THE IMPACT OF PRODUCT AND PROCESS INNOVATION AND TECHNOLOGICAL DIMENSIONS ON THE SUSTAINABLE COMPETITIVE ADVANTAGE OF MANUFACTURING COMPANIES

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ABSTRACT

This study investigates the impact of product, process, and technological innovations on the sustainable competitive advantage of manufacturing companies. An empirical survey was conducted on a sample of 252 employees. The results reveal that product innovation positively influences market share and customer loyalty, while process innovation enhances cost efficiency and operational effectiveness. Moreover, the technological dimension not only directly contributes to competitive advantage but also moderates the relationship between product and process innovations, amplifying their beneficial effects. These findings underscore the strategic importance of investing in technological advancements to maximize the impact of product and process innovations. The study provides valuable insights into the synergistic effect of these innovations, offering practical implications for managers aiming to strengthen competitive positioning. By integrating technological advancements with product and process innovation strategies, companies can achieve long-term sustainability and economic success. The research contributes to the existing body of knowledge by demonstrating the moderating role of the technological dimension in fostering sustainable competitive advantage.

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Introduction

The success of a company, both in domestic and international markets, increasingly depends on its innovativeness. Innovation represents a means of achieving competitive advantage. Ogunkoya and others emphasize that competitive investment in innovation is akin to an arms race. Competition forces companies to innovate (Ogunkoya et al., 2024). Particularly noteworthy is the importance of technological innovation, a significant component of innovations, which is crucial for achieving the competitive advantage of any company (Chen et al., 2023). Through technological innovation, companies are enabled to change their market orientation and, in the case of significantly new technologies, to enter entirely new markets. The innovation process is based on creating new products through which the company achieves a competitive advantage. There is a strong correlation between new products and market behavior Li & Jin, 2023). New products help in capturing and retaining market share, as well as increasing profitability. In the case of more mature and well-known products, the increase in competitive sales arises not only from the ability to offer low prices but also from various non-price factors such as design, adaptability, and quality.

Competitiveness is not an immutable category. Once a competitive advantage is achieved, it is difficult to constantly maintain it and find ways to enhance it. One way to increase competitive advantage is based on increasing productivity through investment in innovations, investment in knowledge, and new technologies (Petrović et al., 2023). Product innovation refers to the introduction of a new or significantly improved product in terms of characteristics and purposes. It involves continuous improvements in technical specifications, components and materials, ease of use, and implemented software. Process innovation represents a type of technological innovation (Balaz et al., 2023). There is a strong connection between process innovation and product innovation. These two processes within a company are sometimes so intertwined that it is difficult to separate and observe them in isolation. When considering process innovation, it can be concluded that it involves improvements in the very process of product manufacturing.

This includes significant improvements in production methods, encompassing changes in equipment and software, techniques, or production organization, or in all these areas. Methods are strictly aimed at increasing the efficiency of the production process, i.e., reducing costs per unit of output. Essentially, the goal is to reduce input for the same output, which leads to increased efficiency as previously mentioned. Technological innovations can rarely be categorized, transferred, and applied in isolation. The usefulness of one invention is closely linked and conditioned by other complementary inventions, i.e., the introduction of technological innovation creates its dependency on other complementary areas. For successful implementation, it is necessary to carry out additional technological changes in the integral system where the desired effects are to be achieved.

Literature Review

Technological innovation acts as a catalyst in enhancing the favorable impact on the value of a company (Yusheng et al.,2023). Modern technologies save time and costs and improve the performance of companies, meet customer needs, and thereby achieve sustainable competitive advantage (Dhanora et al., 2020; Al-Mamary et al., 2020). Research conducted in China by Shi et al. (2018) on a sample of 201 manufacturing companies demonstrated that technological innovation primarily affects product quality and consequently the competitive advantage of companies (Shi et al., 2019). To innovate efficiently, companies collaborate with suppliers to develop modern technologies (Gao et al., 2023). Additionally, collaboration is carried out with research institutions. A study conducted on a sample of Chinese manufacturing companies using regression analysis proved that an increase in technological innovations leads to an increase in the value of the manufacturing chain and has a positive impact on the intelligent transformation of manufacturing companies. Moreover, the study showed that competitive advantage plays a moderating role in the dissemination of technological innovations (Yin et al., 2024).

Nilsson & Goransson (2021) define sustainable innovation as the creation of products, processes, management practices or business models that are new or significantly improved and that bring economic, social and environmental benefits. Rodríguez-Espíndola et al. (2022) point out that innovative practices can be integrated through sustainability at the product, process and organizational levels, with product innovations involving the introduction of improvements or completely new products or services to improve sustainable performance, while process innovations involve redesigning operations to reduce resource use, improve the way services are managed and introduce environmental efficiency into their activities.

It is interesting to observe the reverse relationship, i.e., whether the technological dimension has a moderating role in the relationship between innovation and competitive advantage, which is a derived goal of this paper. Manufacturing companies introduce innovations in logistics processes, thereby increasing efficiency. By introducing innovative changes in production processes, they improve product quality. The goal is to achieve maximum results with minimal investment. Implementing product innovations involves introducing product components with technical specifications and functions different from existing ones. The production process requires raw materials that contribute to the sustainable development of products. Additionally, the production process and the expansion of the product line depend on customer desires and needs. The purpose of the company is to implement changes that customers recognize in the market, enabling a superior market position for the company (Ogunkoya et al., 2024; Yusheng et al., 2023; Shi et al., 2018).

Wojtowicz et al. (2018) conducted research in Poland, where the results proved the positive impact of expenditure on innovative activities in the field of product and process innovations on economic outcomes in the manufacturing sectors (sales volume and gross added value). It is concluded that an important source of competitive

advantage should be the quality and functionality of products, the ability to meet individual customer needs. Quality management practices, such as leadership and top management support, training and employee participation, information and learning, and customer focus, positively affect the creation of product and process innovations.

Accordingly, Soltani & Modaresm (2022) emphasize that these practices should be incorporated into the business strategy, considering that the strategy of product and process innovation performance is a major driver of the competitive advantage of the company. In a study conducted by Henrique et al. (2023) on a sample of 5588 manufacturing companies from Latin American countries, the results showed that research and development as a prerequisite for innovativeness positively impacts product and process innovation.

On the other hand, research conducted on a sample of 238 Tunisian manufacturing firms by Khalifa (2021) shows that the impact of research and development is crucial in product innovation development, thereby enhancing the profitability of the company, but not in the development of production processes. Namely, the innovation of production processes impacts profitability only in combination with product innovation (Khalifa, 2021). Their incorporation undoubtedly leads to company profitability and other benefits. Orlovtseva & Gubanova (2023) point out that process innovations have a stronger impact on company performance than product innovations, which further indicates a greater commitment to process innovations, due to potential feedback.

The results of a study conducted by Canh et al. (2019) show that process and product innovations impact company performance in terms of market share. Additionally, the results indicate that investing in innovative activities requires time to make positive changes in profitability and can help gain customer loyalty (Canh et al., 2019). Lapple & Thorne (2019) in their study on a sample of 342 Irish manufacturing companies confirm the impact of innovations on economic sustainability, highlighting that economic gains depend on the level of innovations. It is evident that all the mentioned studies emphasize the importance of innovative endeavors for profitable business operations, resulting in the creation of sustainable competitive advantage.

Taneja et al. (2023) in their study emphasize that sustainable innovations viewed through products and processes have a positive impact on creating a reputation, or a green image, which further transmits a positive impact on performance. Vacchi et al. (2024) through the study, they emphasize the importance of aligning technological progress with environmental and social goals to achieve long-term sustainability and competitiveness. The authors Getnet Agazu & Amentie Kero (2024) emphasize that adopting innovation strategies is crucial for maintaining a competitive advantage in a dynamic business environment.

Savić & Ilić (2019) point out that strategies for achieving competitive advantage in agricultural production include innovations in production processes, resource optimization, and adaptation to market demands, that is, key elements involve improving product quality, implementing sustainable practices, and enhancing

efficiency by applying modern technologies and employee training. Authors Marković & Nikolić (2020) point out in their study that technological and process innovations, such as equipment modernization and production process improvements, contribute to a company's competitive position by increasing efficiency, reducing costs, and adapting to market demands. Similarly, Jovanović & Petrović (2021) in their study explore key factors that influence competitiveness, including resource efficiency, market access, and the application of technological innovations, with the results showing that modernization of production and increasing product quality significantly contribute to strengthening the position of agricultural enterprises in the market.

Based on the review of the aforementioned research, the following main hypotheses are formed:

H1: Product innovation has a positive and statistically significant impact on the sustainable competitive advantage of companies.

H2: Process innovation has a positive and statistically significant impact on the sustainable competitive advantage of companies.

H3: The technological dimension has a positive and statistically significant impact on the sustainable competitive advantage of companies.

Derived hypothesis:

H4: The technological dimension has a moderating role in the relationship between product/process innovations and sustainable competitive advantage.

Methodology

The research was conducted in the Central Serbia region from July 1 to July 13, 2024. The sample consists of 252 employees, segmented by gender, age, educational level, and work position in the manufacturing company. Table 1 presents the sample structure, indicating that the sample consists of 57% male participants and 43% female participants, aged between 36 and 55 years (52%), and mostly having a high level of education (54%). A larger portion of the sample participants hold managerial positions in the manufacturing company (59%).

Table 1: Sample characteristics

Demographic characteristics		**Numerically**	**%**
GENDER	Female Male	108 144	43% 57%
AGE	18-25 26-35 36-45 46-55 56+	35 47 68 63 39	14% 19% 27% 25% 15%
EDUCATION	Elementary Middle Higher	17 98 137	7% 39% 54%
WORKING POSITION	Leadership	149	59%
	Non-leadership	103	41%

Source: Author's research

For the research, an online survey was used and distributed electronically. The questionnaire consisted of relevant statements grouped into four factors, as shown in Table 2 (product innovations, process innovations, technological dimension, and sustainable competitive advantage). A Likert scale was used in the study, and the obtained data were processed using IBM SPSS. Factor analysis, correlation analysis, regression analysis, as well as moderation analysis were used to measure the impact of the technological dimension on the relationship between product/process innovations and the sustainable competitive advantage of manufacturing companies.

Table 2: Formed factors

	Factor	**Origin**
1. The company develops new products with technical specifications and functions that differ from the existing ones and are adapted to the market.	PRODUCT INNOVATION	Thi, et al., 2023; Gil-Saura et al., 2023; Nikolić et al., 2022; Marin Garcia et al., 2023; Shi et al., 2018.
2. The company improves existing products by adding new components, which are different from the existing ones.		
3. The company involves customers in the product development process, adapting the product design to their needs		
4. The company is expanding the number of product lines.		
5. The company uses raw materials that contribute to sustainable product development.		

	Factor	Origin
6. The company introduces innovations in logistics processes.	PROCESS INNOVATION	Gil-Saura et al., 2023; Nikolic, et al., 2022; Marin-Garcia et al., 2023; Shi et al.,2018.
7. The company increases economy in logistics processes.		
8. The company improves the quality of output (highway) by introducing changes in production processes, techniques, machines and software.		
9. The production process has been modified in order to reduce the consumption of resources (raw materials, energy, etc.).		
10. The company introduces new processes that enable the recovery of end-of-life products for recycling		
11. The company introduces improved information technology/software for product manufacturing.	TECHNOLOGICAL DIMENSION	Shi et al., 2018; Al-Mamary et al., 2020.
12. The company cooperates with suppliers on the development of technologies.		
13. The company cooperates with scientific research institutions on the development of technologies.		
14. The company effectively uses its technological resources, which contribute to competitive advantage.		
15. The company introduces the latest technological solutions, i.e. invests in technology.		
16. The company has a higher level of productivity compared to its competitors.	SUSTAINABLE COMPETITIVE ADVANTAGE	Thi et al., 2023; Al-Mamary et al., 2020.
17. The quality of the company's products is better than the quality of competitors' products.		
18. The company has a superior position on the market.		
19. The company introduces changes that are recognized and appreciated by clients/customers.		
The innovations introduced by the company were a springboard for further development.		

Source: Author's research

Research Results and Discussions

As previously mentioned, factors were formed: product innovations, process innovations, technological dimension, and sustainable competitive advantage, and a reliability analysis was conducted to determine whether there is internal consistency among the statements that constitute these factors. The results of the reliability analysis are presented in Table 3. Based on the value of the Cronbach's alpha coefficient, it can be concluded that there is an adequate level of reliability for all factors. The highest degree of internal consistency of the statements occurs in the factor Sustainable Competitive Advantage (highest Cronbach's alpha value – 0.947), while the lowest degree of internal consistency of the statements occurs in the factor Product Innovations (lowest Cronbach's alpha value – 0.858).

Table 3. Results of factor analysis

Factors	AS	SD	Cronbach's alpha
Product innovation	4.493	0.605	0.858
Process innovation	4.537	0.551	0.867
Technological dimension	4.472	0.672	0.919
Sustainable competitive advantage	4.444	0.736	0.947

Source: Author's research

The next analysis in the research is a correlation analysis to determine the degree of quantitative agreement in the variations of the created factors (Table 4). The results show that there is a strong positive correlation between all observed factors, with the correlation values being statistically significant at the 0.01 level. The highest degree of correlation occurs between the factors of the technological dimension and sustainable competitive advantage, due to the highest value of Pearson's correlation coefficient, 0.908, indicating the strongest correlation.

Table 4. Results of correlation analysis

	Product innovation	Process innovation	Technological dimension	Sustainable competitive advantage
Product innovation	1	0.846**	0.758**	0.799**
Process innovation	0.846**	1	0.861**	0.885**
Technological dimension	0.758**	0.861**	1	0.908**
Austainable competitive advantage	0.799**	0.885**	0.908**	1

Source: Author's research

** Significance at the $p < 0.01$ level

The effects of the independent variables, namely product and process innovations, as well as the technological dimension, on sustainable competitive advantage were tested through multiple regression analysis (Table 5). Based on the obtained value of

the coefficient of determination (R^2=0.870; p < 0.01), it is concluded that 87% of the variability in sustainable competitive advantage is explained by the created factors (product innovations, process innovations, and the technological dimension). The obtained VIF coefficient value indicates that multicollinearity does not occur.

The regression analysis determined that product innovation (β=0.118; p<0.01) and process innovation (β=0.312; p<0.01) have a statistically significant positive impact on sustainable competitive advantage, which confirms hypothesis H1 and hypothesis H2. Process innovation has a greater impact on sustainable competitive advantage (β=0.312) compared to product innovation (β=0.118), as indicated by the higher β coefficient value. Additionally, multiple regression analysis showed that the technological dimension (β=0.550; p<0.01) has a significant impact on sustainable competitive advantage, confirming hypothesis H3. Based on the value of the β coefficient, it can be concluded that the technological dimension has the greatest impact on sustainable competitive advantage compared to product and process innovation (β=0.550).

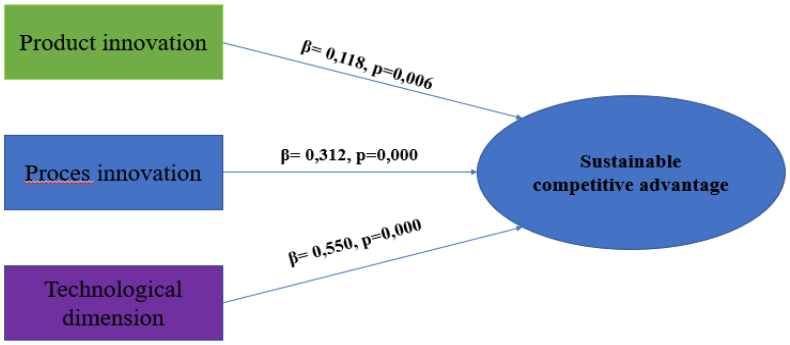
Table 5. Multiple regression analysis

	Sustainable competitive advantage			
Variable	β	T	p	VIF
Product innovation	0.118	2.747	0.006**	3.552
Process innovation	0.312	5.644	0.000**	3.838
Technological dimension	0.550	12.163	0.000**	3.904
	R^2 = 0,870; F = 554,139 (p=0,00 < 0,01)			

Source: Author's research

** The value is significant at the p < 0.01 level

Figure 1. Results of the regression analysis



Source: Author's research

After examining the main effects of the independent variables (product innovation, process innovation, technological dimension) on sustainable competitive advantage, interaction effects were also determined. For this purpose, a moderation regression

analysis was conducted, with the technological dimension used as the moderator. The results of the moderation regression analysis are shown in Table 6. The results indicate that 88.7% of the variability in sustainable competitive advantage is explained by this regression model, as evidenced by the coefficient of determination value of $R^2 = 0.887$. This value is significant at the 0.01 level. The VIF coefficient value indicates that multicollinearity does not occur.

The technological dimension has a statistically significant negative moderating effect on the relationship between product innovation and sustainable competitive advantage ($p=0.003 < 0.01$), as indicated by the negative β coefficient value ($\beta=-0.147$). This means that as the technological dimension strengthens, the relationship between product innovation and sustainable competitive advantage weakens (for example, if a company does not frequently introduce new product lines, there will still be a competitive advantage due to the strength of the existing technological dimension).

The results further show that the technological dimension has a statistically significant positive moderating role in the relationship between process innovation and sustainable competitive advantage ($p=0.000 < 0.01$), with a positive β coefficient value ($\beta=0.272$). This indicates that as the technological dimension strengthens, the relationship between process innovation and sustainable competitive advantage also strengthens.

Table 6. Moderation regression analysis

	Sustainable competitive advantage			
Variable	β	t	p	VIF
Product innovation	0.633	13.769	0.000**	4.609
Process innovation	0.056	1.065	0.288	5.936
Technological dimension	0.391	6.870	0.000**	5.061
Technological dimension * Product innovation	-0.147	-2.966	0.003**	5.358
Technological dimension * Process innovation	0.272	5.854	0.000**	4.707
	$R^2 = 0,887$; F = 387,573 (p <0,01)			

Source: Author's research

** The value is significant at the $p < 0.01$ level

Conclusions

The analysis of the results determined that product, process, and technological innovations have a statistically significant positive impact on sustainable competitive advantage. Product innovations contribute to increased market share and customer loyalty by introducing new and improved products. Process innovations enhance cost efficiency and operational effectiveness, leading to a stronger competitive position. The technological dimension, on the other hand, not only directly influences competitive advantage, but also has a moderating effect on the relationship between product and

process innovation and sustainable competitive advantage. These findings highlight the importance of continuous investment in technological advancements as a strategic approach to maintaining and enhancing competitive advantage.

The theoretical implication of the study involves gaining new insights into the field of innovation and sustainable competitive advantage, contributing to a better understanding of the synergistic effect of product, process, and technological innovations on competitive advantage. The originality of this research lies in acquiring new knowledge about the moderating role of the technological dimension, specifically whether the technological dimension alters the strength of the relationship between innovations and the sustainable competitive advantage of manufacturing companies.

The obtained results provide practical recommendations for business owners and managers, emphasizing the need for strategic investment in product and process innovations supported by technological advancements. This approach not only enhances competitive positioning but also ensures cost efficiency, market responsiveness, and long-term sustainability.

The study faces limitations in terms of spatial scope, sample size, and the fact that only three types of innovations were considered, despite the existence of various different types of innovations. This indicates that future research could be conducted over a longer period and include a larger sample. Research could also be extended to other regions of the Republic of Serbia. Future studies might include other types of innovations, such as marketing innovations, and incorporate sustainability aspects into the research. Another suggestion for future research is to consider another variable as a potential moderator, such as image.

Conflict of interests

The authors declare no conflict of interest.

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