256 enterprises) of enterprises in the wood-processing industry would be willing to invest in a suitable green logistics model, 6,96 % (25 enterprises) of enterprises said that their decision would depend on the financial complexity of this model, and 21,73 % (78 enterprises) of enterprises would not invest in such a model. There are statistically significant differences between the number of enterprises with different attitudes towards investing in a green logistics model suitable for their enterprise, with a significant majority of f enterprises saying they would definitely invest in such a model ($\chi^2 = 243.682$; $df = 2$; $p < 0.0001$). Based on the findings, ***hypothesis H_4 was confirmed.***

Based on the processing and analysis of the data obtained, several measures have been proposed, the implementation of which could significantly contribute to increasing sustainability in enterprises operating in the wood-processing industry. These measures are mainly aimed at promoting environmentally oriented logistics processes, more efficient use of resources and strengthening the environmental identity of enterprises. One of the essential steps is to clearly define the current state of green logistics in the Slovak Republic, which is currently absent in legislative terminology and comprehensive strategic frameworks. At the same time, it is necessary to identify the main barriers that prevent a more effective application of the principles of green logistics, especially in terms of economic, technological and knowledge constraints in the sector. At the core of the proposed approach is the concept of green logistics, which includes ecological principles applied across all logistics processes. In procurement, emphasis should be placed on selecting suppliers with environmental certifications and demonstrable sustainable practices. Production should be oriented towards the processing of recyclable and renewable raw materials, while the resulting products should meet environmental standards and be labelled with appropriate eco-certifications. In distribution, the environmental burden needs to be reduced through the use of electric or other environmentally friendly means of transport and handling equipment, the reduction of non-recyclable packaging materials and the implementation of low-energy 'green warehouses'. In the area of recycling and waste management, we recommend introducing a returnable packaging system, monitoring emissions and noise, and actively treating production residues. From the point of view of energy sustainability, investing in renewable energy sources, especially photovoltaic systems, represents an important solution, whose economic payback according to available analyses is up to 7 years. A complementary technology is using virtual batteries to store surplus electricity efficiently. Reverse logistics is also an integral part of the concept, which involves reverse flows of materials and products - for example, the collection and reuse of scraps, sawdust or defective products. These can then be reprocessed or upcycled (e.g., to produce pallets or decorative products), significantly extending the materials' life cycle and reducing waste. Environmental management certification (ISO 14001) is also an important tool to support this approach and should be complemented by the responsible use of resources and the reduction of the ecological footprint. In addition to internal measures, external communication of environmental values through marketing is also recommended, strengthening the company's brand and innovation potential in sustainability.

In conclusion, the systematic implementation of the above measures can contribute not only to reducing the environmental burden but also to increasing the competitive advantage of wood processing enterprises. At a time of rising energy costs and increasing social pressure for environmental responsibility, these steps appear to be a prerequisite for the long-term sustainability of enterprises in the wood-processing industry.

4. Discussion and conclusions

The questionnaire survey results provide a robust statistical basis for evaluating the current state and attitudes of wood-processing enterprises in Slovakia toward the concept of green logistics and broader environmental responsibility. Despite a relatively low response rate of 14.08 %, the final sample size ($n = 359$) exceeded the calculated minimum threshold ($n = 358$), ensuring the representativeness and generalizability of the findings across the entire population of enterprises in the Slovak wood-processing industry. The confirmed first hypothesis (H_1) reflects the prevailing positive orientation of wood processing enterprises towards environmental values, with up to 80 % of respondents declaring an active or supportive attitude towards ecology. The high statistical significance of the results ($\chi^2 = 128.76$; $p < 0.0001$) confirms that environmental issues are no longer perceived as a peripheral topic but represent an integral part of strategic decision-making. Similarly, 70 % of the companies carry out at least some environmental activities, indicating a growing awareness of sustainability across the sector. These results correspond with research by Asamoah et al. (2024) who likewise highlight the growing environmental orientation of businesses as part of their identity and competitive advantage. Our research findings are also consistent with international studies. Starostka-Patyk et al. (2024) found in their research in Poland that more than 75 % of manufacturing companies already integrate environmental elements into internal processes and also plan to extend green strategies to logistics. Rahman and Hossain (2025), in their study of small and medium-sized enterprises, highlighted the importance of a positive environmental attitude as a starting point for implementing green logistics, which is consistent with our findings that environmental awareness is relatively high in the Slovak wood-processing industry. The second hypothesis (H_2), concerning applying green production strategies and environmental management, was empirically supported. A significant majority of companies (80 %) reported that they take environmental aspects into account in their planning and management of material flows, which is in line with Mondal, Giri and Maiti (2020) assertion that environmental elements are increasingly being incorporated into strategic processes, even in industries based on primary raw materials. Moreover, 69.92 % of the respondents reported the regular use of recyclable and renewable materials, confirming that environmental measures are not isolated initiatives but are becoming a standard part of production systems. These findings are consistent with a study by Fatorachian and Kazemi (2025), who find that firms with developed environmental management are more likely to use renewable raw materials, reducing their overall carbon footprint. Similarly, Roy and Mohanty (2024) showed that in wood and furniture companies in India, environmental certification and the use of green materials have a direct positive impact on the long-term efficiency of the companies. However, in the case of the third hypothesis (H_3), the results point to a weaker degree of greening, especially in the area of transport logistics. Up to 89.97 % of enterprises use diesel vehicles, while eco-friendly alternatives (electric, LPG or CNG) represent only 10.03 %. This situation may be due to several factors, including high upfront investment in green vehicles, limited infrastructure and the absence of effective financial incentives, as also reported by Mihalčová et al. (2021). Although the manufacturing sector has made progress, distribution processes are still lagging, posing a challenge for future improvements in corporate environmental performance. A more positive picture was provided by the fourth hypothesis (H_4), which focused on companies' future intentions and willingness to invest in green logistics. As many as 90.25 % of the enterprises declared their interest in implementing elements of green logistics, and 71.31 % of the respondents stated that they would be willing to make a real investment in this model. Although a smaller proportion of businesses weigh in mainly due to the expected financial costs, the statistically significant differences ($\chi^2 = 243.682$; $p < 0.0001$) suggest that the potential for developing green logistics in the sector is considerable. This positive trend is in line with the research of Rahman and Hossain (2025), who report that investment appetite is one of the main indicators of future readiness to implement sustainable measures. It also significantly reflects confidence in the long-term returns to eco-innovation and its reputational benefits. This trend is also supported by the study of Šimberová et al. (2022), according to which enterprises perceive green innovations as an investment in long-term competitiveness. The findings confirm that green strategies are becoming increasingly established in the wood-processing industry, with the main motivator being not only regulation but also self-initiative and business responsibility. However, the challenge

remains to reduce the ecological footprint in transport, waste management, and reverse logistics areas. At the same time, there is a need for a more favourable legislative framework and financial mechanisms to facilitate the wider application of green technologies and logistics solutions.

The implemented research also has some limitations, which are mainly the accuracy of the obtained data and information, sampling error (few actively involved respondents in the questionnaire survey, insufficient representation of enterprises despite meeting the minimum size of the research sample), or the structure and wording of the questions in the questionnaire itself, which despite the efforts to be unambiguous may have been misinterpreted by some respondents. This is particularly the case for complex terms such as 'green logistics', which are not uniformly defined by legislation or practice and may have affected some responses' quality. Another potential risk is the subjectivity of the answers, as the research works with stated attitudes rather than objectively measured data. Despite these limitations, the findings contribute to the debate on sustainable entrepreneurship in the wood processing sector. The results provide a starting framework for future research that could focus on a deeper analysis of specific environmental measures and their economic efficiency and deepen knowledge in implementing environmental innovations in logistics processes. At the same time, it would be useful to follow up with qualitative research (through interviews or case studies) that would provide a deeper insight into the motivations and barriers of enterprises in putting green logistics principles into practice.

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