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## ASSESSMENT OF THE APPLICATION OF ENVIRONMENTALLY FRIENDLY TECHNOLOGIES TO INCREASE BUSINESS COMPETITIVENESS\*

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**Abstract.** The paper analyses the impact of the application of environmentally friendly technologies on business competitiveness, taking into account the principles of sustainability and the aspects of business competitiveness. The growing awareness of environmental issues encourages companies to introduce innovative, environmentally friendly technologies, which reduce the negative impact on the environment and create the prerequisites for the formation of business competitive advantages. The paper presents a theoretical concept of environmental innovations and an analysis of their benefits for business. It also discusses the key factors influencing the uptake of these technologies, ranging from regulatory policy and financial incentives to consumer expectations and companies' strategic objectives. The empirical part of the study includes an analysis of three production sectors' performance results to assess how environmentally friendly technologies contribute to competitive advantage, digitalisation and sustainability. Following three stages of methodology, the study applies COPRAS method and grouping of countries based on the performance of production sectors (in particular, food, rubber, and furniture). The results reveal that most companies surveyed see the introduction of technology as an investment in long-term business success. The paper provides recommendations for companies seeking to strengthen their market position through sustainable technologies. The results are relevant for both business practice and public policy to create a sustainable and competitive production environment.

**Keywords:** environmentally friendly technologies; business competitiveness; environmental issues; sustainability; production

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**JEL Classifications:** 03, Q01, Q5

### 1. Introduction

This paper aims to examine the impact of advanced technological solutions and green technologies on company competitiveness and environmental sustainability. The aim is to assess how companies adopt sustainable practices, particularly in the food, rubber, and furniture manufacturing industries, while meeting global demands for resource efficiency, reducing environmental impact, and aligning with sustainable development goals (SDGs) such as the United Nations SDGs. The paper aims to identify gaps in integrating green transformation by analysing country-specific practices and providing insights for improving corporate sustainability. Advanced technological solutions have a significant impact on business. This is becoming very important because of the

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growing global demand for efficient business, sustainability, and environmental awareness. The study offers wide-ranging potential outcomes: increased green practices and reduced business technology drive competitiveness and stand out as a new approach in this area.

The EU, the United Nations, and the G20 countries have increasingly implemented policies and actions to promote sustainability (García-Gallo et al., 2020). Policies promoting sustainability can be divided into environmental, socio-economic, and technological. Sustainable policies include climate, air quality, environmental ethics, and others. Therefore, companies need to identify environmental sustainability as an objective rather than using it as a marketing tool. Advanced technological solutions significantly influence business operations, addressing the growing global demand for sustainability, efficiency, and environmental awareness. The integration of green technologies enhances environmental practices and strengthens business competitiveness, positioning sustainability as a strategic necessity rather than an option. The research provides novel multi-criteria assessment approaches by combining environmental, socio-economic, and technological indicators to evaluate the dynamics of corporate competitiveness. Focusing on three key manufacturing industries, food, rubber, and furniture, the paper identifies specific differences in adopting sustainable practices across countries. It reveals neglected aspects such as energy inefficiency and e-waste management. In addition, the study highlights less-researched challenges, such as the impact of environmental noise on corporate performance, and adds new perspectives to sustainable development research. Organisations like the European Union (EU), the United Nations, and G20 countries are increasingly implementing policies and initiatives to foster sustainable development. These policies span environmental, social, economic, and technological dimensions, emphasising critical aspects like climate ethics, air quality, and resource conservation. Companies are now expected to prioritise environmental preservation as a core goal instead of merely utilising it as a marketing tool.

Despite advancements, global circularity has declined to just 7% in 2023. Studies highlight the potential of improving heat energy efficiency in manufacturing to reduce operational costs and environmental harm significantly. It is estimated that up to 50% of energy in the manufacturing sector is wasted due to inefficiencies, emphasising the urgent need for sustainable practices. Addressing these inefficiencies mitigates environmental damage and enhances competitiveness by reducing costs. Environmental noise is a less recognised but impactful pollutant affecting public health and business performance. Long-term noise exposure can lead to health issues such as cardiovascular diseases, sleep disturbances, and psychological stress, which reduce workforce productivity. Studies reveal that addressing noise pollution is critical for community well-being and ensuring industrial competitiveness. For businesses located in urban areas, minimising noise is increasingly important as it influences residential and commercial preferences, thereby affecting market positioning. This research underscores the transformative potential of sustainable practices and green technologies in modern business.

The European Commission focuses on implementing the Green Deal to achieve a lower environmental impact. Technology plays an important role in the European green transformation, aiming to promote sustainability and strengthen the competitiveness of European businesses. Limited and fragmented application of modern environmentally friendly technologies is noticeable at the European Union (EU) level. The results of a bibliometric literature analysis show that the number of articles on green transition is five times lower than on digital transformation (Burinskiene & Nalivaike, 2024). The European Commission's Green Deal highlights the importance of minimising environmental impacts through technological innovation. However, the adoption of environmentally friendly technologies remains fragmented across the EU.

The European Union (EU) political agenda focuses on the priority implementation of the green transformation. Successfully implementing the green transition is essential for achieving the United Nations (UN) declared Sustainable Development (SD) goals.

Recent scientific research highlights the importance of environmentally friendly technologies for this transformation, especially in addressing the challenges of sustainable development in business. It is noted that, despite the increased attention paid to the topic of the green transition, scientific research on the application of environmentally friendly technologies to increase business competitiveness is fragmented, and there is a noticeable lack of knowledge in this research area.

This study aims to make a substantial contribution to the literature on the role of technological solutions in influencing business competitiveness and in helping to find solutions and take initiatives to increase operational efficiency and reduce environmental impacts. This study will contribute to a better understanding of the impact of technological solutions on business competitiveness by addressing existing research gaps. The objectives of the study include:

1. to investigate the need for environmentally friendly innovations, their classification and their impact on business competitiveness.
2. to investigate the determinants of market uptake of environmentally friendly technologies, the main ones being government regulatory policies, financial incentive mechanisms, consumer expectations and firms' strategic objectives.
3. to examine the impact of integrating sustainable solutions into business and eco-innovation on a company's competitive advantage, operational efficiency and corporate reputation.

The paper consists of such sections: theoretical background presented in Section 2; COPRAS analysis results are presented in Section 3; Conclusions section is presented at the end of the paper.

## 2. Theoretical background

The EU, the UN, and the G20 actively support the implementation of policies and actions to promote sustainable development and the transition to a circular economy (European Commission, 2025). Policies to promote sustainable development include environmental, socio-economic and technological aspects. Sustainable policies focus on reducing climate change, improving air quality, environmental values, etc. Companies should, therefore, pursue environmental protection as an objective in its own right rather than treating it as a marketing tool. The UN Sustainable Development goals have led to the emergence of environmental sustainability and green business management principles, which place increasing demands on companies in the area of environmental corporate social responsibility (ECSR). Chuang & Huang (2018) investigated the influence of ECSR on green IT capital and its impact on environmental performance and business competitiveness. Rath et al. (2021) analysed the criteria that are decisive for technologies that help to manage environmental factors, taking into account their mode of operation, their ability to reduce the carbon footprint, their ability to combat air pollutants, their cost-effectiveness or economic dimension and future considerations in line with the sustainable development goals.

Companies are now being encouraged to put environmental protection at the heart of their business and not just as a marketing tool (Msosa et al., 2024). The European Commission's Green Deal highlights the importance of technological innovation in reducing environmental impacts. However, the uptake of green technologies in the EU remains fragmented. The non-metallic minerals industry is the third most energy-intensive industry. The high energy intensity of the production process contributes around 7% of the world's carbon dioxide emissions to the atmosphere. Although the energy efficiency of this sector in the EU has improved significantly since 1995, its energy intensity remains high. To meet the objectives of the Paris Agreement, further action is needed to reduce carbon dioxide (CO<sub>2</sub>) emissions from this sector (Korczak et al., 2022). Despite a strong focus on recycling, the global circularity rate has decreased from 9-8% to 7% between 2021 and 2023. Recycling rates for materials such as paper and plastics are still only around 50% in Europe, indicating that resources are not being used to their maximum efficiency. Recycled raw materials account for only 1.9% of new production in Europe, reflecting the very low level of integration of secondary raw materials in production. Despite technological advances or due to accelerated cycles of technological innovation, product life cycles are getting shorter. This trend is contrary to sustainability principles as it leads to a faster depletion of resources. The 2023 Turnover Gap Report shows that deteriorating turnover is exacerbated by the prevailing trends towards unsustainable consumption and production patterns. The report highlights that high material resource extraction, persistent stockpiling and low efficiency of end-use processes significantly contribute to the current turnover gap, hindering the transition towards a more sustainable and circular economy (Sakao et al., 2024).

The European Commission (2025) also stresses the need to reduce environmental impacts through technological innovation. Research shows that technology application practices affect business competitiveness. Chikan et al. (2022) define business competitiveness as the ability of a company to fulfil its primary objectives sustainably, i.e. satisfy customer requirements and generate profits. A Harvard Business School study empirically identified

a promising triple-bottom-line strategy, which, if successfully implemented, can achieve better business results and increase business competitiveness (Lee et al., 2022). A study by Untari et al. (2021) assessed the impact of new technology applications on business performance. The results revealed that new technologies and innovations affect business competitiveness (Bhawsar, 2023).

Global challenges: global warming, pollution levels, and climate change have become serious threats in recent years and have caused a number of environmental problems that have affected human, animal, and plant health. As a result, regulation, which is important for business competitiveness, has forced various organisations to come together to find solutions and take various initiatives to increase efficiency and reduce environmental impact. The environmental problems of energy consumption, use of natural resources, pollution and waste management are not only constraining but also opening up new competitive opportunities that are changing the competitive landscape for many industries. These environmental challenges and the need to ensure cost-effective operations force companies to rethink their business models. However, sustainability principles are still not sufficiently applied, increasing long-term risks for the environment, the economy and society. Technological solutions are increasingly shaping how we do business as the demand for sustainable, efficient and environmentally friendly solutions grows (Chen et al., 2023). The introduction of green technologies contributes to environmental improvements and strengthens companies' competitive position, making sustainability a necessary strategic orientation rather than an option.

Achieving sustainable development objectives has become crucial for saving and maintaining the environment, and various green technologies are being used to address the problem. Companies that manage environmental factors effectively can achieve a competitive advantage in the market. Processes evolve through life-cycle stages, starting with research, moving on to process engineering, plant operation and finally decommissioning. Most technologies that reduce environmental impacts are applied early in the life cycle. The number of technologies decreases sharply thereafter. Therefore, addressing environmental concerns early in the life cycle is advisable. As the process becomes more mature, the cost of addressing environmental issues increases exponentially as the scale of the equipment increases. The long-term environmental objective is to develop lean processes with 100% material recovery. The short-term emission control strategy is implementing pollution prevention programmes by introducing cost-effective technologies to control general air pollution, effluents and waste generation.

However, the uptake of environmentally friendly technologies across the EU remains insufficient. Despite progress, global circularity has fallen to just 7% by 2023. Studies show that improving thermal energy efficiency in manufacturing can significantly reduce operating costs and environmental damage. Multi-criteria evaluation methods are used to assess progress (Raudeliuniene et al., 2025). This paper aims to investigate the impact of advanced technological solutions and green technologies on the competitiveness and environmental sustainability of companies in different countries.

Environmentally friendly technologies are defined as innovative solutions that reduce negative environmental impacts and promote more efficient use of resources (Javaid et al., 2022; Fernando et al., 2019; Jin et al., 2019). In the scientific literature, ATT is often associated with eco-innovations, which include changes in processes, products or business models that contribute to the implementation of sustainability goals (Passaro et al., 2023; Vence & Pereira, 2019; Pichlak & Szromek, 2021). They can be divided into several groups: waste reduction technologies, energy efficiency solutions, integration of renewable energy sources and the use of sustainable raw materials. Many studies show that applying environmentally friendly technologies can increase a company's competitiveness through several aspects: lower production costs, better reputation, greater customer loyalty and easier access to investment (Shrivastava, 2018; Li et al., 2019). However, it is emphasised that the implementation of technologies is associated with risks and investments, whose payback depends on various internal and external factors - legal regulation, consumer behaviour and technological infrastructure.

Javaid et al. (2022) described the use of artificial intelligence (AI), the Internet of Things (IoT), big data, machine learning (ML), and other advanced technologies to implement Industry 4.0 and how they contribute to creating a sustainable environment. The authors identified twenty key applications of Industry 4.0 in creating a sustainable environment. These technologies are environmentally sustainable, produce goods more efficiently,

and reduce resource consumption. Fernando et al. (2019) analysed the research gap on eco-innovation and its impact, especially the mediation effect of service innovation on business sustainability. The authors found that eco-innovation and service innovation capabilities are significant intangible resources and enable an organisation to achieve long-term goals, competitive advantage and business sustainability. Jin et al. (2019) calculated the green common factor efficiency of industrial water resources. They analysed the effects of technological innovation, the degree of environmental regulation, and the variability and control of the interaction between these two factors. The authors found that the impact of technological innovation and environmental regulation on industrial water resources has regional, economic, and industrial structure differences, so it is relevant to formulate a differentiated technological innovation system and environmental protection policy, improve the green investment in Research and Development (R&D) of industrial enterprises, and form a green development model.

Passaro et al. (2023) analysing the factors determining SMEs' eco-innovation and their interrelationships, found that it is important for SMEs to follow a sustainability direction and invest in eco-innovations that would reduce the social and environmental impact of production activities. Vence et al. (2019) highlighted the importance of eco-innovation, including organisational, social and systemic innovations, in reducing environmental impacts. The authors noted that business models based on eco-innovation ensure the transition to a circular economy. Integrating eco-innovation into business models influences the ecological and social value of the value proposition and changes the practices of producers and consumers. Pichlak & Szromek (2021), analysing the environmental aspects of innovative activities carried out by companies and the tendency of sustainable business leaders to create eco-innovations, found that the greenest companies are those that develop technologies for biodiversity protection and that the adoption of open innovation strategy strengthens the tendency to create eco-innovations.

Li et al. (2019) conducted a hierarchical regression analysis of the impact of energy saving and environmental data on the competitiveness of green technological innovations. The authors found that a firm's green technological innovation capability has a significant positive impact on the firm's competitiveness, provided a new analytical framework to understand the mechanism underlying the impact of a firm's green technological innovation capability on the firm's competitiveness, and provided useful insights into the development of green technological innovation competitiveness and the impact of new government policies on the regulatory framework of green development. Abad-Segura et al. (2025) examined the dynamic relationship between sustainable technological innovation (STI) and business competitiveness, noting that incorporating technology into business strategies will positively impact society and the environment. The authors also described the emergence of technology integration in finance, which promotes the emergence of technology-oriented investment platforms aligned with sustainability criteria and focused on attracting investors who value social and environmental responsibility. Hamdouna & Khmelyarchuk (2025) also studied technological innovations as key factors of sustainable competitiveness of economic entities, increasing their resilience to various challenges and threats, and identified three main scientific approaches: the resource-based approach system, where technological resources enable companies to make efficiency-enhancing decisions, taking into account sustainability aspects. The dynamic capabilities theory extends the resource-based approach system, where companies adapt and reconfigure their resources and capabilities in response to a rapidly changing environment. The triple bottom line system, which focuses only on the company's financial performance, is based on the balance of three main elements - economic, environmental and social goals.

In the literature, different authors have applied the COPRAS approach; for example, Raudeliuniene et al. (2025), to investigate sustainable construction practices in the European region, chose the COPRAS approach for their study, which allowed them to assess the environmental impact of the methods and materials used while optimising the resource allocation. This method helps to ensure the cost-effectiveness and environmental sustainability of building projects. Mishra et al. (2021) examined a two-step hybrid approach to assess sustainable bioenergy production technologies. The authors used the SWARA model to determine the subjective weights of the criteria. In a second step, they ranked bioenergy production technologies using intuitionistic fuzzy sets based on the COPRAS method. The authors evaluated six bioenergy production technologies based on four sustainability dimensions and eleven sub-criteria. Hezam et al. (2023) proposed a hybrid single-valued neutrosophic-informed decision-making approach that combines MASWIP integrating MEREC, an integrative

objective weighting model, which combines integrated objective and subjective weighting models to calculate criterion weights in a single-valued neutrosophic environment, and a complex-proportional assessment using the COPRAS approach to prioritise bioenergy production technologies from a single-valued neutrosophic viewpoint. Ramana et al. (2022) defined the ranking algorithm, the Complex Proportional Assessment - COPRAS approach, as a new integrated approach with non-linear fuzzy data that better represents uncertainty and has an impact on sustainable performance.

The authors noted that the variance method proposed for the weighting of criteria overcomes hesitations and takes into account reliability. Amudha et al. (2021) defined the COPRAS method as a multi-criteria decision-making tool that is used to increase or decrease index values, as well as to reduce attribute indices when evaluating results. It is an ambiguous hierarchical process is an analytical hierarchical process method developed using the theory of ambiguous logic. Badrinath et al. (2022) applied the fuzzy COPRAS method to examine which factors in the shipping industry hinder the sustainability of a shipping port. In their study, the authors proposed an 8-dimensional problem-solving strategy as the optimal strategy for the identified sustainability-influencing criteria, such as loading and unloading of petroleum products, unexpected accidents, high energy consumption, structural failures, and dust generation. Demirci (2021), examining the concept of sustainability, through the interrelated aspects of economic, social and environmental protection, which is a component of the supply chain, emphasised the importance of integrating components of the sustainable supply chain process when selecting suppliers oriented towards green practices. The authors applied multi-criteria decision-making methods that provide the most important decision support opportunity, rationally and conveniently for decision-makers in selecting green suppliers for which criteria were set. Applying the multi-criteria COPRAS decision-making method, green suppliers were selected, as a result of which the most suitable one was determined from 7 alternatives. Kusakci et al (2022) also highlighted the importance of integrating sustainability principles into urban planning at the local level. The authors used fifty-three indicators of economic, social, environmental and institutional dimensions to assess the sustainability indicators of thirty Turkish cities to create a sustainable cities index. For this purpose, the authors applied a new three-stage methodology that hybridised Interval Type-2 Fuzzy Analytical Hierarchy Process (IT2F-AHP) and Complex Proportional Assessment of Alternatives (COPRAS), taking into account the high uncertainty due to the subjective weighting assigned by experts, and calculated the total scores of the 30 cities. Więckowski et al. (2024) conducted a comparative analysis of three selected multi-criteria decision analysis (MCDA) methods to find a solution to a practical decision problem and investigate the results' reliability.

The authors used the COPRAS method for complex proportional assessment, the PROMETHEE method for preference ranking organisation to enrich the assessments, and the EDAS method for distance-from-average assessment and RANCOM method for ranking comparison to determine the weights of the criteria. The application was directed to the management of sustainable development in selected European countries, taking into account different energy sources according to the share of consumption per capita.

### 3. COPRAS analysis

In this paper, a multi-criteria assessment approach COPRAS method was used to analyse three main manufacturing sectors – food, rubber and furniture – in different countries. The methodology of the analysis is based on such three stages:

- 1) Analysis of the indicators representing the application of environmentally friendly technologies to increase production sectors competitiveness.
- 2) Multi-criteria COPRAS method application for the analysis, including indicators reflecting the application of ICT in three main production sectors' competitiveness.
- 3) Comparison of three main production sectors' results and grouping similar performance particular production sectors by countries.

Research methods used during the analysis: 1) indicator analysis, 2) multi-criteria assessment, 3) comparative analysis and grouping.

Indicators of the EU, Norway and Serbia three production sectors (food, rubber and furniture) were retrieved on technology application published by the Eurostat (2023) database and were used during the research.

Five key criteria of corporate behaviour were assessed: (1) companies applying some measures affecting the paper or energy consumption of ICT equipment; (2) companies taking into account their environmental impact before choosing ICT services or ICT equipment; (3) companies handing over ICT equipment at the end of its useful life to e-waste collection and/or recycling companies; (4) companies with a high digital intensity index that consider their environmental impact before choosing ICT services or ICT equipment; (5) companies with a low digital intensity index that apply some measures that affect the paper or energy consumption of ICT equipment) related to companies' environmental and IT behaviours.

The study examines the classification of green technologies to assess their impact on environmental sustainability and business competitiveness. The focus is on evaluating the application of these technologies to improve business performance using an industry competitiveness approach. To this end, a multi-criteria approach was developed that integrates indicators that reflect the dynamic changes in corporate competitiveness. The study uses a variety of research methods, including literature source analysis, comparative analysis, and multi-criteria evaluation, to ensure a comprehensive study of the topic.

The manufacturing sector covers 3 industries (food, rubber, and furniture). In the food industry, the most common measure applied in the countries is that when the ICT equipment of the enterprise is no longer used, it is not sold, returned to a leasing enterprise, or donated (from 63.9% in Slovenia to 89.5% in Ireland). The lowest rate of implementation of the measure was reported by companies with a very high Digital Intensity Index, which have assessed the environmental impact of ICT services or equipment before choosing them and which apply measures that affect the paper or energy consumption of ICT equipment from 0,2% in Romania to 13.4% in Ireland. The Czech Republic and Denmark have similar measures in place, especially affecting the amount of paper used for printing and copying (60.8% and 61.1%, respectively); Estonia and Sweden have measures that reduce/increase the energy consumption of ICT equipment (69.9% and 71% respectively). Meanwhile, in Poland and Romania, ICT equipment no longer in use is mostly neither sold, returned to the leasing company, nor donated (83.0% and 83.6%, respectively).

Interestingly, Norway and Slovenia have the same proportion (88.8% and 85.2%) of measures, which are handed over for collecting and recycling electronic waste at the end of the useful life of the company's equipment. In the food industry, the criterion "When the ICT equipment of the company is no longer used, it is not sold, returned to the leasing company or donated" has the highest minimum and maximum, which means that in countries such as Ireland, Norway, Slovenia it is acceptable to discard the equipment. The results of the assessment are presented below in Table 1.

**Table 1.** Food, rubber, and furniture manufacturing sectors: COPRAS analysis results with country production sector ranks

| Food manufacture |      | Rubber manufacture |      | Furniture manufacture |      |
|------------------|------|--------------------|------|-----------------------|------|
| Country          | Rank | Country            | Rank | Country               | Rank |
| Serbia           | 1    | Hungary            | 1    | Greece                | 1    |
| Bulgaria         | 3    | Romania            | 1    | Hungary               | 1    |
| France           | 3    | Slovenia           | 1    | Romania               | 1    |
| Romania          | 3    | Norway             | 1    | Slovenia              | 1    |
| Slovenia         | 3    | Serbia             | 1    | Slovakia              | 1    |
| Slovakia         | 3    | Bulgaria           | 2    | Norway                | 1    |
| Sweden           | 3    | Croatia            | 2    | Serbia                | 1    |
| Norway           | 3    | Sweden             | 2    | Latvia                | 2    |
| Croatia          | 4    | Greece             | 3    | Poland                | 2    |
| Poland           | 4    | Cyprus             | 3    | Croatia               | 3    |
| Netherlands      | 5    | Poland             | 3    | Lithuania             | 4    |
| Portugal         | 5    | Slovakia           | 3    | Bulgaria              | 5    |
| Greece           | 6    | Latvia             | 5    | France                | 6    |
| Latvia           | 6    | Malta              | 5    | Ireland               | 7    |

|           |    |             |    |             |    |
|-----------|----|-------------|----|-------------|----|
| Hungary   | 6  | Netherlands | 7  | Netherlands | 7  |
| Malta     | 7  | Portugal    | 7  | Estonia     | 8  |
| Cyprus    | 8  | Estonia     | 8  | Italy       | 9  |
| Estonia   | 9  | France      | 9  | Cyprus      | 9  |
| Lithuania | 9  | Ireland     | 14 | Denmark     | 13 |
| Germany   | 14 | Denmark     | 16 | Germany     | 16 |
| Czechia   | 16 | Germany     | 17 | Czechia     | 20 |
| Italy     | 16 | Czechia     | 20 |             |    |
| Denmark   | 20 |             |    |             |    |
| Ireland   | 20 |             |    |             |    |

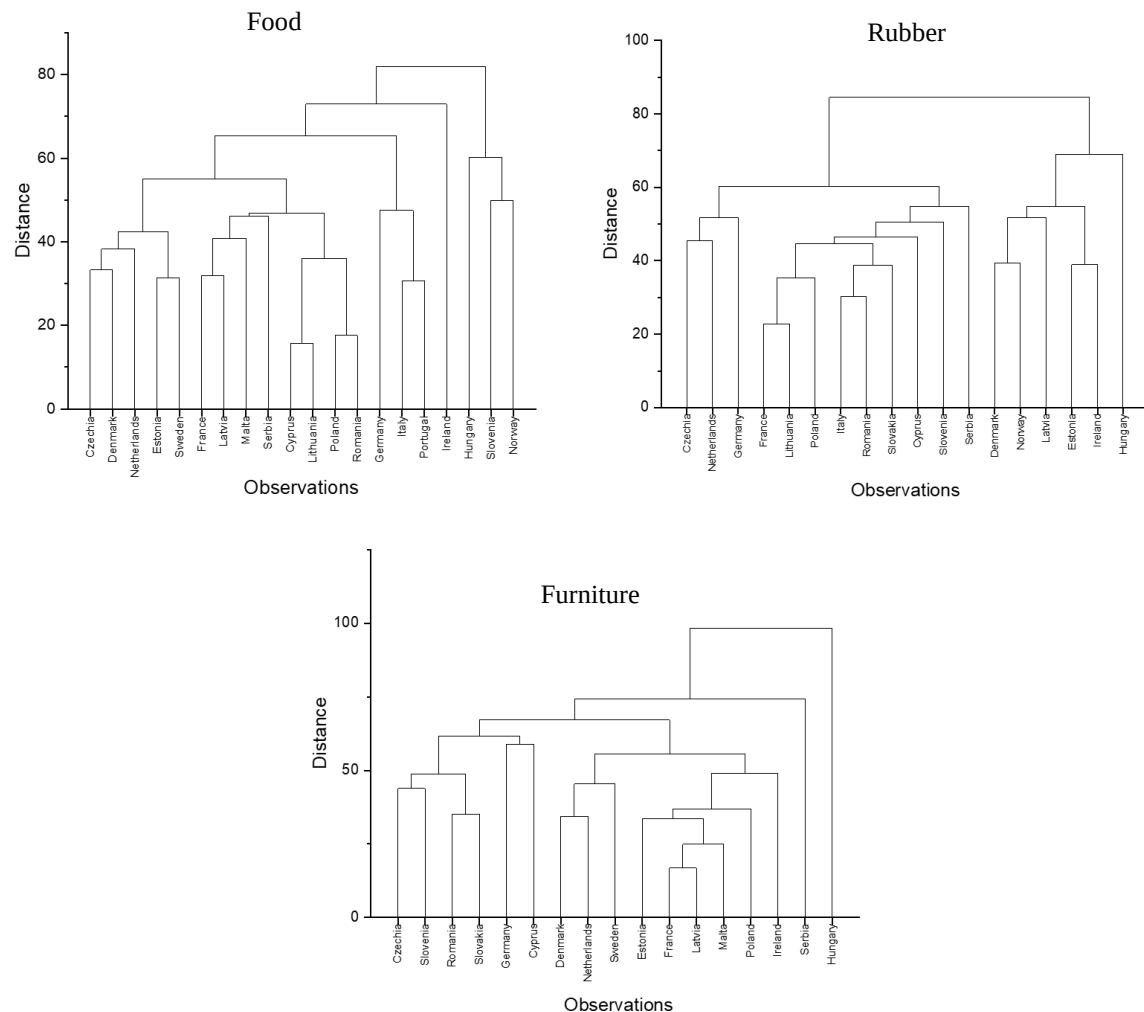
Source: compiled by the authors

Following the COPRAS analysis results for the food manufacturing category, Serbia ranked 1st, having the highest level of environment-friendly integration of ICT. After Serbia, Bulgaria, France, Romania, Slovenia, Slovakia, Sweden, and Norway followed suit in third place with strong results pointing to a relatively high level of sustainable behaviour. Croatia and Poland were the next closest, and the Netherlands and Portugal were behind. Countries such as Greece, Latvia, Hungary and Malta demonstrated intermediate results, and Germany, Czechia, Italy, Denmark and Ireland were ranked lowest, with a great demand for improvement. In the rubber manufacturing sector, the major countries are Hungary, Romania, Slovenia, Norway, and Serbia, which show outstanding practices in the integration of sustainable ICT actions. Countries such as Bulgaria, Croatia and Sweden (2nd place) also achieved strong results. Lower values have been observed for France, Denmark, Germany and the Czech Republic, indicating a significant development of environmental responsibility in this sector. The top-performing country, Greece (1st place), was in the furniture production sector, followed by Hungary, Romania, Slovenia, Norway, Serbia and Latvia, Poland (2nd place).

Following the COPRAS results, the countries were grouped according to their results. The grouping results are presented in Figure 1. Based on Eurostat (2023) data, dendrograms have been produced (Figure 1). A dendrogram of food industry measures in different countries shows that (countries in similar industries have similar ICT use and environmental practices).

Following dendrograms, Lithuania ranked fourth, reflecting its relatively strong performance and commitment to sustainable ICT practices. Countries such as Croatia and Bulgaria, followed by France, Ireland, the Netherlands, Italy, Cyprus, Denmark, Germany, and the Czech Republic, have achieved declines and are pointing to stronger integration of green ICT practices. Overall, the analysis shows that some countries exhibit high-level practices when using environmentally controlled ICT strategies in the most important manufacturing sectors. However, significant differences between countries and sectors still show the need for improvement options and broader adoption of sustainable digital transformation practices.

The COPRAS analysis has evaluated sustainability practices in the food, rubber and furniture sectors based on the five most important environmental standards related to ICT. Serbia, Hungary, Romania, Slovenia and Greece have shown the most powerful integration of sustainable ICT actions. Lithuania was good in furniture (4th place) but showed moderate food production levels. Meanwhile, countries like Germany, Denmark, and Czechia consistently ranked lower across sectors. Results in some regions highlight significant advances and the need for a more comprehensive adoption of environmental manager digital practices to improve sustainability across the manufacturing industry.



**Figure 1.** Grouping of countries by similarity in the food, rubber and furniture manufacturing sectors.  
Source: compiled by the authors

Multi-criteria analysis revealed the following results:

- Food manufacturing: Lithuania ranks 9th. It is in the middle position among the countries analysed. Montenegro and Serbia are the highest-ranked countries which are the most effective in applying environmentally friendly solutions using ICT equipment. Compared to neighbouring countries such as Poland (4th place) and Latvia (6th place), Lithuania is lagging behind, and it is recommended to focus more on the practical implementation of environmentally friendly solutions in companies in this sector.
- Rubber sector: Although no data is available for Lithuania, the analysis shows that Hungary, Romania, Slovenia, Norway and Serbia are the leaders in this sector. These countries are characterised by a high level of responsibility and advanced practices in the use of ICT solutions. In contrast, Germany, Denmark and the Czech Republic have a relatively lower level of adoption of advanced solutions, indicating a potential need for improvement in these countries.
- Furniture manufacturing: Lithuania is ranked 4th, one of the best performers among all sectors analysed, indicating that companies in the country are making responsible decisions in this area to implement sustainable ICT solutions. Lithuania is behind only Greece, Hungary, and Romania, which have achieved the highest scores, reflecting progress in sustainability.

While introducing green technologies can significantly increase competitiveness, an integrated strategy for sustainable management and further research are needed to develop practical solutions. The manufacturing industries analysed still face significant environmental and energy consumption challenges. Insufficient recycling rates and shorter product life cycles threaten sustainability. The food, rubber, and furniture industries need to adapt to sustainability requirements, and technological innovation, resource efficiency, and circular economy models can help increase their competitiveness and reduce their environmental impact.

## Conclusions

The introduction of environmentally friendly technologies has a significant impact on business competitiveness. The study shows that these technologies reduce negative environmental impacts and create the conditions for long-term business success by optimising production costs, improving product quality and increasing attractiveness to consumers and investors.

Eco-innovation is becoming a key competitive advantage for businesses. Companies that integrate sustainable solutions demonstrate a progressive approach to market development and sustainable development. This shows that sustainability is becoming not only an ethical but also a strategic decision that can be profitable.

Environmental innovation is driven by complex factors. Key factors include government regulatory policy, financial incentive mechanisms, consumer expectations and companies' strategic objectives. This reflects the need to align public policy with business needs.

Sustainable technological solutions have a significant impact on business. This is becoming increasingly important in light of the growing global demand for efficient business, sustainability and environmental awareness. The study suggests a wide range of potential outcomes: increased business efficiency, cost reduction, environmental protection and economic progress. These advanced components are crucial for implementing green practices, reducing business vulnerability to climate change. The project's unique focus on responsible resource use, monitoring and environmentally friendly technologies boosts competitiveness and stands out as a new approach in this field.

Sustainable policies cover aspects such as climate, air quality, environmental ethics and others. Therefore, companies need to set environmental sustainability as a goal rather than use it as a marketing tool.

The research results support such Sustainable development goals (SDG):

- Proposed multi-criteria analysis, including indicators reflecting business competitiveness and sustainable partnerships (SDG17).
- Application of environmentally friendly technologies reflecting the reduction of CO2 emissions (SDG13).
- Application of new environmentally friendly technologies reflecting the achievement of responsible business consumption (SDG12).

Together, these efforts offer scalable solutions focused on increasing business competitiveness. In line with above stated, the paper examines the tools and knowledge to implement effective sustainability strategies, fostering long-term economic and environmental benefits.

However, in the current context, companies face challenges in seamlessly integrating environmentally friendly technologies into their operational networks.

Empirical evidence from Lithuanian firms shows the positive impact of technology on the dynamics. Most companies surveyed indicate that introducing environmentally friendly technologies increases operational efficiency and improves market reputation. This confirms that investments in sustainability pay off in the long term.

The COPRAS analysis revealed significant differences between sectors and countries. The food, rubber and furniture manufacturing sectors have shown uneven progress in integrating environmentally friendly ICT

solutions. Countries such as Serbia, Greece and Hungary performed the best, while some Western European countries, such as Germany and Italy, showed significant potential for improvement.

Sustainable digital transformation has not yet been implemented in the same way in all countries and sectors. While some countries already demonstrate a high level of application of green ICT strategies, many still have room for development. This underlines the need to promote a culture of sustainability not only at the national but also at the international level.

Recommendations for public policy and business highlight the need to promote eco-innovation. Strengthening financial and regulatory instruments, promoting cross-sectoral cooperation and educating consumers about the environmental benefits are necessary to accelerate the implementation of sustainability.

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