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AI ASSISTED ECONOMIC ANALYSIS OF GREENHOUSE AND OPEN FIELD SWEET PEPPER PRODUCTION

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ABSTRACT

Sweet pepper is a valued vegetable, both among producers and consumers. During the 2017 and 2018 greenhouse experiments and a field trials with different microbiological fertilizers were used to analyze the yields and profitability of sweet pepper production. Contrary to the yields obtained in the greenhouse (14.23 and 13.42 t/0.1ha), the yields in the open field had significantly lower values (4.324 and 4.877 t/0.1ha). Also, the key difference is in the number of realized harvests and their dynamics during the production season which is also connected to market prices and profit. The coefficients of cost-effectiveness were 1.88 and 1.99 in the greenhouse, and 1.39 and 1.45 in the open field, in 2017 and 2018 respectively. Producers should be opted to the greenhouse production because of the higher yields and number of harvests outside the main season, when product prices are higher.

Introduction

Regardless of the time frames, it is considered that pepper (*Capsicum annuum* L.) reached the Old World, especially Europe and Asia, from the region of original domestication, Mesoamerica and the Andes (Tripodi et al., 2021). Between 16th and 18th century, the cultivation of pepper, predominantly chilly varieties, spread rapidly

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from Spain thru the neighboring countries, and chilies became popular in the whole Europe and Asia. Previously, cultivation was promoted rapidly because chilly varieties were cheaper substitute for expensive black pepper spice (Madala & Nutakki 2020). In recent decades, the selection of peppers is increasingly focused on the creation of new sweet pepper varieties with a higher yield, which is often related to the thickness of the pericarp fruit and other characteristics with which they are correlated (Danojević et al., 2016). Except for the shape of the fruit and the taste (spicy and sweet varieties), the main difference between the genotypes is the time of harvesting, i.e. maturation, especially technological maturation. Some varieties are harvested at the stage of technological maturity (yellow or pale green color of the fruit, or dark green exceptionally for some foreign markets) and those that are grown for harvesting at the stage of biological maturity (red or orange color of the fruit). In the case of varieties that are harvested in the stage of technological maturity, a greater number of partial harvests are performed, which are more frequent in terms of dynamics. In this way, a larger number of fruits per plant is produced and, therefore, a higher yield in case the harvesting costs do not exceed the earnings (Lin et al. 2009; Jang et al., 2023).

At the same time, the technology of pepper cultivation was improved, and one of the main directions of development is pepper cultivation in a controlled environment (protected area). Protected areas include glasshouses and plastic greenhouses. Greenhouses represent an expensive investment, however, with some species it is possible to achieve, under certain conditions, up to 10 times higher yields during the year, comparing to average yields of open field production (Marcelis et al., 2019).

Despite the inefficient use of energy and materials (from the ecological point of view), production in the greenhouses area is increasingly expanding due to the high price of products that are achieved outside the regular ripening season of cultivated species (Farfan et al., 2019; Marcelis et al., 2019; Naderi et al., 2019). Using a remote sensing, around 3019 million hectares in the world are marked as an area covered with plastic materials. This includes mulched fields and greenhouses, as well as facilities intended for other agricultural and non-agricultural purposes (Jimenez-Lao et al., 2020). More than 80 % of these areas are placed in China. Some other data suggested that within the 2000–2020 period, the area covered by agricultural plastic greenhouses in China expanded from 159,466.0 to 1,183,877.0 ha (Liu & Xin, 2023). According to some other sources, about 586,000.0 ha globally was under plastic greenhouses (Lamont, 2009) and total global area covered by greenhouse vegetables was approximately 5.6 million ha in the year 2018, with 4.67 million ha or 83% only in China (Qasim et al., 2021; Pantović et al., 2026).

In Serbia, areas under greenhouse production are significantly smaller and, according to some estimates, they were around 5,000 ha in 2017, with a tendency for a slight increase (Červenski et al., 2020). In the course of the last 10 years, pepper production has been carried out on 9915 to 17386 ha (open field and greenhouses), with a tendency to decrease the area under this crop. Contrary, the yields were with slight tendency of increment during the last decade, with average value of 11.96 t/ha (SORS 2024) and

with an illogically large difference compared to experimental results in recent research (Pavlović et al., 2010; Parađiković et al., 2011; Praća et al., 2014; Parađiković et al., 2013; Adžić et al., 2023).

Modern pepper production in the open field and in greenhouses in the agroecological conditions of Southeastern Europe can be very profitable. Recent research indicates that by choosing new varieties and applying the most modern agrotechnical measures, high yields and profit can be achieved (Pavlović et al., 2010; Parađiković et al., 2011; Parađiković et al., 2013; Adžić et al., 2023; Georgiev, 2025; Avakumović & Avakumović, 2025; Jang et al., 2023). Although the yields that can be achieved are very often much more above the world average, product prices are correct for most of the season, and thus the potential profit is at a satisfactory level, producers timidly decide to produce pepper on larger areas, primarily because of the large investments per unit of area and on the other hand, due to the great risk involved in the production of sweet pepper. The fact that even seemingly insignificant errors can significantly reduce yields and thus put the entire production into question must not be overlooked.

During the same period worldwide, an innovative technology (artificial intelligence AI) is included in almost all human activities, including food production, i.e. research activities related to agricultural products (Sánchez et al., 2020; Jung et al., 2021).

The aim of the work is to determine more efficient and profitable sweet pepper production systems, with the help of readily available artificial intelligence tools. The parameters for the required analysis were obtained by an experimental trial in which the influence of various cheap microbiological fertilizers in the production of sweet pepper (in the greenhouse and open field) on the height of the yield and the time of harvest was examined, in order to evaluate the economic profitability of the new integral methods.

Materials and methods

Open access artificial intelligence tool (ChatGPT 3.5, 2024) was used as an assistance in the selection of the activities that need to be applied in order to calculate the profitability and effective way of improvement of pepper production in the protected area and in the open field. Considering the implementation of those measures, only affordable agrotechnical procedures of yield improvement were taken into account. For the purposes of this work, in order to rate the yields and profitability of integral sweet pepper production, an earlier performed greenhouse experiment (2016-2018) was used as well as the results from the open field experiment performed a year later. The data collected from the mentioned experiments and local producers were used for calculations. The first experiment was set up in the greenhouse of the Secondary Agricultural School in Bačka Topola, located at the school's demonstration farm (N: 45°47'41", E: 19°35'58", 93m above sea level). It is an high block greenhouse covered with plastic film with usable soil surface of about 800 square meters. The three-year experiment included two treatments with different microbiological fertilizers (EM active and Vital Tricho) and control in three repetitions. Yellow sweet pepper cultivar

Blondy F1 (Syngenta; S&G Vegetables) was grown. A number of quantitative and qualitative indicators were monitored, but for the purposes of this work, only yield and harvest time for different treatments were used in order to evaluate the economic profitability of new integral methods of pepper production in tall block greenhouses. Except microbiological fertilizers all agrotechnical measures were applied, as with other producers (tillage, application of basic farmyard manure, placement of plastic mulch film, transplanting, watering, basic chemical protection, tying, harvesting) and according to contemporary cultivation techniques (Kelley et al. 2009). Collected data concerning pepper yields were analyzed using an ANOVA method (STATISTICA 10), and LSD test was performed.

In a two-year trial in an open field, in the immediate vicinity, peppers were grown in approximately identical conditions, except for those that are tied to a protected area (greenhouse). The results of this two-years trial were used as a control and compared with the results collected during the last two years of the greenhouse trial (2017-2018). Among the 43 selected vegetable producers who had pepper production on an area larger than 0.2 ha in an open field or in an open field and in a greenhouse simultaneously, 4 of them who grow sweet pepper (of the same variety) on the open field and who applied agrotechnical measures and irrigation comparable to the experimental environment of the greenhouse in Bačka Topola were selected. Average yield values from the second experiment and from the selected subcontractors and producers were calculated for comparison. The list of subcontractors of the Institute for Vegetable Crops Smederevska Palanka was used for these purposes as well as contacts achieved through the network of Agricultural Advisory and Expert Services under the authority of the Institute for the Application of Science in Agriculture (IASA) (<https://www.psss.rs>).

Greenhouse and open field sweet pepper production costs per area unit were collected thanks to the accounting values of the Institute for Vegetable Crops Smederevska Palanka and the publication of the Cooperative Union of Vojvodina Price list of machinery services in agriculture 2018 as well as via interview of Secondary Agricultural School's staff and local sweet pepper producers. The cost of greenhouse construction and plastic sheeting were calculated by dividing their market prices (and accounting values) by the predicted lifetime expressed in years (Table 1), according to previous trials concerning greenhouse vegetable production (Pavlović, 2014).

The economic analysis has been performed using a method of analytical calculations for the purpose of determining the costs and calculating basic indicators of the profitability of production for the pepper in the open field and greenhouse production, i.e. the total costs (EUR), value of pepper production (EUR/0.1 ha), cost price (EUR/kg), financial results (EUR/0.1 ha), border of profitability i.e. break-even analysis (kg/0.1 ha), business rate of profitability i.e. return on investment (ROI) (%) and coefficient of cost-effectiveness (e) (Bošnjak & Rodić 2010; Pavlović et al., 2010; Pavlović et al., 2014).

Serbian Agriculture Market Information System was used to obtain information about pepper prices on the wholesale market, during the 2017 and 2018 production seasons.

(STIPS 2024). The Monte Carlo method (Johansen et al., 2010) was used to calculate the selling price, as stated in previous research (Mladenović et al., 2016). The calculation was performed with the help of Excel 2007 using the function $=NORM.INV(RAND(),M,STDEV)$ via 100 iterations for each value, where M are the mean sales price at a given time (STIPS 2024) and STDV is the standard deviation of sales prices (Yen, 2024).

Results and Discussion

In agriculture, the search for higher net profit, particularly the decrease of expenses and the total income increase, is the main challenge in the economy of the producer. (Padrón et al., 2016). According to AI assistance's step-by-step guide on how to predict financial results in open field and greenhouse pepper production, the prediction of profit in sweet pepper production is based on analysis of various factors that affect both costs and revenue via already performed trials (ChatGPT, 2024). On the base of collected data and results of performed trials, significantly higher costs were generated in the production of peppers in greenhouses. During 2017, the costs of greenhouse pepper production were 3757.0 euro/0.1ha (37570.0 euro/ha). In the same year, production costs per unit area in the open field were 1509.2 eur/0.1ha (15092.0 eur/ha). Production costs in 2018 were higher and amounted to 4631.3 eur/0.1 ha for production in the high block plastic greenhouse, i.e. 1733.9 eur/0.1 ha for production in an open field. As the majority of production inputs, originating from imports, the increase in their prices and trade margins influenced the growth of the costs of their use in 2018. (Table 1).

Table 1. Costs of greenhouse and open field sweet pepper production per area unit (EUR/0.1 ha) for two consecutive seasons (2017-2018)

Costs	Greenhouse (Eur/0.1 ha)		Open field (Eur/0.1 ha)	
	2017	2018	2017	2018
Fixed costs				
Taxes and rents	15.8	15.6	15.8	15.6
Local administration taxes	5.2	7.4	5.2	7.4
GH construction - amortization	1367.0	1367.0	0.0	0.0
Plastic cover - amortization	185.0	193.7	0.0	0.0
Irrigation pipes and tapes	74.0	88.6	74.0	88.6
Insurance and banking services	189.6	212.2	78.6	98.3
Variable costs				
Tillage and soil preparation	41.1	48.9	22.4	28.7
Fertilizers	122.7	158.0	122.7	158.0
Irrigation	165.0	183.1	133.2	156.1
Plastic mulch film	64.4	72.1	64.4	72.1

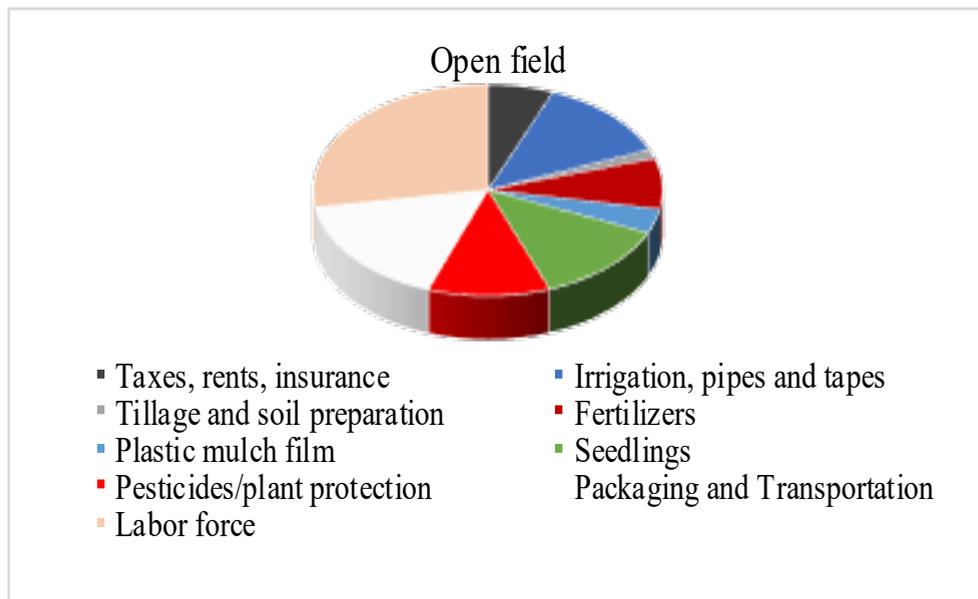
Costs	Greenhouse (Eur/0.1 ha)		Open field (Eur/0.1 ha)	
	2017	2018	2017	2018
Seedlings	1595.5	1904.0	203.4	255.5
Ropes, nets and ties	163.4	175.1	0.0	0.0
Pesticides/plant protection	164.7	182.4	189.3	220.0
Packaging	331.3	342.5	102.7	115.8
Transportation	398.9	450.2	191.1	202.7
Labor force	710.0	765.0	480.0	525.0
Total costs	3757.0	4631.3	1509.2	1733.9

The significant difference between the costs of pepper production in the open field and in the greenhouse was made by the additional costs of depreciation of greenhouse construction (1367.0 and 1367.0 Eur/0.1 ha i.e. 0.0 and 0.0 Eur/ha respectively for 2017 and 2018 growing season) and plastic film foil (185.0 and 193.7 Eur/0.1 ha i.e. 0.0 and 0.0 Eur/ha respectively for 2017 and 2018 growing season). On the other hand, although watering in a protected area is necessary to compensate for precipitation that occurs during vegetation in an open field, the difference in irrigation costs is not significantly higher because in the greenhouse, electricity was available, which as a source of energy is cheaper compared to fossil fuels that were used to run water pumps in the open field where there were no other options.

The production costs of sweet peppers were very high and in the presented research they were significantly higher even compared to the production of peppers in the open field in the organic production system (Pavlović et al., 2010), which can be partly attributed to the difference caused by multi-year inflation. In the structure of production costs, there is also a discrepancy with the results of some previous researches that related to the production of peppers in the open field or the production of other vegetables in the greenhouse conditions (Pavlović et al., 2010; Pavlović et al., 2014; Petrović et al., 2021).

When it comes to particular costs share for the open field production, labor costs accounted for the largest share of the total costs of sweet pepper production (31.0%). The costs share of packaging and transportation (18.9%), transplants acquisition (14.2%), pesticides and plant protection costs share (12.6) and irrigation costs share (14.2%), were slightly lower but still very significant (Figure 1).

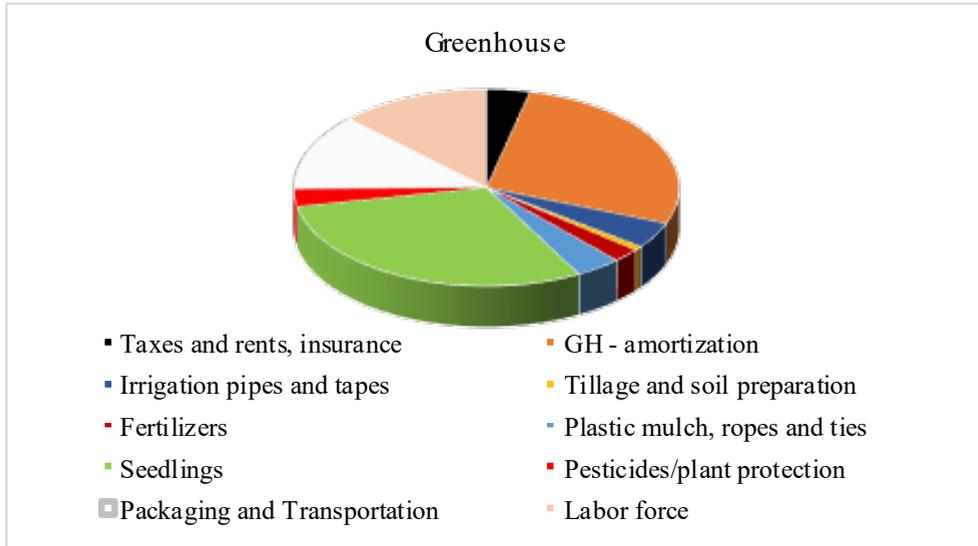
Figure 1. Average share of costs (%) of the open field production for examined period (2017-2018)



Source: Daw E., 2024

Depreciation costs of greenhouse and plastic film, as expected, accounted for a significant portion of the costs of pepper production in greenhouses (23.66%). A no less share, and possibly a higher (depending of the moment of procurement), in the total costs also belonged to the procurement of transplants (up to 29.84%), which in the late winter and early spring period has a significantly higher price comparing to late spring procurement (especially for the open field production). Since the high level of depreciation costs and transplant cost shares, the shares of labor force (12.7%) and packaging and transportation costs (12.53%) were relatively low. The share of every other cost was less than 5% (Figure 2). It was a little bit different ratio compared to previous research (Pavlović et al., 2010), probably due to inflation and changes in the labor market.

Figure 2. Average share of greenhouse production costs (%) for examined period (2017-2018)



Source: Daw E., 2024

As a result of the experimental activities in the greenhouse, statistically significant differences were recorded by microbiological treatments and year (Table 2). Higher yields were achieved in the treatments compared to the control without microbiological fertilization.

Table 2. The analysis of variance for pepper yield per unit area in greenhouses during the experimental period (2016-2018)

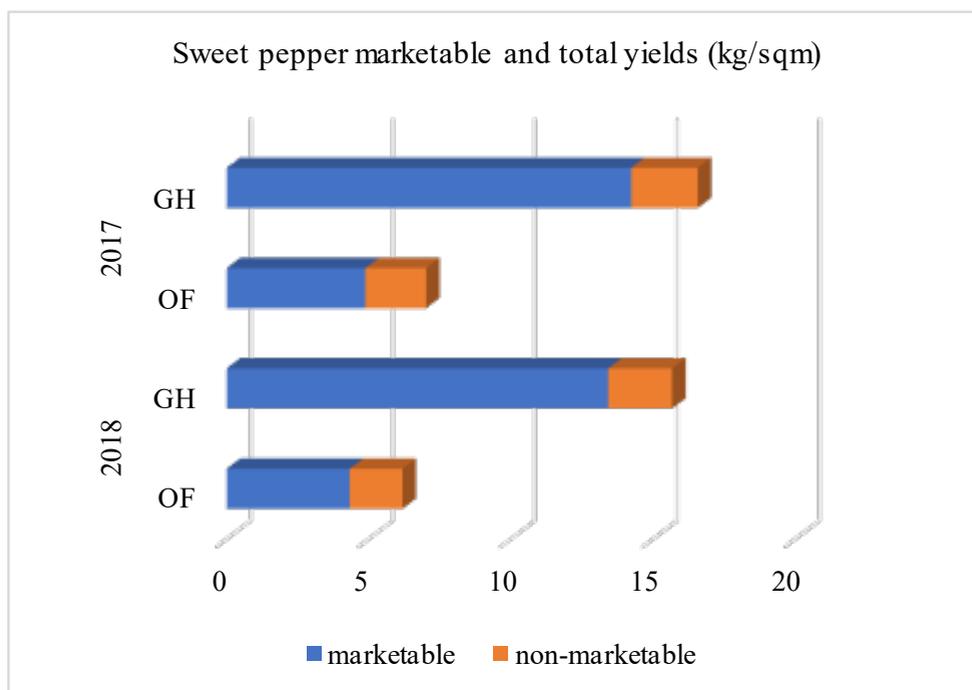
Source of variation	degrees of freedom	Sums of squares	Mean squares	F value	p-value
Blocks	2	11.152	5.576	1.38	
Year (A)	2	29.191	14.595	3.62	0.041*
Treatments (B)	2	37.15	18.575	4.61	0.026*
Interaction (AxB)	4	5.481	1.37	0.34	0.847 ^{ns}
Error	16	64.533	4.033		
Total	26	147.506			

Source: Daw E., 2024

Total average yields of sweet pepper grown in the greenhouse varied from 14.47 t/0.1ha to 17.81 t/0.1ha for different treatments and seasons with average values of 16.57 t/0.1ha and 15.66 t/0.1ha for 2017 and 2018 growing season respectively. During the same period, average yields of sweet pepper grown in the open field were 6.01 t/0.1ha and 4.98 t/0.1ha. Also lower marketable yields of both production models were

recorded in this period i.e. 14.23 and 13.42 t/0.1ha in the greenhouse and 4.324 and 4.877 t/0.1ha in the open field (Figure 3). Recent research indicated that by choosing suitable varieties and applying the most modern agrotechnical measures and different approach in production, high yields of sweet pepper and higher profit could be achieved (Pavlović et al., 2010; Parađiković et al., 2011; Parađiković et al., 2013; Adžić et al., 2023; Jang et al., 2023). Among the large number of pepper varieties, there are those that are used mainly for processing into local specialties and dishes (which are harvested in the phase of physiological i.e. biological maturity) and those that are used for preparing salad or for pickling (which are harvested multiple times in the phase of technological maturity when the fruits are light green or white to white yellow and still not fully biologically ripe (The variety used for this trial was classified in this group). Using such variety, the recorded yields were contrary to the results of experiments performed in Bosnia (Salkić et al. 2020) and Macedonia (Bogevska et al., 2008) but similar to results of experiments performed with the same variety in the relative vicinity of our experimental field (Parađiković et al., 2011; Parađiković et al., 2013).

Figure 3. Average marketable and nonmarketable yields per area unit (t/0.1ha) in the greenhouse (GH) and open field (OF) for the two experimental seasons (2017-2018)



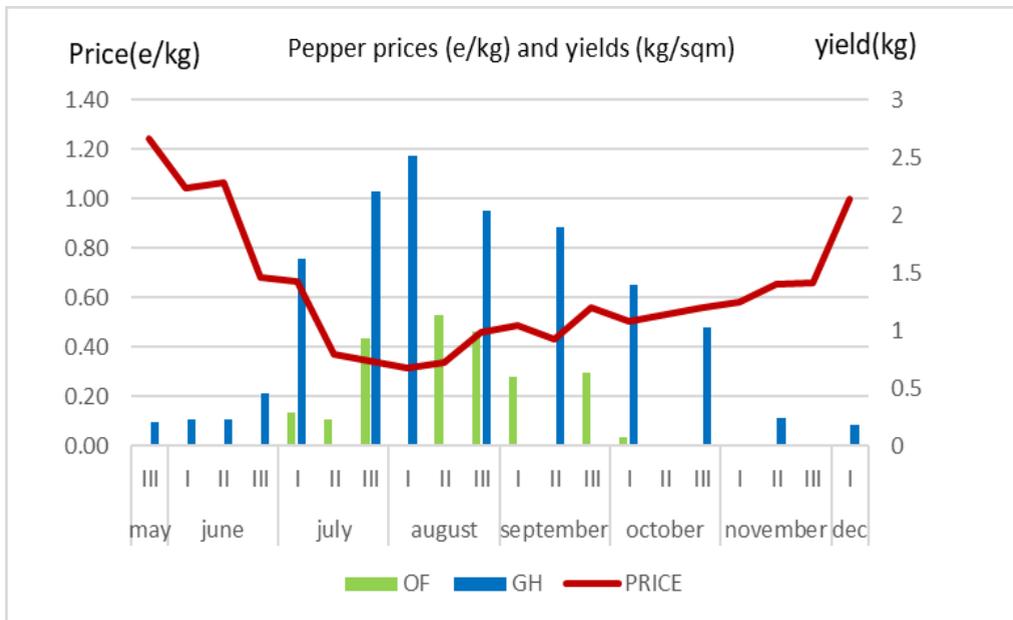
Source: Daw E., personal data, 2024

The prices of sweet pepper as well as other products depend on product's offer and its demand in the market and in the case of fresh sweet pepper market can be characterized as a competitive. That means that no one of growers has production large enough to

influence the market price, and that the price received by growers is due to factors that include consumer demand and supply from other parts of the country and import (McCoy et al., 2013). Since producers cannot significantly influence the average prices of sweet pepper, the only way to increase the financial result, apart from reducing production costs, is to influence the increase in yield.

McCoy et al. (2013) also emphasized the influence of extended season and greater number of harvests in the greenhouse on yield increase. In the production season of 2017, 13 harvests in the greenhouse and 8 in the open field were performed. The highest market price per kilogram of sweet peppers (1.24 euro/kg) was recorded in the third decade of May, when the first harvest in the greenhouse took place (0.22 t/0.1 ha). On the other hand, the lowest price of sweet pepper was in the first decade of August (0.31 euro/kg). In that period, the highest yield harvest was recorded in the open field (1.5 t/0.1 ha). The highest yield harvest in the greenhouse was occurred about 10 days earlier, during the third decade of July (2.57 t/0.1 ha) (Figure 4).

Figure 4. Pepper prices (e/kg) and yields per area unite (kg/sqm) during the 2017 harvest season in the open field (OF) and greenhouse.

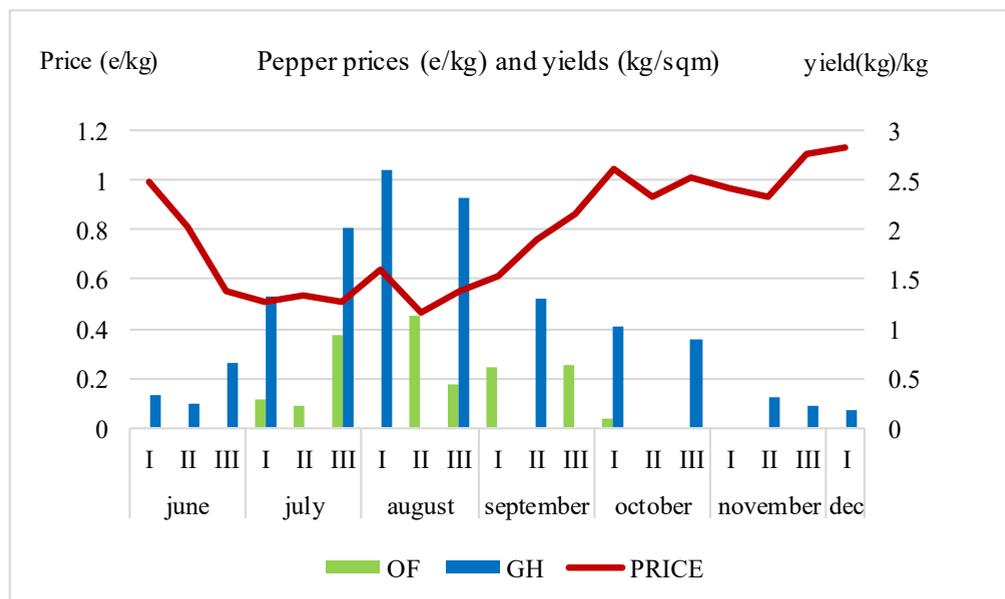


Source: Daw E., personal data, 2024

During the 2018 production season, the same number of harvests were performed in both greenhouse and open field productions. However, the market prices fluctuations were lower, and the highest price of sweet peppers (1.14 euro/kg) was recorded in the first decade of December, when the last and lowest yield harvest in the greenhouse was occurred (0.18 t/0.1 ha). Similarly to the previous season, the lowest prices of sweet pepper were during the summer period, especially during the second decade of August

(0.47 euro/kg). Again during the august, the highest yields harvests were achieved both in the open field (1.13 t/0.1 ha) and in the greenhouse (2.6 t/0.1 ha) (Figure 5).

Figure 5. Pepper prices (e/kg) and yields per area unite (kg/sqm) during the 2018 harvest season



Source: Daw E., personal data, 2024

This arrangement of harvests and marketable yields as well as prices (Figures 4. and 5.), resulted in slightly lower realization prices (0.495, 0.688, 0.43, and 0.58 Eur/kg consecutively for realization prices in the greenhouse in 2017 and 2018 growing season, and the same years in the open field, Table 3.) compared to the average prices of peppers during the production seasons (0.618, 0.787, 0.45, and 0.648 Eur/kg consecutively greenhouse production season in 2017 and 2018, and for the average prices during the open field seasons of both years).

For all analyzed indicators, in both years of research, better results were achieved in greenhouse production. On the other hand, despite lower yields and higher production costs in 2018, better financial results were achieved. In the same time, lower breakeven prices were achieved in the greenhouse (0.26 and 0.35 Eur/kg in 2017 and 2018 respectively) comparing to open field (0.31 and 0.40 Eur/kg in 2017 and 2018 respectively). On the contrary, higher values of the border of profitability were achieved in the greenhouse production (7585.3 and 6729.11 kg/0.1 ha in 2017 and 2018 respectively) comparing to the open field production (3509.76 and 2987.1 kg/0.1 ha). Higher values of this parameter are related to greenhouse production due to the significantly higher costs of this type of production, primarily in terms of depreciation of the greenhouse construction and plastic film for the cover (Table 3.).

In the end, the true result of production is best described by parameters such as Business rate of profitability and Coefficient of cost-effectiveness. In the presented research, the Business rate of profitability was 46.70 and 49.87% in 2017 and 2018 in the greenhouse. In the same period, the values of this parameter were 28.03 and 30.92% in the open field production. In the Greenhouse, the Coefficient of cost-effectiveness values were 1.88 and 1.99 in 2017 and 2018, respectively. At the same time, the values of this parameter in pepper production in the open field were 1.39 and 1.45 (Table 3.). The values of the Business rate of profitability and Coefficient of cost-effectiveness stated by Pavlović et al. (2010) for the production of organic peppers in the open field were 43.33% and 1.76, while for the salad cucumbers in the protected area were 18.9% and 1.23 (Pavlović et al., 2014).

Table 3. Costs of greenhouse and open field sweet pepper production per area unit (EUR /0.1 ha) for two consecutive seasons (2017-2018)

	Greenhouse (Eur/0.1 ha)		Open field (Eur/0.1 ha)	
	2017	2018	2017	2018
Total costs (Eur/0.1 ha)	3757	4631.3	1509.2	1733.9
Yields (kg/0.1 ha)	14231	13422	4877	4324
Average price (Eur/kg)*	0.495	0.688	0.43	0.58
Income (Eur/0.1 ha)	7048.61	9237.68	2097.11	2509.92
Financial result (Eur/0.1 ha)	3291.61	4606.37	587.9	776.02
Breakeven price (Eur/kg)	0.26	0.35	0.31	0.40
Border of profitability (kg/0.1 ha)	7585.3	6729.11	3509.76	2987.1
Business rate of profitability (%)	46.70	49.87	28.03	30.92
Coefficient of cost-effectiveness	1.88	1.99	1.39	1.45

As stated by some researchers, modern sweet pepper production in the greenhouse and open field in the agroecological conditions of Southeastern Europe can be very profitable (Lončarić et al., 1999; Parađiković et al., 2013). However, the highest demand for sweet pepper in Serbia was in the late summer, early and mid-autumn for decades. In the last few decades, with better and long-lasting offers on the market, demand is increasing each season. When it comes to pricing, there is an upward trend in prices, but this is related to the extension of the supply period and high off-season prices when only imported sweet pepper is available on the market. During the season, the highest prices are in the late winter early spring period when only imported sweet pepper is available (SORS, 2024). During the period when greenhouse sweet pepper from domestic production is available, the prices are slightly lower but still relatively high. As a rule, the lowest prices are in the middle and at the end of summer, as well as at the beginning of autumn, when peppers produced in the open field are widely available on the market.

Conclusions

The production of sweet pepper is associated with high costs and investments. Sweet pepper prices are highest in spring and late autumn, while they are lowest in mid-summer. As it is impossible to significantly and directly influence the price on the market and its fluctuation, the producers have to gain higher yields, as well as to extend the supply season and try to aim the maturation of the products at a time when the price of sweet peppers on the market is higher. According to achieved values of business rate of profitability and coefficient of cost-effectiveness, the sweet pepper production is profitable regardless of whether the production is performed in an open field (on average 29.47% and 1.42) or in a greenhouse (on average 48.28% and 1.94). Based on the results of the research, it can be concluded that sweet pepper producers should be opted to the production of pepper in a greenhouse because of the high yields that can be achieved outside the main season, when product prices are significantly higher, and by 194% (total greenhouse yield for the test period 16.14 t/0.1ha) compared to production in the open field (5.49 t/0.1ha). However, every other sweet pepper production season can have different production costs (starting from the costs of greenhouses, seeds or seedlings, up to the establishment of yield dynamics, packaging and transport), which adversely affects accurate cost forecasting, creating the need for further research and analysis. sensitivity. Different production inputs whose prices change from year to year (eg fuel, pesticides, fertilizer) have an influence on the change in costs. In this regard, it is necessary to define integral methods of plant production and protection according to different production systems and the needs of production seasons, which favorably affect high, healthy and stable yields, so that the product is constantly available on the market.

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Conflict of interests

The authors declare no conflict of interest.

References

1. Adžić, S., Cvikić, D., Živković, I., Šević, B., Pavlović, N., Rakić, I., & Đurić, N. (2023). Ekonomska opravdanost proizvodnje semena paprike. *Zbornik radova: Nacionalni naučni skup sa međunarodnim učesćem Biotehnologija i savremeni pristup u gajenju i oplemenjivanju bilja*, Smederevska Palanka 2. novembar, 60-69. <https://rivec.institut-palanka.rs/handle/123456789/725>

2. Avakumović, J., & Avakumović, J. (2025). Digitalno marketing i „VI“ u digitalnom okruženju. *Finansijski Savetnik*, 30(1), 7-39. <https://fa-journal.com/index.php/fa/article/view/1>
3. Bogevska, Z. V., Trpeski, V., Jankulovski, D., Dimovska, M., & Agic, R. (2008, September). Bio-stimulating effect of some fertilizers on the yield of pepper. In *IV Balkan Symposium on Vegetables and Potatoes* 830, 651-656. <https://doi.org/10.17660/ActaHortic.2009.830.94>
4. Bošnjak, D., & Rodić, V. (2010). Economic analysis of soybean production in Vojvodina. *Ratarstvo i povrtarstvo/Field and Vegetable Crops Research*, 47(1), 193-202. <https://scindeks-clanci.ceon.rs/data/pdf/1821-3944/2010/1821-39441001193B.pdf>
5. Červenski, J., Medić-Pap, S., Danojević, D., Savić, A., & Bugarski, D. (2020). The importance of crop rotation in Intensive vegetable production in a greenhouse. *Journal of Agricultural Sciences (Belgrade)*, 65(3), 199-212. <https://doi.org/10.2298/JAS2003199C>
6. ChatGPT 3.5 (2024) <https://chat.openai.com/> (accessed: 17.03.2024)
7. Danojević, D., Medić-Pap, S., Savić, A., & Červenski, J. (2016). Fruit traits of pepper genotypes originating from open pollination. *Ratarstvo i povrtarstvo/Field and Vegetable Crops Research*, 53(2), 69-73. <https://doi.org/10.5937/ratpov53-9761>
8. Farfan, J., Lohrmann, A., & Breyer, C. (2019). Integration of greenhouse agriculture to the energy infrastructure as an alimentary solution. *Renewable and Sustainable Energy Reviews*, 110, 368-377. <https://doi.org/10.1016/j.rser.2019.04.084>
9. Georgiev, M. (2025). Examining the correlation between cloud technology, the improvement of IFRS development, and the efficiency of accounting functions. *BizInfo Blace*, 16(2), 75-84. <https://doi.org/10.71159/bizinfo250017G>
10. Jang, W. D., Jeon, S. J., Choi, K. Y., & Na, J. K. (2023). Evaluation of the Growth and Yield Characteristics of Six Domestic Sweet Pepper Cultivars. *Horticultural Science and Technology*, 41(3), 271-284. <https://doi.org/10.7235/HORT.20230025>
11. Jimenez-Lao, R., Aguilar, F. J., Nemmaoui, A., & Aguilar, M. A. (2020). Remote sensing of agricultural greenhouses and plastic-mulched farmland: An analysis of worldwide research. *Remote Sensing*, 12(16), 2649. <https://doi.org/10.3390/rs12162649>
12. Johansen, A. M., Evers, L., & Whiteley, N. (2010). Monte carlo methods. *International encyclopedia of education*, 296-303. <https://people.bordeaux.inria.fr/pierre.delmoral/teaching-notes-levers-johansen.pdf>
13. Jung, J., Maeda, M., Chang, A., Bhandari, M., Ashapure, A., & Landivar-Bowles, J. (2021). The potential of remote sensing and artificial intelligence as tools to improve the resilience of agriculture production systems. *Current Opinion in Biotechnology*, 70, 15-22. <https://doi.org/10.1016/j.copbio.2020.09.003>

14. Kelley, W. T., Boyhan, G. E., Harrison, K. A., Granberry, D. M., Langston, D. B., Sparks, A. N., Culpepper S., Hurst W. C. & Fonsah, E. G. (2009). *Commercial pepper production handbook*, University of Georgia, SAD. <https://hdl.handle.net/10724/12339>
15. Lamont, W. J. (2009). Overview of the use of high tunnels worldwide. *HortTechnology*, 19(1), 25-29. <https://doi.org/10.21273/HORTTECH.19.1.25>
16. Lin, W. C., Frey, D., Nigh, G. D., & Ying, C. C. (2009). Combined analysis to characterize yield pattern of greenhouse-grown red sweet peppers. *HortScience*, 44(2), 362-365. <https://doi.org/10.21273/HORTSCI.44.2.362>
17. Liu, X., & Xin, L. (2023). Spatial and temporal evolution and greenhouse gas emissions of China's agricultural plastic greenhouses. *Science of The Total Environment*, 863, 160810. <https://doi.org/10.1016/j.scitotenv.2022.160810>
18. Lončarić, Z., Teklić, T., Lončarić, R., Vidović, I., & Jug, D. (1999). The plant population influence on yield and market price influence on profit of high tunnel grown bell pepper. *Poljoprivreda*, 5:53-59.
19. Madala, N., & Nutakki, M. K. (2020). Hot pepper-history-health and dietary benefits & production. *International Journal of Current Microbiology and Applied Sciences*, 9(4), 2532-2538. <https://doi.org/10.20546/ijcmas.2020.904.303>
20. Marcelis, L., Costa, J. M., & Heuvelink, E. (2019). *Achieving sustainable greenhouse production: present status, recent advances and future developments*. In L. Marcelis, & E. Heuvelink (Eds.), *Achieving sustainable greenhouse cultivation* (1 ed., pp. 1-14). Burleigh Dodds Science Publishing.
21. McCoy, S. R., Hochmuth, R. C., Laughlin, W. L., Gazula, A., & Fenneman, D. K. (2013). Economic analysis of fresh green bell pepper (*Capsicum annuum*) production under shade structures. In *Proceedings of the Florida State Horticultural Society*, 126, 101-106. https://svaec.ifas.ufl.edu/media/svaecifasufledu/docs/pdf/agribusiness/McCoy2013_EconAnalShadePeppers.pdf
22. Mladenović, J., Pavlović, N., Ugrinović, M., Pavlović, R., & Zdravković, J. (2016). Analysis and forecasting of profit by using simulation models for growing pea in conventional and organic plant production in Serbia. *Economics of agriculture*, 63(3), 987–995. <https://doi.org/10.5937/ekoPolj1603987M>
23. Naderi, S. A., Dehkordi, A. L., & Taki, M. (2019). Energy and environmental evaluation of greenhouse bell pepper production with life cycle assessment approach. *Environmental and sustainability indicators*, 3, 100011. <https://doi.org/10.1016/j.indic.2019.100011>
24. Padrón, R. A. R., Swarowsky, A., Schons, A., Cánepa, P., & Gamazo, P. (2016). Economic analysis in bell pepper crop on open field production system and under irrigation depths. *Acta Iguazu*, 5(1), 11-21. (<https://doi.org/10.48075/actaiguazu.v5i1.14190>) <https://e-revista.unioeste.br/index.php/actaiguazu/article/view/14190/9638>

25. Pantović, D., Lojanica, N., Bojnec, Š., & Gričar, S. (2026). Assessing Disparities in Climate and Energy Agri-Environmental Indicators Among EU Countries Using the PROMETHEE–GAIA Method and the Entropy Index. *Agriculture*, 16(4), 463. [;https://doi.org/10.3390/agriculture16040463](https://doi.org/10.3390/agriculture16040463)
26. Parađiković, N., Vinković, T., Vinković Vrček, I., Žuntar, I., Bojić, M. & Medić-Šarić, M. 2011. Effect of natural biostimulants on yield and nutritional quality: an example of sweet yellow pepper (*Capsicum annuum* L.) plants. *Journal of the Science of Food and Agriculture* 91:2146–2152. <https://doi.org/10.1002/jsfa.4431>
27. Parađiković, N., Vinković, T., Vrček, I. V., & Tkalec, M. (2013). Natural biostimulants reduce the incidence of BER in sweet yellow pepper plants (*Capsicum annuum* L.). *Agricultural and food science*, 22(2), 307-317. <https://doi.org/10.23986/afsci.7354>
28. Pavlović, N. (2014). *Personal survey*, Unpublished data, Smederevska Palanka, Serbia.
29. Pavlović, N., Ugrinović, M., & Zdravković, M. (2010). Economic and agronomic analysis of organic production of tomato and pepper. *Economics of agriculture*, 57 (Spec. num. 2), 153-157. https://rivec.institut-palanka.rs/bitstream/handle/123456789/227/bitstream_540.pdf?sequence=1&isAllowed=y
30. Pavlović, N., Ugrinović, M., Vojnović, B., & Rudež, J. (2014). Economic and agronomic analysis of conventional and organic concept of cucumber growing. *Economics of agriculture*, 61(4), 895-902. <https://rivec.institut-palanka.rs/bitstream/handle/123456789/149/146.pdf?sequence=1&isAllowed=y>
31. Petrović, M., Savić, B., & Cvijanović, V. (2021). Financial aspects of pepper (*Capsicum annuum* L) production on family farms in Serbia. *Economics of agriculture*, 68(4), 1015-1028. <https://doi.org/10.5937/ekoPolj2104015P>
32. Prača, N., Krstić, S., & Božić, N. (2024). Vrste i metode povećavanja viška vrednosti. *Održivi razvoj*, 6(2), 35-47. <https://doi.org/10.5937/OdrRaz2402035>
33. Qasim, W., Xia, L., Lin, S., Wan, L., Zhao, Y., & Butterbach-Bahl, K. (2021). Global greenhouse vegetable production systems are hotspots of soil N₂O emissions and nitrogen leaching: A meta-analysis. *Environmental Pollution*, 272, 116372. <https://doi.org/10.1016/j.envpol.2020.116372>
34. Salkić, B., Čerkezović, N., Imširović, E., Aličić, D., & Hodžić, A. (2020). Growing forms of peppers. *World Journal of Biology Pharmacy and Health Sciences*, 3(1), 029-037. <https://doi.org/10.30574/wjbphs.2020.3.1.0045>
35. Sánchez, J. M., Rodríguez, J. P., & Espitia, H. E. (2020). Review of artificial intelligence applied in decision-making processes in agricultural public policy. *Processes*, 8(11), 1374. <https://doi.org/10.3390/pr8111374>
36. SORS (2024) – Statistic Office of Republic of Serbia, <https://data.stat.gov.rs/Home/Result/130102?languageCode=en-US> (Accessed 15.03.2024.)
37. STIPS (2024). Sistem tržišnih informacija poljoprivrede Srbije za 2017. i 2018. godinu. <https://www.stips.minpolj.gov.rs/> (accessed: 20.03.2024.)

38. Tripodi, P., Rabanus-Wallace, M. T., Barchi, L., Kale, S., Esposito, S., Acquadro, A., Schafleitner, R., van Zonneveld, M., Prohense, J., José Dieze, M., Börner, A., Salnier, J., Caromel, B., Bovy, A., Boyacih, F., Pasevi, G., Brandt, R., Himmelbach, A., Portis, E., Finkers, R., Lanteric, S., Paranj, I., Lefebvre, V., Giuliano, G., & Stein, N. (2021). Global range expansion history of pepper (*Capsicum* spp.) revealed by over 10,000 genebank accessions. *Proceedings of the National Academy of Sciences*, 118(34), 1-9, <https://doi.org/10.1073/pnas.2104315118>
39. Yen L. (2024). How to Run a Monte Carlo Simulation in Excel: 5 Key Steps. Datamation. <https://www.datamation.com/big-data/how-to-run-monte-carlo-simulation-in-excel/> (accessed: 20.03.2024.)

SUSTAINABLE BITCOIN MINING

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ABSTRACT

Bitcoin, as a digital payment asset, has brought about a kind of revolution in the global market. Despite its numerous economic benefits, bitcoin mining has a significant negative impact on the environment due to its high electricity consumption during the mining process. With this in mind, the study analyzed the profitability of using green energy, specifically solar energy, for bitcoin mining. Based on the movement of Bitcoin's value over the past 50 months, a comparison was made between the profitability of bitcoin mining using energy from non-renewable and renewable (green) sources. Subsequently, a minimum Bitcoin value was determined at which it becomes necessary to cease further green mining and instead commence the production and sale of solar energy to the utility company. The research also demonstrated that greater profit is achieved solely through supplying solar energy compared to green bitcoin mining.

Introduction

Economic development offers many positive benefits, such as improving living standards and developing new technologies that make life easier. However, most of these advantages have a negative impact on the environment. In the 20th century, the need to align economic development with environmental preservation was recognized

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to prevent disruptions in biodiversity on Earth. It became necessary to establish rules and laws for countries to plan their future development with the goal of environmental conservation. From this idea emerged the concept of sustainable development.

Traditional centralized banking systems often did not provide individuals with significant privacy or the opportunity to achieve financial freedom. The development of new technologies prompted developers to consider creating a digital decentralized value system that could potentially replace traditional banking systems in the future. The development of blockchain technology led to the creation of the first crypto currency called Bitcoin. Today, Bitcoin is considered digital gold and is used worldwide for conducting transactions and purchasing goods and services. However, the biggest criticism of Bitcoin's existence and operation is its significant energy consumption for "mining." This is one of the main reasons why Bitcoin has not yet been widely accepted globally as an official means of payment. The issue of high energy consumption in Bitcoin production can be addressed through "green mining," i.e., using energy from renewable sources for its mining operations.

The subject of this research is green bitcoin mining, the production, and use of solar energy as a renewable energy source (RES) for its mining, aimed at environmental preservation.

The objective of the research is to analyze the profitability of bitcoin mining using renewable energy sources (RES) and to determine the minimum bitcoin price at which selling green energy becomes more profitable compared to green bitcoin mining.

The study utilized specialized literature and all available data related to the concept of sustainable development, as well as information on Bitcoin and blockchain technology. In addition to scholarly literature, official data sources were used regarding the movement of Bitcoin and gold prices, including various credible websites interpreting the data.

The authors will establish the profitability of bitcoin mining using green energy - specifically solar energy - in the course of the research. Profitability will be determined using basic investment indicators such as annual return on investment and payback period. The marginal cost of green bitcoin mining, i.e., the lowest cost at which green bitcoin mining becomes profitable, will also be determined. Following this, the profitability of producing and selling solar energy will be assessed by comparison with the results of green bitcoin mining.

Materials and methods

When determining the cost of building a solar power plant, data from the company "MT Komex" specializing in solar power plant construction were used. For the purposes of green bitcoin mining, a solar power plant with a capacity of 56 kW is required. The construction cost of this power plant amounts to \$180,351 USD. The profitability of investing in green bitcoin mining largely depends on the profitability of the mining machine itself. The annual profit was determined based on the median price of Bitcoin

during the last cycle (January 1, 2020, to March 1, 2024), which amounted to \$31,198 USD. In addition to basic indicators such as investment cost and the profitability of the bitcoin mining machine, consideration must also be given to the annual return on investment (ROI) and payback period (PBP). The annual return on investment (ROI) is determined as follows (Gogić, 2014):

$$ROI = \frac{\text{Annual return on investment}}{\text{Cost of investment}} * 100$$

In addition to ROI, another important indicator is the payback period of investment (PBP). Many investors consider this indicator as one of the main metrics of investment viability. The payback period of investment is determined as follows (Gogić, 2014):

$$PBP = \frac{\text{Cost of investment}}{\text{Annual return of investment}}$$

The Payback Period of Investment (PBP) represents the number of years required for the invested funds to be recovered and is considered one of the more significant indicators to consider when starting an investment. Based on formulas 1 and 2, it follows that PBP is inversely proportional to ROI (Return on Investment), meaning that a higher ROI results in a shorter PBP.

When calculating the costs of electricity consumption, it's important to consider the expenses incurred from mining during the night when the solar power plant isn't generating electricity. According to data from "MT Komex," the solar power plant can produce electricity for an average of about 18 hours per day, while for the remaining 6 hours, electricity would need to be sourced from the grid, incurring costs for the investor. For the calculation of electricity costs, a lower tariff of \$0.0159 USD per kWh was used. To determine the profitability of producing and selling green energy, the feed-in tariff in the Republic of Serbia was considered, which amounts to \$0.17 USD per kWh of delivered electricity⁵. According to the Energy Law⁶, a 56 kW solar power plant is classified as a small solar power plant.

Additionally, for calculating certain performance metrics in the research, descriptive and comparative methods will be employed, along with mathematical and statistical methods.

5 Uredba o tržišnoj premiji i fid-in tarifi. "Službeni glasnik RS", br. 45/2023-11, br. 90/2024-3 dr. uredba, Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2023/45/3/reg>

6 Zakon o energetici. "Službeni glasnik RS", br. 145/2014, 95/2018 - dr. zakon, 40/2021, 35/2023 - dr. zakon, 62/2023., Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/skupstina/zakon/2014/145/1/reg>

The concept and importance of sustainable development

The concept of sustainability dates back long before the concept of sustainable development. Many theoreticians were interested in the concept of sustainability because they realized that the progress of society and the development of new technologies cannot be sustainable in the long term. Some early theorists proposed that zero economic and population growth might be necessary to ensure long term sustainability. After the Second World War, there was an accelerated development of almost all world economies, and the greatest importance is attached to scientific and technological progress, which was considered to be unlimited. However, various unexpected events, such as the oil crisis from the 1970s have shown that scientific and technological progress is very limited and that economic growth cannot rest solely on it. The rapid development of agriculture and all industrial branches has led many theoreticians to think about the impact of economic growth and development on the environment.

The concept of sustainable development is not easy to define, because it represents “living matter” that is constantly changing, supplementing and innovating. Also, some criteria used to define the concept of sustainable development are difficult to measure, which is another obstacle when making the final definition. Throughout history, many theoreticians have tried to define the concept of sustainable development, however, that definition was never complete for the previously mentioned reasons. A generally accepted definition that is most used today is the definition of the Brundtland Commission from 1987, which states that sustainable development is the development that satisfies the present needs, without jeopardizing the ability of future generations to meet their own needs (WCED, 1987). Pešić (2020) defines sustainability as an essential prerequisite, but also as the ultimate goal of the efficient organization of numerous human activities on Earth. Derlukiewicz et al., (2020) see sustainable development as a strategic trend that unites socio-economic development and global environmental protection. According to (Emas, 2015), the general goal of sustainable development is the achievement of ecological stability, which is achievable through the integration and appreciation of economic, social and ecological aspects in the decision-making process. Sustainability has a wide application in various disciplines such as agricultural production, business operations, urban development and represents the conceptual basis for the principles of green and circular economy (Ruggerio, 2021).

Sustainable development is a multidimensional concept that includes three different segments: (1) economic, (2) social and (3) environmental. In other words, progress in one dimension depends on achievement in the other two (Stevens, 2011). Economic productivity, for example, will be impaired if there is an imbalance in the social and environmental segments. Effective implementation of this concept implies defining and achieving various goals of sustainable development. During 2015, the General Assembly of the United Nations defined a total of 17 goals, which essentially represent the concretization of the mentioned dimensions (Bargier & Burgess, 2017). Each of the goals should have the following specificities: (1) be precisely defined, (2) measurable, (3) achievable, (4) realistic, (5) and time-bound

(Jovanović Gavrilović, 2008). Achieving goals implies coordination of various activities of participants and stakeholders (inhabitants, companies, organizations), and the necessary institutional support.

In this regard, we distinguish between ecological, social and economic goals of sustainable development. For example, the economic goal implies achieving economic growth without increasing inflation and increasing foreign debts. Social means reducing and completely eliminating poverty, as well as reducing social exclusion and solving all kinds of social problems. The ecological goal refers to spreading awareness of the importance of environmental preservation and achieving sustainability in the use of natural resources with emphasis on the increasing use of renewable energy sources (Pešić, 2020). Sachs et al. (2018) created the SDG index (Sustainable Development Goals – SDG) in order to monitor the implementation and achievement of overall sustainability in different countries in the world. This unique indicator enables simpler definition of priority areas for actions, and facilitates global comparison and benchmarking of economies (Fonseka et al., 2020).

In general, the long-term concept of sustainable development implies constant economic growth that ensures poverty reduction, better management of resources, improvement of health conditions and quality of life, reduction of pollution and preservation of biodiversity. Sustainability as such is based on education, Research and development (R&D), digital society and low-carbon economy, contributes to higher employment on the one hand, and a more equal social position of different groups on the other.

Solar energy as a renewable energy source

There are several different classifications of natural resources in the literature, but one generally accepted classification involves the division of resources into renewable resources and non-renewable resources (Pešić, 2012). Non-renewable sources of energy can include various mineral resources such as metals and non-metals, crude oil, natural gas and others. High level of economic growth leads to high level in consumption of non renewable energy and *vice versa* (Salim et al., 2014). In another words, non renewable sources remain the main driving force behind industrial output and real GDP growth. For example, electricity is produced using coal in a large number of countries⁷, which has a pronounced negative effect on the environment and climate change issues.

⁷ For example, in Serbia around 70% of electricity is obtained from the coal in thermal power plants (source: www.eps.rs, 3.6.2025.)

In particular, the accumulation of ash produced by burning coal in thermal power plants leads to soil degradation, air pollution, negative impact on human health and a large carbon footprint⁸ in the form of greenhouse gas (GHG) emissions.

As previously stated, one of the goals of sustainable development is achieving sustainability in the use of natural resources as well as the transition to the use of renewable energy sources (RES). The term renewable energy sources (RES) is associated with the fact that the rate of consumption of these resources does not exceed the rate of their creation. Renewable resources can be divided into natural biological funds, such as fish in open water or forests, and energy flows such as solar energy, wind energy, tides, etc. (Pešić, 2012). Also, RES include hydropower, geothermal energy and biomass. Some authors (Goodstein, 2003) believe that three renewable resources have the greatest potential: solar, hydropower and wind energy.

The use of RES is significant for several reasons. First, greater use of renewable resources can have positive economic effects in the form of an increase in gross domestic product (GDP) (Radmehr et al., 2021). In this regard, one of the prerequisites for use is investment in infrastructure and necessary equipment, which further encourages the growth of employment and innovation activities. Second, renewable sources reduce environmental devastation (Majeed & Luni, 2019). Third but not least, renewable resources reduce pollution and greenhouse effects (Hatefi & Torabi, 2010). In other words, RES can be seen as an option or a mechanism for mitigating climate change.

The main limitations of these resources are reflected in the lack of continuity, since wind and sun do not always realize their full potential (Goodstein, 2003). In addition, from the aspect of production, a smaller amount of energy is accumulated from alternative sources than from non-renewable ones, which suggests a balanced use of both categories of resources (Harris, 2009).

Greater use of RES in overall energy production is important for several reasons. First, they emit zero or minimal CO₂ into the atmosphere. Second, a greater share of RES in total energy increases the energy stability of a country's electrical energy system. And thirdly, by lowering the installation costs of systems for the production of energy from renewable sources, it can be expected that RES will become economically competitive source of energy, especially solar energy, wind energy and biomass energy.

Energy in its various forms is an indispensable factor for economic growth and development in every country, regardless of its level of development. Worldwide, numerous studies examine the impact of energy on national and global economies. A

8 The total quantity of carbon dioxide (CO₂) released by an activity, either directly, indirectly, or cumulatively, during the course of a product's life cycle is referred to as its "carbon footprint" (goods and services). This includes activities made by individuals, groups of individuals, governments, organizations, procedures, various industries, and so forth. To account for the differing impacts of other greenhouse gases on global warming, it is represented in grams of CO₂ equivalent per kilowatt-hour of generation (gCO₂ eq/Kwh) (Rai et al., 2025).

connection has been established between energy, economy, and ecology (known as the “3E”). Accelerated economic development is based on increased use of energy from conventional sources, leading to heightened greenhouse gas (GHG) emissions and environmental pollution. Due to a lack of understanding of resource characteristics (inexhaustibility), it was once believed that humans could utilize all resources in unlimited quantities. There was even a belief that nature could naturally neutralize waste generated by human activity (Stern, 2010). Energy in its various forms is an indispensable factor for economic growth and development in every country, regardless of its level of development. Worldwide, numerous studies examine the impact of energy on national and global economies. A connection has been established between energy, economy, and ecology (known as the “3E”). Accelerated economic development is based on increased use of energy from conventional sources, leading to heightened greenhouse gas (GHG) emissions and environmental pollution. Due to a lack of understanding of resource characteristics (inexhaustibility), it was once believed that humans could utilize all resources in unlimited quantities. There was even a belief that nature could naturally neutralize waste generated by human activity (Stern, 2010).

Solar radiation reaching the Earth’s surface depends on the angle at which solar rays strike, climatic conditions, and terrain. The incident angle at which solar rays hit the Earth is determined by the season and the geographical latitude of the location. Due to Earth’s atmospheric pollution with particles, solar rays passing through the atmosphere are scattered and reflected off particles, reducing the amount of solar energy reaching the Earth. The lower the incident angle of the solar rays (closer to the poles), the longer the path of the solar rays, and the greater the scattering (Energy Efficiency & Renewable Energy).

On the Sun, a constant nuclear fusion process generates energy that spreads through space in the form of electromagnetic radiation. Approximately 1.5×10^9 terawatt-hours (TWh) of this energy reaches the Earth’s surface after passing through the atmosphere.⁹ By reflecting approximately 30% of the energy back into space, and absorbing 70% on Earth’s surface (amounting to 1.05×10^9 TWh), solar energy quantities surpass the total reserves of coal and oil combined. Despite its inexhaustibility in terms of duration and quantity, solar energy currently contributes only 2-3% to global primary energy production (Smil, 1991).

The advantages of using solar energy compared to other energy sources include: its availability in unlimited quantities for the next 5 billion years, low maintenance costs during the operational period of solar systems, and the ease of transport and installation of solar panels on various surfaces. Because of these benefits, solar energy can be applied in locations where it’s not feasible to transport or generate electricity from other sources. The production cost of solar panels has decreased by over 50% in the last 15 years. The manufacturing technology in the solar industry is continuously advancing, driven by innovations in quantum physics and nanotechnologies. Consequently, these advancements will significantly increase the efficiency and power output of solar panels (Stevanović et al., 2022).

It is necessary to mention the disadvantages of using solar energy. Recent production of solar panels is still characterized by high production costs.⁹ The efficiency of solar systems drastically decreases during nighttime, seasonal changes, and varying weather conditions. Due to the specific nature of solar energy production, it must be immediately used or stored in batteries, which still represent a significant cost in the construction of solar systems. It is common practice to supply excess solar energy produced during the day to electrical distribution systems, while at night, during production deficits, the same energy is taken from the distribution grid. Considering that the amount of solar energy produced depends proportionally on the size of the solar panel and the amount of sunlight reaching the panel, solar panels often occupy large areas and must be placed where sunlight can reach them without obstruction or shadows for most of the day. Although environmental pollution during the production of solar energy is negligible compared to other energy sources, the production of solar energy is associated with environmental pollution¹⁰ (Vierda, 2018).

Discussion

When analyzing Bitcoin mining investments, it is essential to understand the cycles through which Bitcoin's value fluctuates. The cryptocurrency market resembles traditional stock exchanges in many ways. Consequently, the value of Bitcoin and other cryptocurrencies moves through two fundamental cycles: bull market and bear market (Gonzalez & Shi, 2006). Bull markets are characterized by a strong, impulsive rise in the value of Bitcoin, often accompanied by positive news related to the cryptocurrency market. During this cycle, Bitcoin typically reaches new all-time highs (ATH). In contrast, bear markets are marked by significant declines in the value of Bitcoin and all other crypto currencies. In a bear cycle, Bitcoin usually drops to values that are 70-80% lower than the peak achieved at the beginning of this cycle (see Graph 1)¹¹. Depending on the global economic situation, these cycles have alternated fairly predictably since Bitcoin's inception, occurring approximately every two years¹². The beginning of a bull cycle is typically marked by the halving event while the end of a bull cycle and the beginning of a bear cycle are characterized by major changes in the global economy, often accompanied by negative news related to the crypto currency market. It is common practice for miners to sell their earned Bitcoins in the latter half of the bull period in anticipation of achieving a new ATH. New investments in Bitcoin mining infrastructure usually commence in the upcoming bear cycle.

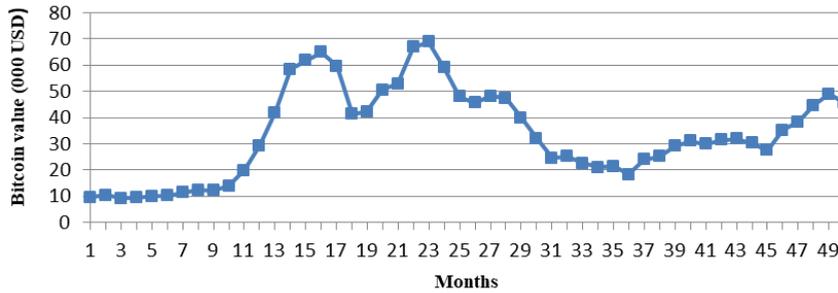
9 The continuous increase in solar system production, particularly in China, along with their growing use in energy production, will certainly lead to a decline in the prices of these systems in the future.

10 However, this concerns indirect pollution that occurs during the production, transportation, and installation of solar systems.

11 <https://www.tradingview.com/chart/?symbol=BITSTAMP%3ABTCUSD> (from 08.11.2021. to 21.11.2022. price of Bitcoin dropped for approximately 79%)

12 <https://www.tradingview.com/chart/?symbol=BITSTAMP%3ABTCUSD> (bull cycle occurred from 01.04.2019. to 08.11.2021. while bear cycle occurred from 15.11.2021. to 13.03.2023.)

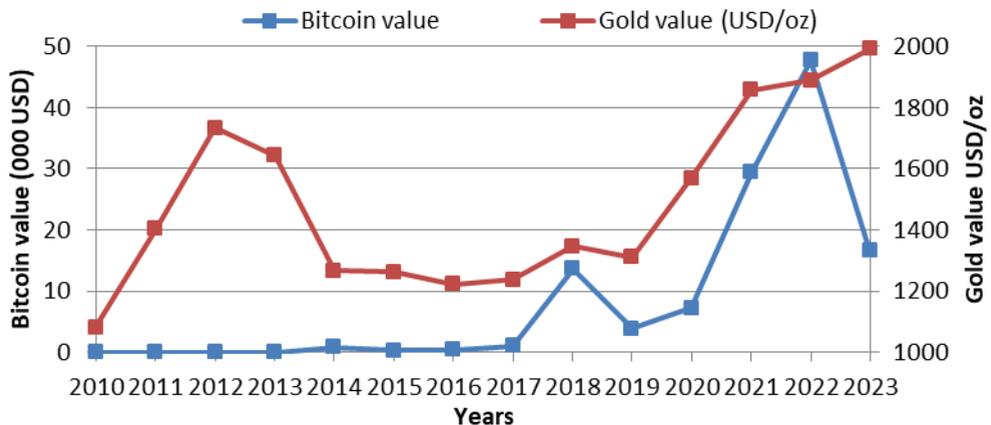
Figure 1. Monthly movement of Bitcoin value during one cycle (from 01.01.2020. to 01.02.2024).



Source: Tradingview (<https://www.tradingview.com/chart/?symbol=BITSTAMP%3ABTCUSD>)

Since its inception in 2010, the value of Bitcoin has been constantly growing, although followed by corrections, on a macro level it's in an constant upward trend. The lowest price of Bitcoin was \$0.09 in 2010, and the highest was \$68,436 in 2021. This represents a significant increase of 76,039,900%. The first notable price spike occurred in 2014 when one Bitcoin was valued at \$754.22. Another significant increase happened in 2018 when one Bitcoin reached \$13,657.20. A parabolic rise in value began at the onset of the COVID-19 pandemic, with Bitcoin's value increasing from \$7,200 at the beginning of 2020 to \$29,374 in 2021. Later that year, it reached a new all-time high of \$68,436. The rate of change in Bitcoin's value was 183.39%. Analyzing the movement of Bitcoin's value during one cycle reveal significant fluctuation.

Figure 2. Value movements of Bitcoin and gold from 2010 to 2023.



Source: Tradingview (<https://www.tradingview.com/chart/F1w4jrZc/?symbol=TVC%3AGOLD>)

Therefore, investors need to have a clearly defined moment in the cycle of price movements when they will sell their mined Bitcoin to achieve the highest profit. The value of Bitcoin during the last cycle ranged from \$9,553 to \$68,789 (Graph 1). Given that Bitcoin is now considered “digital gold,” it is often compared to gold from an investment perspective over the long term. According to data from the trading view website¹³ the price of gold in the observed period also varied, from a low of \$1,081.48 per ounce in 2010 to \$1,991.41 per ounce in 2023. The price of gold in the mentioned period increased by 84.14%, while Bitcoin increased significantly more, by 18,472,222%. From the above, it can be concluded that if an individual had invested \$100 in gold in 2010, by 2023 it would have been worth \$184.14. However, if the same amount had been invested in Bitcoin, by 2023 it would have amounted to \$18,472,122.20. Of course, it should be noted that gold is generally considered a relatively safe and low-risk investment in the financial world, whereas Bitcoin was initially seen as a highly risky investment. However, as Bitcoin has gained increasing significance, investing in it has become less risky, and a large number of individuals now include it in their investment portfolios.

Results

As previously mentioned, what “hinders” the acceptance of Bitcoin as an official means of payment on a global level is the energy consumption required for its mining. A significant portion of the profits of Bitcoin mining companies goes towards electricity costs, which vary depending on the country where the company operates. The solution proposed in this paper is to transition to mining using renewable energy sources (RES), specifically solar energy. If a larger number of companies switched to Bitcoin mining using RES, it would quickly gain acceptance as a currency of payment by all countries worldwide. Of course, companies are aware of this problem and the potential solution, so they have already started directing their investments towards RES. The most commonly used RES are solar energy and energy from mini-hydro power plants. Solar energy is particularly attractive to investors because it is accessible to both large companies and individuals aiming to generate additional income through passive earnings.

To assess the profitability of investing in the construction of a solar power plant for Bitcoin mining in Serbia, the following parameters need to be considered:

- 1 The cost of the machine used for Bitcoin mining (increased by transportation and customs expenses),
- 2 The cost of the solar power plant that would meet the electricity needs of the Bitcoin mining machine,
- 3 The surface area where the solar power plant will be located,
- 4 Number of sunny days,
- 5 Bitcoin value.

13 <https://www.tradingview.com/chart/F1w4jrZc/?symbol=TVC%3AGOLD>

After considering all the previous parameters, the profitability of the investment and the payback period can be estimated approximately. The realized profit from such an investment will largely depend on the value of Bitcoin at the time the investor decides to sell it. Given that the value of Bitcoin moves in cycles and experiences significant fluctuations, for the purposes of calculation in this study, the median value from the last cycle lasting 50 months will be used (Figure 1.).

Bitcoin mining is conducted using ASIC miners, specialized machines designed with sufficient hardware power for these operations. The price of ASIC miners varies depending on their hardware capabilities and profitability. The power of a miner is expressed in hashrate per second, and its profitability is determined based on this hashrate and the electricity consumption required for its operation. Currently, the most powerful ASIC miner on the market is the “Whatsminer M63S Hydro” model from MicroBT, which has a hashrate of 390 Th/s. It consumes 7,250 watts of power to operate.¹⁴ According to the manufacturer’s official website¹⁵, the price of this machine is \$11,000 USD. In addition to the machine’s cost, customs duties must be considered, calculated as 15% of its value, amounting to \$1,650 USD for this specific model. Transportation costs are included in the final price. Therefore, the total value of this machine “delivered at place” (DAP) amounts to \$12,650 USD.

Table 1. Annual profit of the Bitcoin mining machine “Whatsminer M63S Hydro” based on the source of electricity in the Republic of Serbia* (USD)

Source of electrical energy	Earnings (USD)	Electricity costs (0,105 USD/kWh)	Profit (USD)
Non-renewable sources	9.542 ¹⁶	6.351	3.191
Solar power plant	9.542	1.950 ¹⁷	7.592

Source: Author’s calculation

* Median price of Bitcoin during the last cycle: \$31,198 USD

Green Bitcoin mining investment (Table 1.) is significantly more profitable when solar energy is used for mining compared to conventional energy sources. The following sections will determine the annual return and payback period of the green Bitcoin mining investment, specifically using solar energy for Bitcoin mining.

14 <https://whattomine.com/miners> (28.12.2023.)

15 <https://shop.whatsminer.com/products?token=null> (28.12.2023.)

16 The value of \$9.542 USD was obtained from a website specialized in calculating the profitability of ASIC machines for Bitcoin mining (<https://whattomine.com/miners> (28.12.2023.))

17 Even though it’s a renewable energy source, there are electricity costs associated with solar power because the solar plant doesn’t generate electricity at night. In calculating electricity costs, a time period of 6 hours at the lower tariff rate has been considered.

Table 2. Annual return on investment of green Bitcoin mining*

Source of electrical energy	Earnings (USD)	Total investment cost (USD)	Return on investment (%)
Solar power plant	7.592	193.000	3,94

Source: Author's calculation

*Median price of Bitcoin during the last cycle: \$31,198 USD

Table 3. Payback period of investment in green Bitcoin mining*

Source of electrical energy	Earnings (USD)	Total investment cost (USD)	Payback period (years)
Solar power plant	7.592	193.000	25

Source: Author's calculation

*Median price of Bitcoin during the last cycle: \$31,198 USD

The value of Bitcoin at \$6,400 USD represents the lower limit of profitability for green Bitcoin mining, meaning it is the threshold below which minimal profit is realized or operations break even without losses. At this Bitcoin value, the annual electricity costs of around \$1,950 USD are covered. Any Bitcoin value below this threshold would make green Bitcoin mining unprofitable, meaning the investor would operate at a loss. If the investor decides to transition from green Bitcoin mining to producing and selling green energy from a solar power plant, this investment could yield significant annual revenues. When calculating the profitability of producing and selling green solar energy, the feed-in tariff in Serbia should be included, which amounts to \$0.17 USD per kWh.¹⁸ The calculation is based on the average annual household electricity consumption in Serbia, which is 5,544 kWh¹⁹. Considering all factors, a 56 kW solar power plant would produce approximately 367,920 kWh annually in Serbia. Subtracting the average annual household consumption (5,544 kWh), the net production from the solar power plant would be approximately 362,376 kWh per year²⁰. At the feed-in tariff rate of \$0.17 USD per kWh, the solar power plant would generate a revenue of approximately \$61,600 USD annually. This amount needs to be reduced by taxes and fees totaling around \$1,950 USD per year for the 56 kW plant, as well as for the cost of purchased electricity during nighttime hours, which is also around \$1,950 USD per year. This leaves an annual profit of approximately \$57,703 USD. The construction costs of the 56 kW solar power plant amount to around \$180,350 USD. Therefore, the annual return on this investment would be approximately 32%, with a payback period of around 3 years.

18 Uredba o tržišnoj premiji i fid-in tarifi. "Službeni glasnik RS", br. 45/2023-11, br. 90/2024-3 dr. uredba, Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2023/45/3/reg>

19 <https://www.politika.rs/scc/clanak/455113/Domacinstva-u-Srbiji-trose-50-odsto-vise-struje-od-evropskih>

20 This data were obtained in consultations with company „MT Komex“ after their engineers internally performed calculations.

If mined Bitcoins were sold at the median price of \$31,198 USD, it can be concluded that the production and sale of electricity from a solar power plant is far more profitable compared to green Bitcoin mining.

Conclusion

The concept of sustainable development today has a significant influence on shaping economic growth and policies development in almost all countries worldwide. Bitcoin, as a revolutionary payment method, emerged with the idea of decentralized value creation without the intervention of a central bank, providing users with anonymity and privacy in financial transactions. It represents a contrast to traditional money and is often referred to as digital gold. The advent of Bitcoin led to the creation of the cryptocurrency market, which functions as a unique form of exchange. Other cryptocurrencies have emerged thanks to Bitcoin, offering various solutions and possibilities across all sectors of the economy.

One of the main criticisms of Bitcoin is its environmental impact, as it is not aligned with the concept of sustainable development or being “green.” Bitcoin mining requires a significant amount of energy consumption, thus negatively affecting the environment. However, advancements in technologies enabling better energy conversion from renewable sources can address this issue. Major companies in the Bitcoin mining industry are increasingly shifting towards renewable energy sources, directing their future investments in that direction. If Bitcoin were to become entirely “green,” its acceptance as a global trading medium would become more certain.

When analyzing the profitability of green Bitcoin mining using solar energy, the investment cost and expected annual revenue must be considered. The cost of such an investment in Serbia would amount to approximately \$193,000 USD. Given the median price of Bitcoin in the last cycle, which was \$31,198 USD, the expected annual return on the total investment would be around 3.94%, with a payback period of approximately 25 years.

Transitioning from green Bitcoin mining to selling solar energy to power distribution companies would occur when the value of Bitcoin falls below \$6,400 USD. Research indicates that greater profit is achieved through supplying solar energy compared to green Bitcoin mining.

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Conflict of interests

The authors declare no conflict of interest.

References

1. Barbier, E. B., & Burgess, J. C. (2017). The Sustainable Development Goals and the systems approach to sustainability. *Economics*, 11(1), 20170028.
2. Derlukiewicz, N., Mempel-Śnieżyk, A., Mankowska, D., Dyjakon, A., Minta, S., & Pilawka, T. (2020). How do Clusters Foster Sustainable Development? An Analysis of EU Policies. *Sustainability*, 12(4), 1297
3. Elektroprivreda Srbije, Proizvodnja uglja, <https://www.eps.rs/lat/poslovanje-ugalj/Stranice/Proizvodnja-uglja.aspx> (access: June 3rd 2024.)
4. Emas, R. (2015). The concept of sustainable development: definition and defining principles. *Brief for GSDR*, 10-13140
5. Energetski portal, Fid in tarife, <https://energetskiportal.rs/ministarstvo/fid-in-tarife/> (access: June 20th 2024.)
6. Fonseca, L. M., Domingues, J. P., & Dima, A. M. (2020). Mapping the sustainable development goals relationships. *Sustainability*, 12(8), 3359
7. Gogić, P. (2014). *Teorija troškova sa kalkulacijama*, Poljoprivredni fakultet, Beograd [in English: Gogić, P. (2014). *Theory of costs with calculations*. Faculty of Agriculture, Belgrade].
8. Gonzalez, L., Shi, J. (2006). Defining and Dating Bull and Bear Markets: Two Centuries of Evidence, *Multinational Finance Journal*, Global Business Publications
9. Goodstein, E. (2003). *Ekonomika i okoliš*, Mare, Zagreb [in English: Goodstein, E. (2003). *Environmental economics*, Mate, Zagreb].
10. Harris, J. M. (2009). *Ekonomija životne sredine i prirodnih resursa*, Data Status, Beograd [in English: Harris, J. M. (2009). *Environmental economics and natural resources*, Data Status, Belgrade].
11. Hatefi, S.M. & Torabi, S.A. (2010). A common weight MCDC-DEA approach to construct composite indicators. *Ecological Economics*, 70 (1), 14-120
12. Klimatizacija.hr, Blog – solarni paneli, <https://klimatizacija.hr/> (access: December 28th 2023.)
13. Majeed, M. T., & Luni, T. (2019). Renewable energy, water, and environmental degradation: A global panel data approach. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, 13(3), 749-778
14. Milutinović, S. (2020). *Upravljanje prirodnim resursima*, Fakultet zaštite na radu, Niš [in English: Milutinović, S. (2020). *Natural resources management*, Faculty for Occupational safety, Niš].
15. Pešić, R. (2012). *Ekonomika životne sredine i prirodnih resursa*, Poljoprivredni fakultet, Beograd [in English: Pešić, R. (2012). *Environmental economics and natural resources*, Faculty of Agriculture, Belgrade].

16. Pešić, R. (2020). *Ekonomika životne sredine i prirodnih resursa*, Poljoprivredni fakultet, Beograd [in English: Pešić, R. (2020). *Environmental economics and natural resources*, Faculty of Agriculture, Belgrade].
17. Politika, Domaćinstva, <https://www.politika.rs/scc/clanak/455113/Domacinstva-u-Srbiji-trose-50-odsto-vise-struje-od-evropskih> (access: June 20th 2024.)
18. Politika, Domaćinstva, <https://www.politika.rs/scc/clanak/455113/Domacinstva-u-Srbiji-trose-50-odsto-vise-struje-od-evropskih> (access: June 20th 2024.)
19. Prozjumeri.rs, Solarni kalkulator, <https://prozjumer.rs/solarni-kalkulator/> (access: December 28th 2023.)
20. Radmehr, R., Henneberry, S. R., & Shayanmehr, S. (2021). Renewable energy consumption, CO₂ emissions, and economic growth nexus: a simultaneity spatial modeling analysis of EU countries. *Structural Change and Economic Dynamics*, 57, 13-27
21. Rai, N. K., Vishwakarma, Y. K., Bardhan, S., & Singh, R. S. (2025). Carbon Footprints and Ecological Footprints: Estimation and Mitigation Practices. In *The Intersection of Global Energy Politics and Climate Change: A Comprehensive Analysis of Energy Markets and Economics* (pp. 353-371). Singapore: Springer Nature Singapore
22. Ruggerio, C. A. (2021). Sustainability and sustainable development: A review of principles and definitions. *Science of the Total Environment*, 786, 147481
23. Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., & Fuller, G. (2018). *SDG index and dashboards report 2018*. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN)
24. Salim, R. A., Hassan, K., & Shafiei, S. (2014). Renewable and non-renewable energy consumption and economic activities: Further evidence from OECD countries. *Energy economics*, 44, 350-360
25. Selin, Noelle Eckley. "carbon footprint". *Encyclopedia Britannica*, 19 Jun. 2024 <https://www.britannica.com/science/carbon-footprint> (09.07.2024.)
26. Smil, V. (1991). Does Energy Efficiency Explain Japan's Economic Success?, Current History p. 175, University of Manitoba, Canada
27. Stern, D.I. (2010). *The Role of Energy in Economic Growth*. CCEP working paper 3.10, Centre for Climate Economics & Policy, Crawford School of Economics and Government, The Australian National University, Canberra. <https://ageconsearch.umn.edu/record/249380/files/CCEP-3-10.pdf>
28. Stevanović, S., Stevanović S. (2022). Solar Energy as a Renewable Energy Source, *International Scientific Conference "Sustainable Agriculture and Rural Development II", Thematic Proceeding*, Institute of Agricultural Economics, Belgrade, February, 2022, p. 353-363. ISBN 978-86-6269-111-8, ISBN (e-book) 978-86-6269-110-1. <https://www.iep.bg.ac.rs/images/stories/izdanja/Tematski%20Zbornici/Zbornik%20radova%202022lq.pdf>

29. Stivens, K. (2011). Održivost kao novi kvalitet društvenog i privrednog razvoja, *Putokaz ka obnovljivom razvoju*, Beograd: Ministarstvo za nauku i tehnološki razvoj, 10-22 [in English: Stivens, K. (2011). Sustainability as a new quality of social and economic development, *Sustainable development road map*, Belgrade Ministry for science and technological development].
30. Trading View, Crypto coins screener, <https://www.tradingview.com/> (access: December 25th 2023.)
31. Uredba o tržišnoj premiji i fid-in tarifi. “Službeni glasnik RS”, br. 45/2023-11, br. 90/2024-3 dr. uredba, Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2023/45/3/reg> [in English: Regulation on market premium and feed in tariff “Službeni glasnik RS”, br. 45/2023-11, br. 90/2024-3 dr. uredba, Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2023/45/3/reg>].
32. Vierda, G. (2018). *Sunce kao obnovljivi izvor energije*, Sveučilište u Dubrovniku, pomorski odjel, Diplomski studij pomorstvo, Dubrovnik (Diplomski rad);
33. Visual Capitalist, Bitcoin mining, <https://www.visualcapitalist.com/> (access: December 25th 2023.)
34. Vuković, N. (2012). *Osnove verovatnoće*. Univerzitet u Beogradu, Fakultet organizacionih nauka, Beograd [in English: Vuković. (2012). *Principles of probability*, Faculty of organizational sciences, Belgrade].
35. What to mine, Miners, <https://whattomine.com/miners> (access: December 28th 2023.)
36. Whatsminer, Products, <https://shop.whatsminer.com/products?token=null> (access: December 28th 2023.)
37. World Commission on Environment and Development (1987), *Our Common Future*, Oxford University Press, Oxford.
38. Zakon o energetici. “Službeni glasnik RS”, br. 145/2014, 95/2018 - dr. zakon, 40/2021, 35/2023 - dr. zakon, 62/2023., Beograd. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/skupstina/zakon/2014/145/1/reg> [in English: Energy law “Službeni glasnik RS”, br. 145/2014, 95/2018 - dr. zakon, 40/2021, 35/2023 - dr. zakon, 62/2023., Belgrade. <https://pravno-informacioni-sistem.rs/eli/rep/sgrs/skupstina/zakon/2014/145/1/reg>].
39. Jovanović Gavrilović B. (2008). Ciljevi i indikatori održivog razvoja u Evropi. U: Vujošević, M., Filipović, M. (Ur). *Nova generacija evropskih dokumenata održivog razvoja i pouke za Srbiju* (str. 31-47). Beograd: Centar za izdavačku delatnost Ekonomskog fakulteta [in English: Jovanović Gavrilović B. (2008). Indicators and goals of sustainable development in Europe. Vujošević, M., Filipović, M. (Ed). *New generation of european documents for sustainable development and lessons for Serbia*, (pp. 31-47). Faculty of Economics, Belgrade].

EVALUATION OF THE ENVIRONMENTAL PERFORMANCE OF AGRICULTURAL PRODUCTION IN THE EUROPEAN UNION: SUSTAINABLE PRACTICES AND THEIR IMPACTS

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ABSTRACT

Agriculture is a major contributor to climate change, exerting significant pressure on environmental systems. The aim of this paper is to examine the relationship between the environmental performance of agricultural production and climate change in the European Union (EU) countries and to assess the degree of their homogeneity according to sustainability indicators. Correlation and cluster analyses were applied using data from the Environmental Performance Index (EPI). The results confirm a statistically significant positive correlation between agricultural performance and climate change mitigation, identifying three clusters of EU countries with different levels of environmental efficiency. The findings indicate that countries with higher agricultural sustainability achieve better results in reducing greenhouse gas emissions. The paper concludes that future agricultural policies within the European Union should promote sustainable production models that contribute to climate change mitigation while simultaneously enhancing the overall environmental performance of the agricultural sector.

Introduction

In the last few decades, environmental problems have become a global problem of humanity in terms of their existence and impact, as well as the socio-economic forces that produce them. The environmental problems that arise are closely related to the ever-

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increasing demand which comes from the increasing growth of the world population. Over the next 40 years, it is estimated that the demand for fresh water will increase by 50%, the demand for food by 70%, and the demand for energy will almost double (Naam, 2013). Most of the activities that man undertakes in order to satisfy the basic goals of life harm the living environment, leading to serious disturbances of the natural systems on the planet.

The overall development of human society in recent decades has led to increasingly unfavorable climate changes and a rise in the frequency of natural disasters. Climate change, biodiversity loss, and other environmental issues represent some of the greatest societal challenges of the 21st century. To address these challenges and guide society toward a sustainable future, it is essential to reduce greenhouse gas emissions and strengthen ecological resilience. Agriculture plays a crucial role in feeding the growing world population while simultaneously maintaining the delicate balance between production needs and environmental protection. However, agricultural activities are also a major source of greenhouse gas emissions and environmental degradation. Although numerous studies have examined the relationship between agriculture and the environment, the existing literature often lacks a comprehensive comparative analysis of the environmental performance of agricultural production across EU countries, particularly in the context of their contribution to climate change mitigation.

This paper seeks to fill that gap by analyzing the relationship between the environmental performance of agriculture and climate change in the European Union (EU) countries. Specifically, the study aims to group EU member states into homogeneous clusters according to their achieved level of environmental performance in agriculture and climate change mitigation. The analysis and discussion of results provide insights into the degree of ecological sustainability of agricultural production and its impact on climate change across EU countries.

Literature Review

Agriculture is an activity whose importance goes beyond the basic production of food, and is of crucial importance for maintaining the general existence of the human population, which is experiencing constant growth. With regard to this, agriculture has influenced the transformation and increase in the sensitivity of ecosystems, but also the dependence and vulnerability of society on the environment (Milinčić et al., 2013). Agriculture uses about half of the global earth's surface and its existence and sustainability depend directly on the state of environment. Sunlight, water, nutrients and diversity of plants, animals and microbes play a fundamental role in agricultural production resulting in global food security (Ilić, 2022).

Human activities, in particular the emission of greenhouse gases, are the primary drivers of climate change (IPCC, 2023). Almost a decade has passed since the signing of the Paris Agreement on climate change, which envisages limiting global warming to 1.5 °C in order to avoid a climate crisis, but the emission of greenhouse gases continues

to grow (Ozdemir et al., 2023). Therefore, urgent action is needed to reverse this trend, given that the world may be approaching a dangerous tipping point in the climate system (Lenton et al., 2023).

The environmental impacts of the agricultural sector have been analyzed in numerous studies (Radivojević et al., 2019; Dabkiene et al., 2021; Wang et al., 2022; van Der Werf et al., 2020; Martin et al., 2023; Ncube et al., 2024). Given the high degree of interdependence, agriculture can sustain or degrade the environment. Agriculture contributes to significant greenhouse gas emissions that cause climate change, 17% directly through agricultural activities and an additional 7 - 14% through land use change (OECD, 2016). In addition, the global emission of greenhouse gases is one of the environmental threats associated with food production, which contributes more than one quarter (26%) of emissions (Poore & Nemecek, 2018; Cui et al., 2024). The use of land in terms of changes caused by agriculture, which are harmful to the living environment, is reflected in the fact that about 44% of the inhabited land in the world is used precisely for agricultural production (Ritchie & Roser, 2024). Also, 70% of available drinking water globally is used for agriculture (FAO, 2011), while as much as 78% of freshwater and ocean pollution with nutrient-rich pollutants is caused by agricultural production (Poore & Nemecek, 2018). Agriculture is also considered responsible for major changes in biodiversity, where it is a threat to 24,000 species that are estimated to be at risk of extinction (Bar-On et al., 2018).

Due to the increasingly present biodiversity and climate crisis, caused by agricultural production that degrades the environment, meeting the growing demand for agricultural products will have to be done by maximizing the productivity of agricultural land (Pretty, 2018). For the sake of achieving higher productivity in agricultural production, the use of pesticides, which prevent crop loss and bring economic benefits to producers, is more and more common (Popp et al., 2013). This practice is accompanied by detrimental effect on the environment if used excessively (Larsen et al., 2017). The solution to the climate crisis requires a transition from the conventional model of production to alternative models which respect the natural limits of agricultural development at the expense of the environment (Žukowska et al., 2016). The contribution of agriculture to greenhouse gas emissions varies considerably as a result of differences in agricultural practices, as well as diverse natural and climatic conditions, including soil characteristics and temperature regimes. The mitigation of greenhouse gas emissions can be facilitated through a reduction in the demand for emission-intensive food products and the adoption of environmentally responsible agricultural production and land-management practices (Springmann, et al., 2018; Krstič, 2024). The application of renewable energy sources and the achievement of a higher level of energy efficiency can be a generator of future reductions in total greenhouse gas emissions. The COP 28 report recognized significant progress in terms of ending the use of fossil fuels, increased investments in solar energy, greater competitiveness of renewable energy sources, green construction and the application of agricultural innovations. Additionally, the rise in global awareness of climate change and willingness to reduce greenhouse gas emissions has never been greater (IEA, 2023).

The agricultural sector of the European Union contributes about 10% to the total emission of greenhouse gases (EC, 2019; EC, 2023.). Although agriculture is one of the sectors at the European Union level that has a small share of total greenhouse gas emissions, it contains “hidden emissions” attributed to other sectors, such as carbon dioxide emissions from fossil fuels and electricity that are used for agricultural machinery, crop drying and fertilizer production related to the energy sector (Paloviita & Järvelä, 2015).

Good progress was made in reducing emissions between 1990 and 2017, during which time greenhouse gas emissions from agriculture were reduced by around 20% (EC, 2021), contributing to the achievement of the European Union’s 2020 target. Furthermore, over the period from 2005 to 2022, the European Union achieved a reduction of approximately 5% in greenhouse gas emissions originating from the agricultural sector. At the same time, a further 2% reduction in these emissions is projected between 2022 and 2023 (EEA,2024). The European Union is making great efforts to reduce greenhouse gas emissions from agriculture, but on the other hand, it is trying to adapt agricultural production as much as possible to the current climate changes, which have a significant impact on its development.

Materials and methods

The aim of the paper is to monitor the relationship between the environmental performance of agricultural production and climate change, as well as the homogeneity of the countries of the European Union according to the effect of agricultural production on the occurrence of climate change. In order to achieve the set goal, it is assumed that

- 1) *there is a positive correlation between the environmental performance of agricultural production and both overall environmental performance and climate change-related environmental performance and*
- 2) *the countries of the European Union are not homogeneous according to the achieved level of environmental performance in agriculture and climate change.*

The empirical foundation of this research is based on secondary data obtained from the Environmental Performance Index (EPI), published by the Yale Center for Environmental Law and Policy at Yale University in collaboration with the Center for International Earth Science Information Network of Columbia University, as presented in the 2024 annual report. The 2024 EPI evaluates and ranks 180 countries using 58 environmental performance indicators organized into 11 issue categories, which are further aggregated into three overarching policy objectives: Environmental Health, Ecosystem Vitality, and Climate Change. In order to monitor progress towards sustainable intensification of agricultural production, the Environmental Performance Index within the issue category *Agricultural* (which is part of the component - Ecosystem Vitality) monitors the productivity of agricultural production and the excessiveness of pesticides use. The contribution of agriculture to climate change and habitat loss is taken into account through a special component - Climate Change, which consists of the issue category - *Climate Change Mitigation* (Block et al., 2024).

EPI provides a tool to track countries' progress towards meeting UN Sustainable Development Goals and other international policy targets. The, SDGs include several goals directly focused on environmental sustainability, one of which is Climate Action (SDG 13). The research focuses on the 27 member states of the European Union, as defined in 2024, with no exclusions. This selection ensures comparability across countries with harmonized agricultural and environmental policies under the EU framework. The EPI data were used in their original form (without modification), as they provide standardized, internationally comparable metrics for environmental performance. To test the proposed hypotheses, correlation analysis was employed to assess the relationships among the observed variables, while cluster analysis using Ward's method was applied to classify European Union countries according to their levels of environmental performance in agriculture and climate change mitigation. Data processing and statistical analysis were conducted using SPSS software. The use of these EPI metrics allows for the identification and understanding of the state of agricultural production in European Union countries in terms of sustainability as well as climate change mitigation efforts.

Results and Discussions

To evaluate the environmental performance of European Union countries, descriptive statistics for the variables included in the analysis are presented in Table 1. The value of the EPI index for the countries of the European Union ranges from 54 to 75.3, while the maximum possible value of this index is 100. The first twenty countries in the ranking according to environmental performance in the world are European countries during 2024, whose average value is 65.75. Estonia (75.3) ranks first in the world ranking according to environmental performance, followed by Luxembourg, Germany, Finland, Austria and Denmark. Cyprus is the lowest ranked country in the European Union according to the environmental performance value (54.00). According to the category - *Agricultural*, a value of as much as 78.8 was achieved by Germany, which is the fourth country on the score list of the best performances. Germany is a leader in introducing pesticide-free non-organic farming systems, which are easier for producers to adopt than full organic farming and have less associated yield losses (Finger & Niklas, 2024). According to the level of environmental performance in agriculture, Cyprus has the lowest value of 35.70, which places it in the 162nd place in the world ranking of 180 countries. Estonia is the leader among countries at the global level according to the issue category *Climate Change Mitigation* with a value of 82.8, reducing the level of greenhouse gas emissions by 40% over the last decade (Block et al., 2024), while Cyprus achieves very poor results (42.60) in mitigating climate change. In addition to the minimum, maximum, and mean values of the analyzed indicators, Table 1 also reports the standard deviation and the coefficient of variation for each observed category within the sample of EU countries. Closely the same level of variability is present among the EU countries when categories *Agriculture* and *Climate Change Mitigation* are observed. Approximately the same level of variability is present among EU countries when observing issue categories, *Agriculture* and *Climate Change Mitigation*.

Table 1. Descriptive statistics of the observed category

	N	Minimum	Maximum	Mean	Std. Deviation	Variation Coefficient
EPI24	27	54	75.3	65.7513	5.68259	8.64248
Agricultural24	27	35.70	78.80	65.2815	10.21598	15.64912
Climate Change Mitigation24	27	42.60	82.80	57.7444	8.87058	15.36179

Source: Authors' calculation

The initial phase of the analysis focuses on examining the relationship between agricultural production and overall environmental performance, as well as its influence on climate change across EU countries. To identify the degree of interdependence among the observed variables, correlation analysis was employed. Subsequently, cluster analysis was applied to assess the homogeneity of EU countries based on their achieved levels of environmental performance in agriculture and climate change mitigation.

To test the initial assumptions, both correlation and cluster analyses were employed. Correlation analysis was used to examine the relationships between the environmental performance of agricultural production and overall environmental performance, as measured by the Environmental Performance Index (EPI), as well as between the environmental performance of agricultural production and climate change mitigation performance across EU countries. The strength and direction of these relationships were assessed using the Pearson correlation coefficient. Table 2 presents the values of the Pearson correlation coefficient (ρ) along with the corresponding levels of statistical significance (sig.) for the analyzed relationships. The results reported in Table 2 indicate the existence of a positive correlation between EPI and agricultural performance, with the highest correlation observed between EPI and climate change mitigation performance. The interdependence monitored on the basis of the value of the Pearson coefficient between the issue categories *Agricultural* and *Climate Change Mitigation* is of a moderate level. There is a moderate to strong statistically significant positive correlation between the variables included in the analysis. The obtained results of the existence of interdependence between the analyzed variables confirm the first assumption of the research. Namely, the existence of interdependence between the issue category *Agricultural* and the effect on EPI and the issue category *Agricultural* as well as the issue category *Climate Change Mitigation* in the countries of the European Union was established.

Table 2. Correlation matrix

		EPI2024	Agricultural24	Climate Change Mitigation24
EPI2024	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	27		
Agricultural24	Pearson Correlation	.412*	1	
	Sig. (2-tailed)	.003		
	N	27	27	
ClimateChangeMitigation24	Pearson Correlation	.776**	.601	1
	Sig. (2-tailed)	.000	.002	
	N	27	27	27
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Authors' calculation

As the existence of a positive correlation between agricultural production and climate change has been confirmed, we move on to the second part of the analysis. In order to quantitatively investigate the impact of agricultural production and the occurrence of changes in the climate, an analysis of the aggregation of European Union countries according to the achieved environmental performance within the issue categories *Agriculture* and *Climate Change Mitigation* was performed. The existence of three clusters was identified when classifying the countries of the European Union according to environmental performance within the issue categories *Agriculture* and *Climate Change Mitigation* (Table 3).

Table 3. Distribution of European Union countries by clusters according to the values of issue categories - *Agriculture* and *Climate Change Mitigation* in 2024

Cluster	N	Max	Min	Mean	Country
1	11	74.2 (Agricultural)	64.4 (Agricultural)	69.6 (Agricultural)	Austria, Bulgaria, Croatia, Czech Republic, Hungary, Ireland, Latvia, Lithuania, Poland, Romania, Slovakia
		56 (Climate Change Mitigation)	45.7 (Climate Change Mitigation)	51.34 (Climate Change Mitigation)	
2	10	78.8 (Agricultural)	64.1 (Agricultural)	70.09 (Agricultural)	Belgium, Denmark, Estonia, Finland, France, Germany, Greece, Luxembourg, Netherlands, Sweden
		82.8 (Climate Change Mitigation)	59.7 (Climate Change Mitigation)	66.49 (Climate Change Mitigation)	

Cluster	N	Max	Min	Mean	Country
3	6	56.7 (Agricultural)	35.7 (Agricultural)	49.35 (Agricultural)	Cyprus, Italy, Malta, Portugal, Slovenia, Spain
		63.6 (Climate Change Mitigation)	42.6 (Climate Change Mitigation)	54.9 (Climate Change Mitigation)	
Sum	27				

Source: Authors' calculation

Cluster 2 demonstrates the highest level of performance, followed by Cluster 1, while Cluster 3 exhibits the lowest overall performance. The second cluster includes ten countries of the European Union (Belgium, Denmark, Estonia, Finland, France, Germany, Greece, Luxembourg, Netherlands, Sweden) that strive for sustainable agricultural production and moderately use nitrogen fertilizer and pesticides, which was confirmed by the research, if we bear in mind that the average value within this cluster of ecological agricultural performance is 70.06. The maximum value of *Agriculture* within the cluster is 78.8 and the minimum is 64.1 - they can be associated with sustainable nitrogen management (less than 70 kg per hectare per year) (Zhang et al., 2015) while increasing the yield of agricultural production in the countries of the second cluster. All the countries in this cluster strive to remove subsidies that can create “perverse incentives” for excessive fertilization, which causes serious damage to both the climate and the environment (Zhang, 2017). Along with the efficient use of nitrogen in agriculture, it is also characteristic of the countries of the second cluster that they take care of the emission of gases that create a greenhouse effect and influence the occurrence of climate change. High values of the issue category *Climate Change Mitigation* (maximum 82.8) for countries gathered in this cluster are typical - because they strive to mitigate climate change by using renewable energy sources (minimize carbon emissions) and encourage decarbonization of all sectors of the economy. The average value of the analyzed issue category *Climate Change Mitigation* within the group is at a significant level of 66.49, while the minimum value is 59.7. It can be concluded that the countries comprising the second cluster exhibit a high degree of homogeneity across the analyzed key categories, wherein the attained level of environmental performance in agriculture is closely associated with climate performance. Controlled use of nitrogen does not contribute to the intensive emission of greenhouse gases that are the cause of climate change.

Cluster 1 consists of 11 countries of the European Union (Austria, Bulgaria, Croatia, Czech Republic, Hungary, Ireland, Latvia, Lithuania, Poland, Romania, Slovakia) whose environmental performance in the field of agriculture is at approximately the same level as for the countries of the European Union classified in cluster 2, bearing in mind that the maximum value is 74.2, and the minimum is 69.9. The difference compared to cluster number 2 is in the environmental performance in the area of

Climate Change Mitigation, where the average value is low (51.34). This indicates that countries from this group are directed towards carrying out agricultural production in an ecologically acceptable manner with highly efficient application of nitrogen. Owing to the uneven application of nitrogen in agricultural production, which adversely affects climatic conditions, this cluster is characterized by comparatively lower performance in the domain of *Climate Change Mitigation*. More precisely, the group of countries of cluster 1 strives to fight climate change caused in part by agricultural production and strives to mitigate it.

The remaining six countries (Cyprus, Italy, Malta, Portugal, Slovenia, Spain) of the European Union are in the third cluster. This cluster is characterized by low environmental performance in the area of *Agriculture* with a maximum value of 56.7 and a minimum of 35.7, while the performance in the area of *Climate Change Mitigation* is at a slightly higher level than in cluster 1, with an average value of 54.9. Overall, countries within the third cluster adhere to the principles advocating the reduction of greenhouse gas and pollutant emissions that significantly impact the atmosphere; however, their agricultural production is simultaneously characterized by high output levels achieved through the intensive use of nitrogen fertilizers, which poses a substantial threat to the environment.

Table 4. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Agricultural24	Equal variances assumed	1.020	.330	-5904	14	.000
	Equal variances not assumed			-5.371	7.940	.001
ClimateChange24	Equal variances assumed	.105	.751	-3.177	14	.007
	Equal variances not assumed			-3.197	10.874	.009

Source: Authors' calculation

T-test for two independent samples (Independent Sample Test) was used to check the statistical significance of differences in the average values of variables (values of issue categories – *Agriculture* and *Climate Change Mitigation*) between clusters. Based on the results presented in Table 4, the values of the significance levels for *Agriculture* and *Climate Change Mitigation* indicate homogeneity of variances within the groups, as well as statistically significant differences in mean values among the clusters, given that

the significance level is below 0.05. These findings provide empirical support for the confirmation of the second research assumption. Specifically, the results demonstrate that European Union countries are not homogeneous with respect to their achieved levels of environmental performance in agriculture and climate change mitigation. This was shown by classifying the countries of the European Union into three clusters that are characterized by different levels of achieved environmental performance in the observed categories during the analyzed year.

Conclusions

The challenge of agriculture in the 21st century requires an integrated approach that combines ecological, social, and economic dimensions of development to meet present needs without compromising the well-being of future generations. Agricultural activities significantly affect the environment, the management of natural resources, and climate stability. The interaction between agriculture and climate change is characterized by a complex causal relationship: while agriculture contributes to global warming through greenhouse gas emissions, it also holds potential for climate change mitigation through sustainable practices, emission reduction, and carbon sequestration.

The main empirical findings of this paper confirm a statistically significant positive correlation between agricultural performance, overall environmental performance, and climate change mitigation indicators among EU countries. Cluster analysis revealed three distinct groups of EU member states with different levels of sustainability. Countries such as Cyprus, Italy, Malta, Portugal, Slovenia, and Spain demonstrate lower environmental efficiency and require stronger efforts to adopt sustainable agricultural practices that can reduce greenhouse gas emissions. Policy implications suggest that the findings can support the ongoing reform of the Common Agricultural Policy of the European Union. Policymakers should strengthen agri-environmental measures, promote carbon-efficient farming systems, and encourage innovation in sustainable agricultural technologies. Special attention should be given to supporting lagging regions through targeted incentives, capacity building, and the integration of environmental indicators into performance-based funding mechanisms. Limitations of the study arise primarily from the use of secondary data and aggregated EPI indicators, which may not fully capture specific regional variations or sectoral nuances. Future research should focus on detailed case studies of individual EU member states, the inclusion of time-series data to analyze trends, and the integration of economic performance indicators (e.g., agricultural productivity, investment efficiency, and rural income). This would allow a more comprehensive understanding of the interplay between agricultural sustainability, environmental performance, and economic development in the European context.

Conflict of interests

The authors declare no conflict of interest.

References

1. Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*, 115(25), 6506–6511. <https://doi.org/10.1073/pnas.1711842115>
2. Block, S., Emerson, J. W., Esty, D. C., De Sherbinin, A., Wendling, Z. A., et al. (2024). *2024 Environmental performance index*. Yale Center for Environmental Law & Policy. <https://epi.yale.edu/>
3. Cui, X., Bo, Y., Adalibieke, W., Winiwarter, W., Zhang, X., Davidson, E. A., ... & Zhou, F. (2024). The global potential for mitigating nitrous oxide emissions from croplands. *One Earth*, 7(3), 401–420. <https://doi.org/10.1016/j.oneear.2024.01.005>
4. Dabkiene, V., Balezentis, T., & Streimikiene, D. (2021). Development of agri-environmental footprint indicator using the FADN data: Tracking development of sustainable agricultural development in Eastern Europe. *Sustainable Production and Consumption*, 27, 2121–2133. <https://doi.org/10.1016/j.spc.2021.05.017>
5. European Commission (EC). (2019). Agriculture and climate change. https://ec.europa.eu/info/food-farming-fisheries/sustainability-and-natural-resources/agriculture-and-environment/agriculture-and-climate-change_en?cookies=disabled
6. European Commission (EC). (2021). Climate change - driving forces. *Eurostat Statistics Explained*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Climate_change_-_driving_forces#Agricultural_emissions
7. European Commission (EC). (2023, November 13). Study on options for mitigating climate change in agriculture by putting a price on emissions and rewarding carbon farming. https://climate.ec.europa.eu/news-your-voice/news/looking-how-mitigate-emissions-agriculture-2023-11-13_en
8. European Environmental Agency (EEA). (2024). Greenhouse gas emissions from agriculture in Europe. <https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-agriculture>
9. Finger, R., & Niklas, M. (2024). The emergence of pesticide-free crop production systems in Europe. *Nature Plants*, 10(3), 360–366. <https://doi.org/10.1038/s41477-024-01650-x>
10. Food and Agriculture Organization (FAO). (2011). *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk*. Food and Agriculture Organization of the United Nations.
11. Ilić, I. (2022). *The effects of integration of ecological measures in the Common agricultural policy of the European Union* (Doctoral dissertation). University of Nis, Serbia. <https://phaidrani.ni.ac.rs/view/o:1902>

12. Intergovernmental Panel on Climate Change (IPCC). (2023). *Summary for policymakers*. In *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1–34). Geneva, Switzerland. <https://doi.org/10.59327/IPCC/AR69789291691647.001>
13. International Energy Agency (IEA). (2023). *World Energy Outlook 2023*. <https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2aedf61467e070/WorldEnergyOutlook2023.pdf>
14. Krstić, M. (2024). Agriculture and greenhouse gas emission – results of econometric analysis. *Ekonomika Poljoprivrede*, 71(2), 427–441. <https://doi.org/10.59267/ekoPolj2402427K>
15. Larsen, A. E., Gaines, S. D., & Deschênes, O. (2017). Agricultural pesticide use and adverse birth outcomes in the San Joaquin Valley of California. *Nature Communications*, 8(1), 302. <https://doi.org/10.1038/s41467-017-00349-2>
16. Lenton, T. M., McKay, D. I. A., Loriani, S., Abrams, J. F., Lade, S. J., Donges, J. F., ... & Rockström, J. (2023). *The global tipping points report 2023*. University of Exeter. <https://global-tipping-points.org>
17. Martin, M., Elnour, M., & Siñol, A. C. (2023). Environmental life cycle assessment of a large-scale commercial vertical farm. *Sustainable Production and Consumption*, 40, 182–193. <https://doi.org/10.1016/j.spc.2023.06.020>
18. Milinčić, M., Tucović, M., & Mandić, B. (2013). Some aspects of agricultural influence on the environment. *Collection of Papers - Faculty of Geography at the University of Belgrade.*, 61, 31–58. <https://scindeks-clanci.ceon.rs/data/pdf/1450-7552/2013/1450-75521361031M.pdf>
19. Naam, R. (2013). *The infinite resource: The power of ideas on a finite planet*. UPNE.
20. Ncube, A., Fiorentino, G., Panfilo, C., De Falco, M., & Ulgiati, S. (2024). Circular economy paths in the olive oil industry: A life cycle assessment look into environmental performance and benefits. *The International Journal of Life Cycle Assessment*, 29(8), 1541–1561. <https://doi.org/10.1007/s11367-022-02031-2>
21. Organisation for Economic Co-operation and Development (OECD). (2016). *Agriculture and climate change: Towards sustainable, productive and climate-friendly agricultural systems*. https://www.oecd.org/agriculture/ministerial/background/notes/4_background_note.pdf
22. Ozdemir, I., Yngson, D. S. M. P., Israel, D., Otundo, J., Beasnael, N., Ceesay, A., & Zaman, A. (2023). COP28. <https://www.connaissancedesenergies.org/sites/connaissancedesenergies.org/files/pdf-actualites/cop-presidences-comparative-analysis-tracked7073-230927011708.pdf>
23. Paloviita, A., & Järvelä, M. (2015). Climate change adaptation and food supply chain management: An overview. In *Climate change adaptation and food supply chain management*. 19–32. Routledge. <http://urn.fi/URN:NBN:fi:ju-201709193760>

24. Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), 987–992. <https://doi.org/10.1126/science.aag0216>
25. Popp, J., Pető, K., & Nagy, J. (2013). Pesticide productivity and food security: A review. *Agronomy for Sustainable Development*, 33(1), 243–255. <https://doi.org/10.1007/s13593-012-0105-x>
26. Pretty, J. (2018). Intensification for redesigned and sustainable agricultural systems. *Science*, 362(6417), eaav0294. <https://doi.org/10.1126/science.aav0294>
27. Radivojević, V., Krstić, B., Krstić, M., & Petković, M. (2019). Benchmarking agricultural and other environmental performances of Central and East European countries. *Ekonomika Poljoprivrede*, 66(2), 471–484. <https://doi.org/10.5937/ekoPolj1902471>
28. Ritchie, H., & Roser, M. (2024). Half of the world's habitable land is used for agriculture. *Our World in Data*. <https://ourworldindata.org/global-land-for-agriculture?ref=insights.onegiantleap.com>
29. Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassalle, L., ... & Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, 562, 519–525. <https://doi.org/10.1038/s41586-018-0594-0>
30. van Der Werf, H. M., Knudsen, M. T., & Cederberg, C. (2020). Towards better representation of organic agriculture in life cycle assessment. *Nature Sustainability*, 3(6), 419–425. <https://doi.org/10.1038/s41893-020-0489-6>
31. Wang, Q. J., Wang, H. J., & Chang, C. P. (2022). Environmental performance, green finance and green innovation: What's the long-run relationships among variables?. *Energy Economics*, 110, <https://doi.org/10.1016/j.eneco.2022.106004>
32. Zhang, X. (2017). A plan for efficient use of nitrogen fertilizers. *Nature*, 543, 322–323. <https://doi.org/10.1038/543322a>
33. Zhang, X., Davidson, E. A., Mauzerall, D. L., Searchinger, T. D., Dumas, P., & Shen, Y. (2015). Managing nitrogen for sustainable development. *Nature*, 528, 51–59. <https://doi.org/10.1038/nature15743>
34. Żukowska, G., Myszura, M., Baran, S., Wesołowska, S., Pawłowska, M., & Dobrowolski, Ł. (2016). Agriculture vs. alleviating the climate change. *Problemy Ekorozwoju*, 11(2), 67–74. <https://ph.pollub.pl/index.php/preko/article/view/4944>

ASSESSMENT OF HUNGARIAN PLUM PRODUCTION COMPETITIVENESS ON THE SINGLE MARKET OF THE EU

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ABSTRACT

The research assesses the competitiveness of Hungarian plum production in the EU single market between 2004 and 2020. The plum production area remained relatively stable at 7,900 hectares during the observed period, whereas the yield per hectare fluctuated from 3.6 to 9.8 tones per hectare, influencing the annual plum harvest output from 27,000 to 70,000 tones per year. Hungary has predominantly been an export-oriented country with regard to in terms of plum production. This was supported by a positive RCA index measured during the investigated period. The most significant decrease in competitiveness was established at the end of the investigated period in 2020. According to the regression analysis results, harvested production was a highly significant positive predictor of RCA (standardized $\beta = 0.81$, $p < 0.001$). In order to preserve the competitive advantage of Hungarian plum production, it will be necessary to boost yield stability and add value to primary agricultural production.

Introduction

V4 (containing Czech Republic, Hungary, Poland and Slovakia) countries became members of the EU in 2004 along with six other countries. A study conducted by Svatoš and Smutka (2012) proved that three of them increased their agricultural production and export volumes. Hungarian agriculture faced challenges and structural decline. This unfavourable development was due to Hungary's focus on low-value commodities. Such a narrow approach and territorial focus of the export policy made Hungary

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vulnerable to market shocks. The results emphasized the need for diversification, value-added production, and alignment with the EU market to improve long-term performance. These needs can be fulfilled through the implementation of innovative technology, structural reforms, and improved market adaptability (Cuaresma et al. 2008; Böwer and Turrini, 2010).

Competitiveness of agricultural sector research has undergone a broad change in the past decades. Policy reforms alone are not sufficient unless they forget to address the small and medium-sized or otherwise disadvantaged farmers. In case of EU countries, it further requires adapting measures ensuring fair distribution of CAP finances (Gorton, M., Davidova, S., Ratinger, T., 2000; Viegas et al., 2023). Apart from adapting the political measures it is important to implement modern technologies in small and medium-sized farms as well. Digitalization can help to enhance resilience, sustainability, and global competitiveness too (Tomashuk et al., 2025).

High competitiveness of the agricultural sector does not automatically mean that it is sustainable from a long-term point of view, nor that it excels in productivity. Serbia is one of those countries with higher comparative advantages, but this is mostly based on low prices and comparatively high yields per hectare. Moreover, from the social and economic side, there is low labor productivity and outdated technology included which leads to lower added value in the chain. To improve this situation local economists recommend aligning national agricultural policy to the EU's CAP and investments in innovation and processing to ensure future competitiveness. Similar observations were seen in other Balkan countries as well as other less developed countries outside of the European continent (Ahmed et al., 2022; Chiarella et al., 2023; Dimitrijević et al., 2025).

The inconsistency with the international quality standards and low domestic processing confirmed the decreasing export and agricultural competitiveness in China. Over two decades, the competitiveness and comparative advantage (RCA) indices have proved the decreasing role of agriculture in global trade. The results have shown that to boost production, it is necessary to reform the national policies and align them with global policies to improve market access. Along with the policy reforms, it is necessary to improve the sector through investments in innovative technologies and structural reforms to reinforce the global trade position (Long, 2021; Dubey et al., 2022; Tang et al., 2024).

Similar results were observed in Malaysian agricultural production. Using a similar methodology, economists found out that only 1/3 of the commodities have a higher comparative advantage with palm oil as their top commodity. The reasons for negative development were prices, GDP per capita and reliance on exporting mainly raw materials with lower value added for long-term sustainability. Among the key factors that can improve the situation are stable prices on the market, a more skilled labor force, and capital investments in the sector to promote the processing and increase the value added (Siew-Ling Liew et al., 2021; Saxena et al., 2023).

Targeted and updated policy reforms along with the agility on the market, are important in enhancing competitiveness. Similar problems are observed globally, but are visible especially in India using indexes such as Revealed Comparative Advantage (RCA). For the past 30 years their agricultural production and export have increased in absolute values but their share of the global market is decreasing and indicating the loss of competitiveness. It provides another signal that quality is gaining over quantity, as the main challenges for Indian producers are not only higher transaction costs after COVID-19 but also lower phytosanitary standards. Current trade conditions and government contracts lead to higher exports to countries such as Bangladesh, Iran and Thailand (Kumar, 2022).

Positive impacts of changes in the policy can be observed in Romania. After entering the EU, Romania, as other new member states after 2004, was eligible for the Single Area Payment Scheme (SAPS). This supranational support led to stabilizing income and prices, especially in the case of the small and medium-sized farmers. Nevertheless, it should be emphasized that with positive impact on competitiveness came excessive bureaucracy and limited access to other financial sources. Furthermore, the economists claimed that long-term competitiveness requires policy reforms focused on innovation, market development, and structural modernization. Furthermore, the structure of ownership highly influences the distribution of subsidies (Cugleşan, 2021; Barral and Detang-Dessendre, 2023; Ionaşcu, 2024; Pokrivcak et al., 2025).

On the other hand, critical voices are emerging that relying on the Balassa's RCA analysis is both overestimated and limited in scope, and therefore, alternative aspects, such as circular economy principles and technological/digital innovations, should be brought into consideration in boosting competitiveness. Countries with high raw cereal exports (like Romania and Hungary) often lack competitiveness in processed foods, whereas countries with cereal trade deficits (like Italy and Ireland) excel in value-added exports. This suggests inefficiencies in resource management and underscores the need to trace added value along the entire agri-food chain. We can see cooperative networks in Asia or Europe but these seem to be more regionally embedded. More researchers call for a global agenda to address the emerging challenges. Similarly, Ukrainian researchers confirm that an integrated approach is necessary to enhance the competitiveness of agricultural enterprises. Amplifying the production can be achieved through innovative technologies, modern equipment, and high professional standards, all aligned with European quality benchmarks. On the other hand, the relationship between the producers and innovators is the main weakness (Istudor, et al., 2022; Mahiiiovych and Zelisko, 2022; Rodríguez-Mañay et al., 2024).

Competitiveness of the agricultural sector depends on several environmental, economic and social factors that enhance the effectiveness of the sector. Among the most important we can count innovation in the sector, investments into infrastructure, education in the country and lastly the public support. Innovation factor is connected to use of digital technologies such as drones or other types of automated systems focused on increasing productivity and sustainability. But even the increased role of the government does

not guarantee the resiliency of the sector. This can be achieved by activities focused on rural development and applying up to date environmental practices. There have been several studies carried out and all of them resulted in call for a comprehensive, multi-level approach combining public, social, economic and environmental efforts leading to increased competitiveness of the sector (Borisov et al., 2021; Abad-Segura et al., 2024; Rizzo et al., 2024; Kuandykova et al., 2025).

Based on the previously conducted research, the article focuses on a specific agricultural commodity (plum) in a selected EU country (Hungary). Investigation conducted by the statistical models seeks the answer what are actually the key production factors that determine revealed comparative advantage of Hungarian plum production on the Single market of the EU.

Materials and methods

The research conducts an investigation of Hungary's plum production and trade competitiveness between 2004 and 2020. It is a period beginning with Hungary's accession to the European Union. The time period was chosen for an assessment of competitiveness within the EU Single Market under relatively consistent policy conditions. Investigating the within this time series major disruptions after that date were avoided (such as Brexit and COVID-19). The data investigated within the article corresponds to annual observations within a 17-year period.

Following data sources were used for obtaining data for further analysis:

- Eurostat,
- Crop production under standard humidity,
- EU external trade database,
- Hungarian Central Statistical Office – national series on orchard area, fruit yields and gross production, cross-checked against Eurostat for consistency.

Table 1. Variables used for calculations

Variable	Unit	Identification
Orchard area (A)	Ha	Land under plum trees
Harvested production (P)	t	Total fresh plum output
Yield per ha (Y)	kg ha ⁻¹ (or t ha ⁻¹)	Productivity indicator
Exports (X)	€ 000	Trade supply to EU and world markets
Imports (M)	€ 000	Foreign supply to the Hungarian market

Source: prepared by authors

All monetary data are in current EUR. Physical quantities represent metric units (ha, kg, t).

Basic analysis of all variables has been provided by the descriptive statistics when each variable was observed for the observed period of time (N=17). Measures of central tendency, dispersion and variance were identified.

In order to identify competitive advantage of the country we used the concept of Revealed Comparative Advantage first introduced by Liesner (1958) and further improved by Balassa (1965). In the common years, there were significant modifications to the original competitiveness index introduced by Balassa (1965) with different approaches (Vollrath, 1991; Laursen, 1998; Yu et al., 2009). The competitiveness index introduced for the first time by T. L. Vollrath was applied in calculations based on its advantage of reflecting imports, normalized outcome and symmetric. Following this approach three formulas were adapted accordingly:

$$RXA_{i,a} = \ln\left(\frac{\frac{X_{i,a}}{X_{i,total}}}{\frac{X_{r,a}}{X_{r,total}}}\right) \quad (1)$$

Where:

- i Hungary
- a Product (fresh plums)
- r EU-27
- $X_{i,a}$ Hungary's plum exports
- $X_{i,total}$ Hungary's total exports
- $X_{r,a}$ EU plum exports
- $X_{r,total}$ EU total exports

$$RMA_{i,a} = \ln\left(\frac{\frac{M_{i,a}}{M_{i,total}}}{\frac{M_{r,a}}{M_{r,total}}}\right) \quad (2)$$

Where:

- $M_{i,a}$ Hungary's plum imports
- $M_{i,total}$ Hungary's total imports
- $M_{r,a}$ EU plum imports
- $M_{r,total}$ EU total imports

$$RCA_{i,a} = \ln(RXA_{i,a}) - \ln(RMA_{i,a}) \quad (3)$$

Where:

- $RXA_{i,a}$ Relative export advantage
- $RMA_{i,a}$ Relative import advantage
- $RCA_{i,a}$ Revealed comparative advantage
- $RCA > 0$ represents comparative advantage in plum production of Hungary.

In order to quantify relationships between production, factors observed within the previously conducted research and the revealed calculated advantage a multiple linear regression model was deployed:

$$RCA_t = \beta_0 + \beta_1 P_t + \beta_2 A_t + \varepsilon_t \quad (5)$$

Where:

RCA_t	Revealed comparative advantage in year t
P_t	Harvested production
A_t	Orchard area
β_0	Intercept
β_1, β_2	Slope coefficients
ε_t	OLS residual

Based on the regression analysis, a residual autocorrelation was conducted using the Durbin-Watson test:

$$DW = \frac{\sum_{t=2}^T (e_t - e_{t-1})^2}{\sum_{t=1}^T e_t^2} \quad (6)$$

Where:

E_t	Regression residual
T	Sample size
DW	Durbin-Watson static

Based on data processed and calculations conducted the two hypotheses were set as the primary aim of the article mentioned within the introduction part:

H1: There is a positive relation between harvested production and the RCA of Hungarian plum production.

H2: Orchard area does significantly affect RCA index of Hungarian plum production.

Results and Discussion

Characteristics of plum production in Hungary between years 2004 and 2020

The statistical data provide a comprehensive view of the development of plum cultivation in the period under review, analyzing three key indicators: production in tons, orchard area in hectares, and yield in kilograms per hectare. The following text interprets the minimum and maximum values, quartiles, averages, and variance, including standard deviation.

Table 2. Descriptive statistics of production (thsd. kg), area (thsd. hectare) and yield (thsd. kg/hectare)

Statistic	Production	Area	Yield
Number of observations	17	17	17
Minimum	27.040	7.060	3.607
Maximum	70.850	9.000	9.772
1st quartile	43.270	7.540	5.453
Median	46.020	7.920	5.960
3rd quartile	51.490	8.280	6.635
Mean	47.428	7.933	5.989
Variance (n)	134.635	0.350	2.217
Standard deviation (n)	11.603	0.591	1.489

Source: Authors' calculations based on Eurostat database (ds-045409)

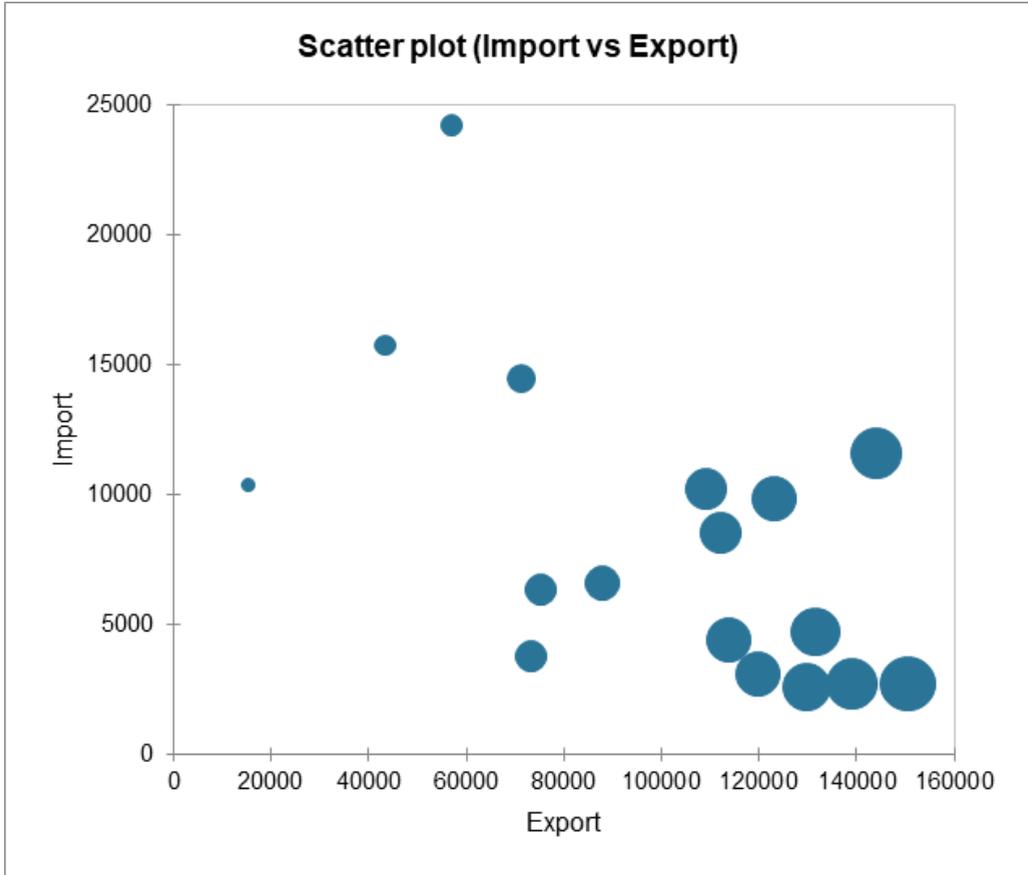
Plum production ranged from 27,040 tonnes (lowest) to 70,850 tonnes (highest). This significant difference indicates high interannual variability, probably caused by climatic conditions, diseases or interventions in orchard areas. The area of plum orchards fluctuated between 7,060 ha and 9,000 ha, which indicates a relatively stable area, without dramatic fluctuations. The yield per hectare reached only 3,607 kg/ha in the lowest year, while in the best year it reached 9,772 kg/ha. This variability indicates the influence of cultivation intensity, technology and climatic factors on production efficiency. The quartile distribution of the data suggests that most years are concentrated in the production range of 43,000 to 51,000 tonnes and yields between 5,400 and 6,600 kg/ha, with extreme fluctuations being the exception rather than the rule.

The average annual production was 47,428 tonnes, which is slightly above the median, indicating that extremely high values in some years increased the overall average. The average area of orchards was 7,933 ha, confirming the stability of the area. The average yield was 5,989 kg/ha, which is only slightly above the median. This indicates a uniform distribution of the data and no significant deviations.

The standard deviation of production at 11,603 tonnes indicates significant year-to-year fluctuations, probably caused by external factors such as weather or pest occurrence, while the standard deviation of orchard area of only 0.591 ha confirms their almost constant size, and the yield deviation of 1,489 kg/ha indicates slight to moderate variability, mainly influenced by growing conditions and technology.

Changes in Hungarian plum export and import values between 2004 and 2020

Figure 1. Import vs. export relation reflecting the trade balance value between the 2004 and 2020



Source: Authors' calculations based on Eurostat database (ds-045409)

Hungary is an export-oriented market economy with a strong emphasis on foreign trade. Its foreign trade is territorially focused primarily on EU member states, where the customs union ensures the free movement of goods and services. The following Figure 1 shows the relationship between the values of Hungarian plum exports and imports during the observed period from 2004 to 2020. In general, export values are higher than import values. In several years, however, imports exceeded exports, which may indicate an increased demand for imported plums. It can be concluded that Hungary is more of an exporter than an importer of plums. The volume of exports increased between 2004 and 2020, while imports remained relatively low.

Influence of area and harvested production on the revealed comparative advantage of the Hungarian plum production

In the following section, we compare the revealed export advantage, revealed market advantage, and revealed comparative advantage of Hungarian plum production between the years examined (2004-2020).

Table 3. Comparison of revealed export advantage, revealed market advantage and revealed comparative advantage of the Hungarian plum production between 2004 and 2020

Year	Ln RXA	Ln RMA	RCA
2004	1.93	-1,69	3.62
2005	0.81	-0,38	1.20
2006	2.32	-1,53	3.84
2007	1.36	-0,01	1.37
2008	1.98	-0,98	2.96
2009	2.19	-2,07	4.26
2010	2.22	-1,98	4.21
2011	1.69	-1,65	3.33
2012	2.21	-1,85	4.06
2013	2.00	-1,19	3.19
2014	2.06	-0,60	2.67
2015	1.74	-0,94	2.68
2016	2.08	-0,64	2.72
2017	1.69	-0,47	2.15
2018	1.87	-0,78	2.66
2019	1.96	-0,17	2.13
2020	0.45	-0,64	1.10

Source: Authors' calculations based on Eurostat database (ds-045409)

The revealed export advantage indicator varied during the period under review, but in most years RXA is above 1, which means that Hungary had a relative advantage in plum exports. The highest value was observed in the year 2006 (2.32)... The RMA indicator is below 1 in all observed years, which means that Hungary primarily focused on exports and less on plum imports. The latter RCA indicator was significantly above 1 in almost all years, meaning that Hungary had a strong comparative advantage in plum exports in the long term.

The highest value was in 2009 (4.26) and 2010 (4.21), the strongest years for plum exports. The last RCA indicator was significantly above 1 in almost all years, which means that Hungary has had a strong comparative advantage in plum exports in the long term. The highest value was in 2009 (4.26) and 2010 (4.21), the strongest years for plum exports. In 2020, the RCA dropped sharply to 1.10, indicating that Hungary has lost its dominance in this sector.

The above values show that Hungary was a strong exporter of plums in period 2009-2019, while imports were minimal. The situation started to change in 2017, when

imports started to grow, and exports decreased. In 2020, a turning point occurred, when Hungary lost its export and comparative advantage. This situation occurred due to a combination of several factors. In particular, weather problems are the main reason for the decrease in trade volume and imports of fresh plums. Trade prices move along with the availability of fruit. Shortages result in higher prices. Plums must remain affordable, otherwise consumers will not buy them. Lower availability and high prices increase opportunities for alternative suppliers, especially in neighboring countries.

Comparison of revealed market advantage and revealed export advantage as factors of the revealed comparative advantage

Table 4. Regression analysis between harvested production, area and RCA

Analysis of variance (RCA)							
Source	DF	Sum of squares	Mean squares	F	Pr > F	p-values signification codes	
Model	2.000	10.400	5.200	12.262	0.001	****	
Error	14.000	5.937	0.424				
Corrected Total	16.000	16.337					
<i>Computed against model Y=Mean(Y)</i>							
<i>Signification codes: 0 < **** < 0.001 < *** < 0.01 < ** < 0.05 < . < 0.1 < * < 1</i>							
Model parameters (RCA)							
Source	Value	Standard error	t	Pr > t	Lower bound (95%)	Upper bound (95%)	p-values signification codes
Intercept	3.189	2.134	1.494	0.157	-1.389	7.767	*
Area	-0.454	0.273	-1.661	0.119	-1.040	0.132	*
Harvested production	0.068	0.014	4.911	0.000	0.039	0.098	****
<i>Signification codes: 0 < **** < 0.001 < *** < 0.01 < ** < 0.05 < . < 0.1 < * < 1</i>							
Standardized coefficients (RCA)							
Source	Value	Standard error	t	Pr > t	Lower bound (95%)	Upper bound (95%)	p-values signification codes
Area	-0.274	0.165	-1.661	0.119	-0.627	0.080	*
Harvested production	0.810	0.165	4.911	0.000	0.456	1.163	****
<i>Signification codes: 0 < **** < 0.001 < *** < 0.01 < ** < 0.05 < . < 0.1 < * < 1</i>							

Source: Authors' calculations based on Eurostat database (ds-045409)

Regression analysis showed that the model consisting of two explanatory variables – area and harvested production – has a statistically significant explanatory power in relation to the RCA indicator.

In order to verify autocorrelation a Durbin-Watson test has been implemented to the calculation.

Table 5. Durbin-Watson test of harvested production, area and RCA variables

DW	1.639
rho	0.133
p-value (one-tailed)	0.334
alpha	0.05

Source: Authors' calculations based on Eurostat database (ds-045409)

The resulting Durbin-Watson statistical value (Table 5.) of $DW = 1.639$ indicates a weak positive autocorrelation. The p-value (0.334) exceeds the significance level of 0.05. This result suggests that the regression model satisfies the assumption of independence of residuals, supporting its statistical reliability in terms of autocorrelation. The residuals are not autocorrelated.

Based on the values measured in the regression analysis, it was also possible to identify hypotheses H1 and H2. Hypothesis H1 focused on the positive relationship between RCA and Hungarian plum exports. For the years 2004 to 2020, regression analysis (Table 4.) identified that the coefficient for the variable harvested production had a positive value (0.068) at a significance level of $p < 0.001$. At the same time, based on the results obtained, it was identified that the variable harvested production has a strong influence on RCA (standardized coefficient 0.810). Thus, in the case of the indicator under review, an increase in plum production in Hungary leads to an increase in RCA itself, and the scope of production is a key factor in Hungary's competitiveness in the agricultural commodity of plums on the single EU market.

In the case of hypothesis H2, which examined the positive effect of orchard area on RCA, the measurement results were different. In this case, hypothesis H2 was not confirmed, as the value $\beta = -0.454$ was negative. However, on the other hand, this result was not supported by the required level of significance (measured value $p = 0.119$). The standardized coefficient was -0.274, which is statistically inconclusive. In view of the above, it was identified in the case of hypothesis H2 that changes in orchard size do not have relevant predictive value or are statistically unreliable when assessing their significance for RCA Hungary in plum production.

Conclusions

Plum production in Hungary has experienced a change in trade dynamics over the observed period (2004-2020). According to the data observed, the area of plum orchards has remained relatively stable (averaging around 7,900 hectares). A more dynamic

development was apparent in the yield per hectare, which oscillated between 3.6 and 9.8 tonnes per hectare. This value reflects the yearly variations in climate conditions that fruit growers have experienced in recent decades. Based on these changes, the annual plum production also varied significantly. Production experienced significant changes during the observed period, reaching values ranging from 27,000 to 70,000 tonnes (averaging 47,000 tonnes). Hungary remained an export-oriented country within the EU single market for most of the time, but this changed due to a decrease in production in 2020. The RCA index calculated for the entire period of Hungarian plum production research corresponded with these findings, decreasing to 1.1 in 2020 and indicating that Hungary's once strong comparative advantage in this area had almost been lost by the end of the research period.

Based on previous findings, statistical analysis in the form of regression was conducted to obtain further economic data to support the evidence obtained from initial descriptive statistics and the RCA calculation. These findings provide evidence of the significance of harvested production on the RCA index in relation to the cultivated production area in Hungary. Thus, the results show evidence of a strong association between an increase in output and a subsequent increase in the RCA index value. Thus, we have confirmed the H1 hypothesis. However, changes in the orchard area proved to be a very limited factor affecting the RCA index (rejecting the H2 hypothesis). This shows that achieving higher yields per hectare through improved technology and practices is more important for the sustained competitive advantage of Hungarian plum production in the EU single market than expanding the area of plum orchards. This particular case study provides evidence that land-use efficiency and production intensity have a greater impact on plum competitiveness than land area alone in Hungary during the observed period.

The observed decline in the RCA index, which proves a decline in competitiveness by 2020, is driven by both external factors, such as weather-induced crop shortfalls or growing market competition, and internal factors, such as farm efficiency and infrastructure. This leads to the need for strategic interventions to strengthen Hungary's plum production sector. In order to protect its competitive advantage in the EU single market against other EU countries, targeted measures should be pursued, including investment in technology and innovation, climate variability resilience, value-added processing, and market adaptability.

Conflict of interest

The authors declare no conflict of interest.

References

1. Abad-Segura E., Castillo-Díaz F. J., Batlles-delaFuente A., Belmonte-Ureña L. J. (2024). Enhancing competitiveness and sustainability in Spanish agriculture: The role of technological innovation and corporate social responsibility. *Business Strategy Development*, 7, e70021. <https://doi.org/10.1002/bsd2.70021>

2. Ahmed M., Asim M., Ahmad S., Aslam M. (2022). Climate change, agricultural productivity, and food security. In: Ahmed M. (Ed.), *Global Agricultural Production: Resilience to Climate Change*, 31–72. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-031-14973-3_2
3. Balassa B. (1965). Trade liberalization revealed comparative advantage. *The Manchester School of Economic and Social Studies*, 33, 99–123. <https://doi.org/10.1111/j.1467-9957.1965.tb00050.x>
4. Barral S., Detang-Dessendre C. (2023). Reforming the Common Agricultural Policy (2023–2027): Multidisciplinary views. *Review of Agricultural, Food and Environmental Studies*, 104, 47–50. <https://doi.org/10.1007/s41130-023-00191-9>
5. Borisov P., Stoeva T., Dirimanova V. (2021). Methodology for assessing the competitiveness of agricultural enterprises. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 21(4), 81–88.
6. Böwer U., Turrini A. (2010). EU accession: A road to fast-track convergence? *Comparative Economic Studies*, 52, 181–205. <https://doi.org/10.1057/ces.2010.7>
7. Chiarella C., Meyfroidt P., Abeygunawardane D., Conforti P. (2023). Balancing the trade-offs between land productivity, labor productivity and labor intensity. *Ambio*, 52, 1618–1634. <https://doi.org/10.1007/s13280-023-01887-4>
8. Crespo Cuaresma J., Ritzberger-Grünwald D., Silgoner M. A. (2008). Growth, convergence and EU membership. *Applied Economics*, 40(5), 643–656.
9. Cugleşan N. (2021). Romania and post-accession compliance with EU environmental policy. In: Todor A., Helepciuc F. E. (Eds.), *Europeanization of Environmental Policies and Their Limitations: Capacity Building*, 151–164. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-68586-7_10
10. Dimitrijević M. S., Mrdalj V., Leković M. (2025). Competitiveness of the agricultural sector of Southeast Europe: The Western Balkans vs. European Union. *Ekonomika Poljoprivrede*, 72, 255–269. <https://doi.org/10.59267/ekoPolj2501255D>
11. Dubey S. K., Gills R., Singh A., Sah U., Burman R. R. (2022). Agricultural value chains: A cardinal pillar for future development and management of farming. In: Kumar A., Kumar P., Singh S. S., Trisasonko B. H., Rani M. (Eds.), *Agriculture, Livestock Production and Aquaculture: Advances for Smallholder Farming Systems*, 2, 243–273. Springer International Publishing, Cham.
12. Eurostat: EU trade since 1988 by HS2-4-6 and CN8 (ds-045409)
13. Gorton M., Davidova S., Ratering T. (2000). The competitiveness of agriculture in Bulgaria and the Czech Republic vis-à-vis the European Union. *Comparative Economic Studies*, 42, 59–86.
14. Ionaşcu A. (2024). Impact and challenges of SAPS1 on Romanian agricultural competitiveness. *Proceedings of the International Conference on Business Excellence*, 18, 1613–1626. <https://doi.org/10.2478/picbe-2024-0134>

15. Istudor N., Constantin M., Ignat R., Chiripuci B.-C., Petrescu I.-E. (2022). The complexity of agricultural competitiveness: Going beyond the Balassa index. *Journal of Competitiveness*, 14(4), 61–77. <https://doi.org/10.7441/joc.2022.04.04>
16. Kuandykova M., Khishauyeva Z., Salzhanova Z., Zhangirova R., Kernebaev A., Horská E. (2025). Increasing the competitiveness of the agricultural sector. *Montenegrin Journal of Economics*, 21(2), 285–296.
17. Kumar K. N. R. (2022). Competitiveness of Indian agricultural exports: A constant market share analysis. *Research on World Agricultural Economics*, 3, 25–38. <https://doi.org/10.36956/rwae.v3i2.514>
18. Liesner H. H. (1958). The European common market and British industry. *The Economic Journal*, 68(270), 302–316.
19. Long Y. (2021). Export competitiveness of agricultural products and agricultural sustainability in China. *Regional Sustainability*, 2, 203–210. <https://doi.org/10.1016/j.regsus.2021.09.001>
20. Mahiiovych R., Zelisko N. (2022). Increasing the competitiveness of agricultural enterprises in conditions of economic risks. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(1), 385–392.
21. Pokrivcak J., Toth M., Ciaian P., Juliny M. (2025). Does farm ownership structure matter? Distribution of CAP subsidies between primary and final beneficiaries in Slovakia. *Agricultural Economics (Zemědělská Ekonomika)*, 71, 71–85. <https://doi.org/10.17221/186/2024-AGRICECON>
22. Rizzo G., Migliore G., Schifani G., Vecchio R. (2024). Key factors influencing farmers' adoption of sustainable innovations: A systematic literature review and research agenda. *Organic Agriculture*, 14, 57–84. <https://doi.org/10.1007/s13165-023-00440-7>
23. Rodríguez-Mañay L. O., Guaita-Pradas I., Marques-Pérez I. (2024). Competitiveness in the agricultural sector: A literature review. *Clio América*, 18, 52–69. <https://doi.org/10.21676/23897848.5913>
24. Saxena R., Singh R., Agarwal P., Kumar R., Raman M. S. (2023). Structure, performance and competitiveness in Indian agricultural exports. In: Narula S. A., Raj S. P. (Eds.), *Sustainable Food Value Chain Development: Perspectives from Developing and Emerging Economies*, 295–317. https://doi.org/10.1007/978-981-19-6454-1_14
25. Siew-Ling L., Arip M. A., Puah C.-H. (2021). Determinants of export competitiveness of agricultural products in Malaysia. *International Journal of Business and Society*, 22, 618–636. <https://doi.org/10.33736/ijbs.3747.2021>
26. Svatoš M., Smutka L. (2012). Development of agricultural trade and competitiveness of the commodity structures of individual countries of the Visegrad Group. *Agricultural Economics (Zemědělská Ekonomika)*, 58, 222–238. <https://doi.org/10.17221/51/2011-AGRICECON>

27. Tang H., Liu X., Li M. (2024). Research on the influencing factors of Chinese agricultural brand competitiveness based on DEMATEL-ISM. *Scientific Reports*, 14, 11363. <https://doi.org/10.1038/s41598-024-62068-1>
28. Tomashuk I., Koliadenko S., Burdiak M. (2025). The impact of digital innovations on the development of agricultural business. *Baltic Journal of Economic Studies*, 11, 361–375. <https://doi.org/10.30525/2256-0742/2025-11-1-361-375>
29. Viegas M., Wolf J., Cordovil F. (2023). Assessment of inequality in the Common Agricultural Policy in Portugal. *Agricultural and Food Economics*, 11, 13. <https://doi.org/10.1186/s40100-023-00255-w>
30. Laursen K. (2015). Revealed comparative advantage and the alternatives as measures of international specialization. *Eurasian Business Review*, 5, 99–115.
31. Vollrath T. L. (1991). A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage. *Weltwirtschaftliches Archiv*, 127(2), 265–280.
32. Yu R., Cai J., Leung P. (2009). The normalized revealed comparative advantage index. *The Annals of Regional Science*, 43, 267–282.

CUSTOMER SHOPPING ORIENTATION AND PERCEPTIONS OF FOOD LOYALTY PROGRAM REWARDS: A SOCIAL EXCHANGE PERSPECTIVE

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ABSTRACT

Loyalty as the basis for developing long-term relationships with customers is researched in the frame of Social Exchange Theory. Companies invest a lot in loyalty programs to ensure adequate customer relationship management. The survey on random sample of Serbian citizens aims to identify factors that cause satisfaction or dissatisfaction with loyalty programs and, through understanding them, direct further efforts in the development of these programs. The research tested and proved the influence of the instant of rewards, but also the functionality of the applications especially on mobile phones, indicating differences in purchasing food and non-food products.

Introduction

Loyalty programs (LPs) have proven to be key competitive assets of retailers, especially in highly competitive markets, such as food retail, where the maximization of customer retention and lifetime value is an unavoidable success precondition (Neset et al., 2021). Therefore, understanding how customers perceive and engage with different LP rewards is vital for grocers to design and implement a well-functioning and attractive LP.

LP implementation revolves around understanding relations among different LP rewards, LP functionalities, customer value perceptions and behavioral determinants. Prior research has shown that LP rewards, observed as direct or indirect, tangible or intangible, drive customer satisfaction, increase perceived value, and subsequently

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increase overall loyalty (Y. Hwang & Mattila, 2018; Meyer-Waarden, 2015). Moreover, the effectiveness of LPs has been shown to depend not only on the reward characteristics themselves but also on customers' shopping motivations and orientations, as they influence customers' reward preferences and responsiveness to loyalty initiatives (Bombaj & Dekimpe, 2020; García Gómez et al., 2012). Despite these insights, existing literature does not provide an answer on how customers' perception and preferences of specific LP rewards and functionalities differ depending on customers' shopping (loyalty) orientation.

Customer attitudes towards loyalty rewards and functionalities are influenced by their relational and transactional orientations towards the retailer. This in terms is directly reflected onto customer's long-term LP engagement and overall loyalty (Rehnen et al., 2017). This perspective is theoretically grounded in Social Exchange Theory (SET), framed by the fact that individuals engage in and maintain relationships based on subjective evaluations of the rewards and costs associated with these exchanges (Emerson, 1976). SET provides a valuable relational perspective on customer LP participation and perception, as customers weigh the perceived benefits of LP rewards against the efforts or constraints of program participation (Cropanzano et al., 2017). The theory suggests that customer perceptions of rewards are not uniform, but rather contingent upon individual shopping (loyalty) orientation, which affects the perceived utility and emotional value of LP participation.

By basing our conceptual model in SET, we could explore how customer shopping orientation influences the perception of loyalty program rewards in the food retail sector. Thus, our guiding research question was how does LP ownership shape customers' preferences towards different LP rewards and functionalities. The paper aims to provide precise insights into how customer segments differentiated by shopping (loyalty) orientation assess LP rewards and functionalities. Research findings have several managerial implications, which can help retailers align their LP reward structures with customer expectations and their perceived value frameworks.

The paper is structured to adequately explore the research question. Next section is dedicated to the overview of relevant theoretical concepts and literature, followed by implemented research methodology. The next two sections cover the results of hypotheses testing with corresponding discussion. The final section includes concluding remarks, along with research limitations and future research outlook.

Literature Review and hypothesis development

Building customer loyalty in retail

In its broadest sense a loyalty program (LP) represents an incentive-based marketing instrument aimed at generating customer loyalty (J. Hwang & Choi, 2020). Loyal customers can be perceived as those with formed identifications to retailer's brand, products, services or employees (Jones & Sasser, 1995). However, creating and maintaining customer loyalty is not an easy task in a competitive retail market.

Companies have been investing significant effort in maintaining relationships with their customers, recognizing that attracting new shoppers is much costlier than keeping the existing ones (Mainardes et al., 2020).

There is ample of motivation for retailers to develop loyalty programs. Loyal customers tend to stay with the chosen retailer longer, spend more money on its products and shop more frequently (Meyer-Waarden & Benavent, 2009). Also, loyalty drives customers to be less price sensitive, have a positive attitude towards the retailer and be less prone to disappointment in bad service situations (Danaher et al., 2016).

On the other hand, customers continuously compare their perceived benefits and perceived costs. The resulting difference, if positive, constitutes perceived value created, manifested through positive emotional response, satisfaction or motivation (Y. Hwang & Mattila, 2018). Basically, value for the customer is generated through loyalty program rewards, since rewards lead to a fulfillment of customers' desires or goals (J. Hwang & Choi, 2020).

Loyalty program rewards and customer shopping orientation

Loyalty reward programs consist of well-integrated marketing incentives aimed at increasing customer spending and shopping frequency (Y. Hwang & Mattila, 2018). These incentives, or rewards, represent any concrete or abstract customer-oriented stimuli which lead to a positive mental response (Meyer-Waarden, 2015).

Although with the same end goal, loyalty program rewards differ significantly amongst themselves. Consequently, existing literature diverges into several categorization paths. Kim et al. (2021) point out hard and soft loyalty program benefits, in which rewards, such as prizes, discounts or rebates represent tangible benefits, whereas soft benefits revolve around special customer privileges, such as personalized communication, cueing prioritization, etc. Similarly, Bombaij and Dekimpe (2020) differentiate between direct and indirect retailer rewards. Direct rewards are related to the retailer, such as giveaway products, whereas indirect rewards are unrelated to the retailer.

Within the existing loyalty program reward literature there are two distinct research directions – the one focused on the effects of reward program characteristics and design, and the other analyzing the influence of customer behavioral and psychographic characteristics on loyalty reward preferences. Furthermore, customer's value perception of LP rewards has been shown to influence their loyalty towards the LP (J. Hwang & Choi, 2020), while LP design undeniably affects customer loyalty and LP enrolment (Meyer-Waarden, 2015).

By focusing on differentiating between direct and indirect rewards, Rothschild and Gaidis (1981) demonstrated that direct rewards are more likely to trigger desired customer response, due to more intrinsic value being delivered to the customer. Direct rewards are an effective marketing tool for retailers to further improve customer loyalty (Bombaij & Dekimpe, 2020). Söderlund and Colliander (2015) investigated how customer satisfaction changes depending on the three types of rewards in a retail LP (under-reward, equity reward, and over-reward).

LP rewards are oftentimes put in the specific context of customers' mindset or behavioral pattern. One example is determining that when customer satisfaction is high, delayed rewards are better suited to driving customer loyalty compared to immediate rewards (Huang & Chen, 2010). On the other hand, shopping motives are also very important when it comes to shaping customer's loyalty (García Gómez et al., 2012). In this context, Taylor and Neslin (2005) show that a frequency reward program can cause customer response in terms of price consciousness and shopping enjoyment.

Within the domain of customer's denominators of LP rewards preferences, shopping orientation plays an important role. Shopping orientation stems from two distinct research streams – the one that underlines shopper's propensity towards shopping, and the other emphasizing the importance of context, such as purchasing situation or product category (Jensen, 2011). For example, Jang and Mattila (2005) showed that immediate monetary rewards are preferred by customers to nonmonetary ones, when visiting fast food or casual dining restaurants. Similarly, Cortiñas et al. (2008) observed brand choices within different product categories of card and non-card holders.

LP effectiveness varies significantly depending on LP design characteristics, such as the program structure, reward content and delivery, as well as industry characteristics (Belli et al., 2022). This has driven many researchers to focus their effort on deciphering the importance of shopping orientation on grocery LPs (Bombajj & Dekimpe, 2020; Filipe et al., 2017; Meyer-Waarden et al., 2023; Nettet et al., 2021). These papers mainly investigate the effect of customers' predominant orientation on food retailers and food product categories. There are also few papers focused on the non-food loyalty program context, such as the one by Das (2014).

In sum, prior research on LP reward programs is abundant and clearly shows that shopping orientation of LP users affects their purchasing decision-making. Although several papers have confirmed that LP reward (preferences) vary depending on specific customer shopping orientations and LP reward preferences, to date there have been insufficient studies on customer preferences of different LP reward types, depending on the customer shopping orientation displayed through food or non-food LP ownership. The following section introduces social exchange theory as a theoretical foundation for deriving hypotheses suggesting that LP owners' shopping orientation influences their preferences towards specific LP rewards.

Social exchange theory

Social exchange theory, according to Blau (1986) in its broadest sense deciphers long-term behavior of individuals (or organizations) in the conditions of tangible and intangible resource exchange. The underlined notion in the context of marketing application is that resources can over time evolve into long-standing relationships (Cropanzano et al., 2017), and ultimately customer loyalty (Casper Ferm & Thaichon, 2021).

Possessing a distinct utilitarian premise, SET suggests that customer decision is preceded by a subjective cost-benefit analysis (Emerson, 1976). Within these considerations,

customers are often faced with a choice of whether or not to engage and/or maintain a relationship with the seller (Chang et al., 2015).

As a well-established theory, SET functions as an explanatory and predictive framework whose power and precision depend on the manner in which a customer actually fits a specific category or a segment (Emerson, 1976). Although customers derive satisfaction as the difference between perceived rewards and costs, this equation's outcome varies depending on relationship dynamics, inter-personal influences and developed emotions (Lee et al., 2014).

Rewards, as well as other aspects such as promotions, fall into the category of extrinsic benefits for the customer. These are also coupled by different intrinsic benefits as well (Casper Ferm & Thaichon, 2021). As per SET, customer perception of different loyalty reward programs can differ depending on associations to specific behavioral or psychological customer categories. In their paper, Rehnen et al. (2017) showed that attitudinal loyalty of customers gathering loyalty points is much more demonstrated on social media, compared to traditional transactions. Fan et al. (2021) also implemented SET to observe how employee loyalty changes with the level of ethical leadership.

On the basis of SET's notion of loyalty development and reward perception, this study will try to understand how customer shopping (loyalty) orientation influences customer perception of loyalty reward schemes.

Hypotheses

Literature on LP functionalities and reward systems is abundant, covering multiple topics, such as comparisons between different types of reward types, conditions of reward preferences, importance of various LP functionalities on LP usage, etc. Despite being abundant, there are several shortcomings present in the existing literature. As pointed out by Bombaij and Dekimpe (2020), although the importance of LP rewards and functionalities have been confirmed, research on specific elements is mostly not present. In this sense, when analyzed, design elements are observed individually, in empirical isolation, very rarely together with other LP design aspects. Furthermore, very few contingency factors are considered in these studies.

Several studies confirm the positive effect that the well implement LP design elements have on increasing LP effectiveness (Danaher et al., 2016), customer enrollment and overall loyalty (Meyer-Waarden, 2015). Following the reasoning of Hwang & Choi (J. Hwang & Choi, 2020) who demonstrated in their paper that consumer evaluations of LP rewards and functional characteristics influence their loyalty towards the LP, we propose following hypotheses:

H1. Loyalty program owners value LP rewards more than non-users.

H2. Loyalty program owners value LP functionalities more than non-users.

The literature review pointed out that customer shopping orientation is also an important aspect to consider when investigating customer perception of different LP

design elements. In this regard, most studies focus on comparing customers with and without LP, whilst only few implement a non-binary empirical approach (Bruneau et al., 2018). Drawing upon this, in our study we also differentiate between LP users and non-users, however we further classify the customer shopping (loyalty) orientation into three distinct groups – food LP owners, non-food LP owners, and owners of both types of LPs.

By doing so, we observe our respondents' attitude and exhibited behavior towards sellers of specific product categories. Thus, food LPs are related to grocery retailers, whereas non-food LPs are related to pharmacies, bookstores, petrol stations, etc. Extending our research along this premise, we can formulate two additional hypotheses:

H3. Customer shopping (loyalty) orientation affects customer perception of LP reward.

H4. Customer shopping (loyalty) orientation affects customer perception of LP functionalities.

Methodology

Sample selection and data collection

The total number of respondents was 800 adult citizens of Serbia aged 18 to 64 (Table 1). The respondents were recruited from a panel using a quota sample with key variables being age, gender and region. Quotas were set based on the latest official Census data (SORS, 2022).

Table 1. Sample description

VARIABLE	N	%
AGE		
18-24	96	12.0%
25-34	156	19.5%
35-44	185	23.1%
45-54	184	23.0%
55-64	179	22.4%
EDUCATION		
Incomplete primary school	3	0.4%
Primary school	13	1.6%
Secondary school, high school	367	45.9%
College (3-year post-secondary)	147	18.4%
University degree (Bachelor's)	213	26.6%
Master's, Magister or Doctorate	57	7.1%
MARITAL STATUS		
Living alone	145	18.1%
Married, in a common-law union, living with a partner	457	57.1%
Divorced	70	8.8%
Widower / Widow	31	3.9%
Prefer not to answer	97	12.1%

VARIABLE	N	%
HOUSEHOLD SIZE		
1	145	18.1%
2	135	16.9%
3	150	18.8%
4	191	23.9%
5	92	11.5%
6 or more	45	5.6%
Prefer not to answer	42	5.3%
EMPLOYMENT STATUS		
Employed full-time	495	61.9%
Employed part-time	18	2.3%
Self-employed	56	7.0%
Farmer	19	2.4%
Currently unemployed	91	11.4%
Retired	25	3.1%
In education (including occasional work while studying)	45	5.6%
Homecare	14	1.8%
Prefer not to answer	37	4.6%
PERSONAL MONTHLY INCOME		
No personal income	73	9.1%
Up to 30,000 RSD	35	4.4%
30,001 – 50,000 RSD	42	5.3%
50,001 – 75,000 RSD	105	13.1%
75,001 – 100,000 RSD	160	20.0%
100,001 – 125,000 RSD	114	14.3%
125,001 – 155,000 RSD	66	8.3%
155,001 – 185,000 RSD	25	3.1%
185,001 – 225,000 RSD	20	2.5%
More than 225,001 RSD	16	2.0%
Prefer not to answer	144	18.0%
CUSTOMER SHOPPING (LOYALTY) ORIENTATION		
Only have food LP	83	10.4%
Only have non-food LP	102	12.8%
Possess both types of LP	444	55.5%
Do not possess LP	171	21.4%

Source: Authors' calculations

Demographic and socio-economic variables used in quota setting were interlinked to avoid skewed recruitment and sample which would result in sample distortion and predominant recruitment of respondents of a certain age or gender in a certain region. Consumers' educational, occupation and income levels were observed as proven predictors of consumer loyalty behavior (White & Tong, 2019). For example, high-income customers react to marketing instruments differently from the low-income ones, especially when it comes to retail prices, which is reflected onto their attitude towards loyalty (Klopotan et al., 2016). By crossing demographic variables and setting

more detailed quotas, greater fit of the sample to population data was enabled while a well-recruited sample leads to higher-quality data.

Exclusion criteria included underaged respondents, while participating in loyalty program was not used in the recruitment process with both users and non-users included into the study. The sample is likely to be biased towards more digitally literate respondents due to panel data collection method and may not be fully representative of the broader population of adults in Serbia.

The panel that was used for the study was based on overall non-probability sampling which does not guarantee that each individual has a known chance of selection, which is an additional limitation for the sample representativeness. The panel was opt-in panel recruited through online advertisement. The participation in the study included incentives such as points.

Instruments for data collection

The mindset a customer adopts when shopping, focusing on the objectives, whether they be efficiency or enjoyment, is known as shopping orientation. It can be categorized as either task-focused, where the objective is to make a purchase quickly and efficiently, or experiential, where the focus is on the pleasure, enjoyment, discovery or elements of the shopping experience (such as browsing aisles or looking for inspiration). This study employed food and non-food shopping, and shopping of both categories, as the categories influence how shoppers navigate the process and interrelate with different product categories. Both Food Shopping Orientation and Non-Food Shopping Orientation might be task focused (consumers prioritize the speed and efficiency) or experiential (shoppers may enjoy exploring new food options, discovering ingredients or a new smell of detergent, browsing for a new style of clothing, etc.). Other Shopping Orientations might include Value-Consciousness (shoppers seek a balance between price and quality), Convenience-Oriented (shoppers may be willing to pay more for convenience or speedy access to things because they value ease and speed when buying), etc.

The questionnaire measured demographic data (gender, age, region, type of settlement urban and rural), as well as loyalty programs usage, and the most often used loyalty program in different product categories (groceries, cosmetics, pharmacy products, products at gas stations, pharmacy products, products at gas stations, sports equipment, products in bookstores, with open ended options at the end to fill in other types of products for which respondents have loyalty programs). Focus was on frequently used and large monthly expenditures products, low price categories. Loyalty program usage was measured on multiple selection question, while the most often used loyalty program was identified on a single item selection question. The key analytical questions were related to likability of the reward systems and functionalities in loyalty programs and how much shoppers would like each of them to be in their loyalty program and the importance of particular selected functionalities on a Likert 1 to 5 scale. Research from multiple areas (i.e. education, advertising, employee attitudes, social studies, studies

of medical outcomes, marketing, etc.) show that single-item scales provide reliable measures comparable with multiple scales (Bergkvist & Rossiter, 2007, 2009; Youngblut & Casper, 1993). Single item scales are particularly useful to control the length of the questionnaire, with repeating multiple-item scales fatiguing for respondents. Independent variables are tangible and one-dimensional, also fitting for single item scales.

The theoretical framework of the study directed us to items related to rewards and functionality of loyalty programs in order to confirm both types of aspects and their role in loyalty management. Loyalty programs and rewards are closely related. Rewards are a crucial tool used by loyalty programs to motivate consumer interaction and create enduring bonds, which promotes repeat business and brand promotion.

We included 6 items related to rewards drawn from the literature review:

- Point collection (q1) – as a basic mechanism and well-integrated incentives to earn rewards in LP, aimed at increasing customer spending and shopping frequency (Y. Hwang & Mattila, 2018).
- Product discounts at the register (q2) and Occasional larger rewards (q3) – items related to the effects of reward program characteristics and design, we based this item on differentiating between direct and indirect rewards (Rothschild & Gaidis, 1981). Based on their research we are testing direct rewards, as a mechanism which is more likely to trigger desired customer response, due to more intrinsic value being delivered to the customer.
- Personalized rewards (q4) – well known mechanism of rewards, indirectly linked to psychographic characteristics, directly to the loyalty reward preferences, as well as to value perception of LP rewards which has been shown to influence customer loyalty and LP enrolment (Meyer-Waarden, 2015).
- Profile instant info and data (q5) and Combined household reward gathering (q6) – items testing customer preferences of different LP reward types, and linked to the customer shopping orientation related to household, as a unit, which approaches shopping and manages rewards, including the household's goals, preferences, and the specific context of households shopping trips.

Apart from rewards, we also included 7 items related to functionalities. Tested functionalities are included at the hypothetical level related to customer behavioral and psychographic characteristics, more specifically to basic human values (Schwartz's theory of basic human values). We tested speed (q8. Fast activation at the register), ease of access (q9. Easy access to customer profile) and notification types customization, assuming they are linked to hedonic values. Reward control through profile (q10. Point and reward control through profile), automatic purchase recording (q7. Automatic purchase recording) and notification control (q13. Notification type customization) were also included, with the assumption they are linked to one of the basic controlling needs. Finally, we observed family LP and point transferability (q11. Family LP, and q12. Point transferability), which are assumed to be linked to shopping process.

During questionnaire design special attention was paid to the length of the questionnaire, to avoid lengthy survey causing fatigue among respondents and jeopardizing the quality of data collection.

Methods used for analysis

Exploratory factor analysis (EFA) with Direct Oblimin rotation was used to identify and derive relevant factors from measured LP items. Data adequacy was checked using Kaiser-Meyer-Olkin (KMO) statistic and Bartlett's test of sphericity. To check for convergent validity of derived factors Average Variance Extracted (AVE) was measured, whereas internal consistency was confirmed through Composite Reliability (CR and Cronbach's Alpha).

Initial analysis included testing the sample data for normality (using Shapiro–Wilk and Kolmogorov–Smirnov tests) and homoscedasticity (using Levene test). Since the data demonstrated non-normal distribution and heteroscedasticity, the accepted option for testing differences between more than two observed groups is using non-parametric tests, more precisely Kruskal-Wallis test, also known as one-way ANOVA on ranks (Nahalkova Tesarova & Krizanova, 2023). Which observed groups demonstrated significant preferential differences in LP rewards and functionalities was tested post hoc using Dunn's test with Bonferroni correction.

Results

In total, the sample consisted of 800 responses through 17 item questions. The assumption of normal distribution of data was assessed using the Shapiro–Wilk test. The test statistics were significant for all observed items, which implies that data deviates significantly from a normal distribution pattern. This was also confirmed through graphical analysis. Levene's test was used to test the assumption of homogeneity of variances. All question items, except for q12 and q13 exhibited heteroscedasticity.

Next, observed item questions were put through EFA in order to identify relevant LP design variables. The use of EFA was justified through Kaiser-Meyer-Olkin and Bartlett's tests. The results pointed out two distinct factors. Items in the first factor represent tangible and personalized rewards, while the second factor includes features related to ease of use and digital functionalities of the LP (Table 2).

Table 2. Results of the conducted EFA analysis

Variables	Item loadings	AVE	CR	Cronbach's α
<i>LP rewards</i>		<i>0.640</i>	<i>0.857</i>	<i>0.892</i>
q1. Point collection	0.738			
q2. Product discounts at the register	0.740			
q3. Occasional larger rewards	0.878			
q4. Personalized rewards	0.858			
q5. Profile instant info and data	0.816			

Variables	Item loadings	AVE	CR	Cronbach's α
q6. Combined household reward gathering	0.759			
<i>LP functions</i>		0.633	0.923	0.910
q7. Automatic purchase recording	0.759			
q8. Fast activation at the register	0.828			
q9. Easy access to customer profile	0.814			
q10. Point and reward control through profile	0.788			
q11. Family LP	0.815			
q12. Point transferability	0.771			
q13. Notification type customization	0.791			

KMO statistic = 0.937

Bartlett's test Sig. < 0.001

Source: Authors' calculations

Since AVE values were above the threshold of 0.5, CR was higher than 0.7 (Bagozzi & Yi, 1988) and Cronbach's α exceeded 0.7 (E. Kim et al., 2017), convergent validity and internal consistency were confirmed.

Since the use of non-parametric tests to determine whether significant differences between observed customer groups exist was justified, Kruskal-Wallis test was performed (Table 3).

Table 3. Results of Kruskal-Wallis test on testing the differences within LP rewards and LP functionalities perceptions

Variables	No LP	Non-food LP	Both LPs	Food LP	χ^2	p-value	η^2
LP rewards	256.36	405.20	461.77	363.90	99.891	<0.001	0.122
LP functionalities	294.08	402.54	450.34	350.64	60.796	<0.001	0.085

Source: Authors' calculations

Results show that significant differences within how customers perceive and prefer LP rewards and functionalities exist, driven by customer orientation. Also, by observing the effect size (η^2) we can conclude that for both LP rewards and functionalities the effect is medium (Tomczak & Tomczak, 2014).

Post hoc comparisons using Dunn's test with Bonferroni correction revealed significant differences in LP reward importance between customers without LP and all other observed groups. Customers without LP value LP rewards much less than LP owners, regardless of their shopping orientation. Additionally, customers with both LPs valued LP rewards much more compared to customers with only grocery shopping LP orientation. No other group difference was statistically significant.

When it comes to LP functionalities, similarly to rewards, customers without LPs value LP functionalities much less compared to customers oriented on only non-food, as well as on both LPs. Also, customers oriented on both food and non-food LP displayed much higher valuation of LP functionalities compared to only food-oriented LP owners.

Results of the analysis and implications on the hypotheses testing are shown in Table 4.

Table 4. Hypotheses testing results

Hypothesis	Conclusion
H1	Confirmed
H2	Confirmed
H3	Not confirmed
H4	Confirmed

Source: Authors' calculations

Extending the analysis on the level of individual LP reward type, Dunn's post hoc testing demonstrates similar patterns to the one related to general LP rewards perception differences (Table 5).

Table 5. Results of Dunn's post hoc testing of the differences within LP rewards customer preferences

Items	No LP	Non-food LP	Both LPs	Food LP	χ^2	p-value*	η^2
q1. Point collection	321.61	436.12	429.95	361.75	34.291	<0.001	0.039
q2. Product discounts at the register	310.94	384.46	444.23	370.78	47.957	<0.001	0.056
q3. Occasional larger rewards	325.36	399.72	441.47	337.12	41.117	<0.001	0.048
q4. Personalized rewards	322.36	396.66	439.66	356.73	37.879	<0.001	0.044
q5. Profile instant info and data	279.80	403.40	447.07	396.48	71.471	<0.001	0.086
q6. Combined household reward gathering	279.35	397.27	452.53	375.72	76.257	<0.001	0.092

*Adjusted p-values based on Bonferroni's correction

Source: Authors' calculations

Customers without LP clearly value every LP reward type less than customers with distinctive shopping LP orientation. Also, customers with both LPs usually prefer LP rewards more than the ones with food LP orientation, except when it comes to collecting points and receiving instant information and data on the profile page, upon using the LP. No significant differences were identified between food and non-food LP oriented customers.

Similar conclusion was derived for LP functionalities as well based on post hoc testing (Table 6).

Table 6. Results of Dunn's post hoc testing of the differences within LP functionalities customer preferences

Items	No LP	Non-food LP	Both LPs	Food LP	χ^2	p-value*	η^2
q7. Automatic purchase recording	281.05	417.33	449.80	362.20	73.838	<0.001	0.089
q8. Fast activation at the register	270.18	414.57	450.62	383.57	87.572	<0.001	0.106
q9. Easy access to customer profile	263.75	428.78	450.27	381.27	94.278	<0.001	0.115
q10. Point and reward control through profile	262.90	422.77	457.70	350.62	103.854	<0.001	0.127
q11. Family LP	270.92	384.89	455.35	393.24	87.305	<0.001	0.106
q12. Points transferability	314.14	389.80	435.31	405.37	36.52	<0.001	0.042
q13. Notification type customization	308.20	398.20	441.12	376.20	44.805	<0.001	0.053

* Adjusted p-values based on Bonferroni's correction

Source: Authors' calculations

Customers without LP do not value functionalities as much as LP owners. When it comes to food LP oriented customers, differences between owners of both LP types are not present in preferences of fast activation of LP at the register, having a family LP, being able to transfer LP points and having customizable notifications. Although no evidence of differences between food and non-food LP oriented customers were found, owners of only non-food LPs were much more reserved to having a family LP compared to customers owning both types of LP.

Discussions

The introductory question in the questionnaire singled out respondents who have and use a loyalty program, and the next question asked them to choose what they were satisfied with in the programs they use. The answers that illustrate the previously tested relationships are presented in **Figure 1**.

Figure 1. Importance of different LP satisfaction factors

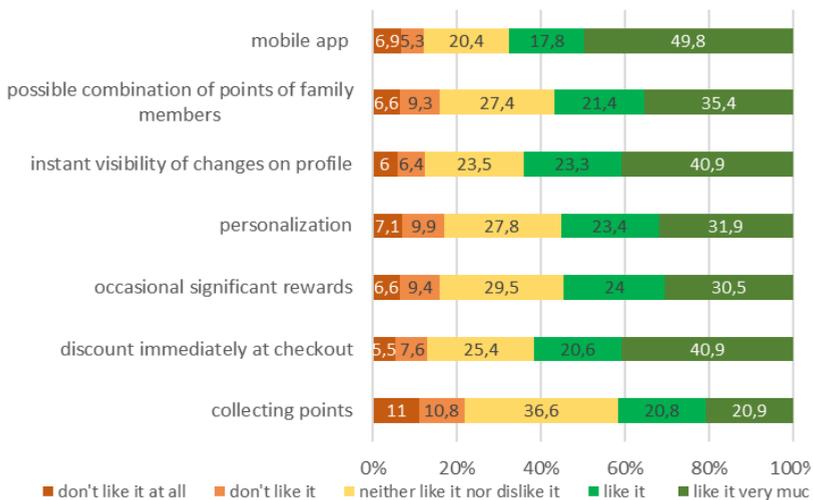
Source: Authors' calculations

The most frequently cited sources of satisfaction with loyalty programs are economic motives that form the basis for the decision to join a loyalty program. Urban residents are more pragmatic in this regard and statistically significantly more often recognize motives such as direct discounts on certain products and vouchers compared to respondents from rural areas. While financial rewards and benefits such as direct discounts on certain products and discounts through accumulated points and total spending are the most important sources of satisfaction with loyalty programs for 84% and close to 70%, respectively, comfort factors such as personalization and easy fulfillment of reward requirements are mentioned by 13.8% and 14.6% of respondents.

These factors, which are less frequently cited as a source of satisfaction, are, however, no less important, since based on qualitative data from group interviews with consumers, it can be concluded that these are often reasons for dissatisfaction (Alshmemri et al., 2017). In addition, personalization of loyalty programs is statistically significantly more important for women than for men. This finding is the result of a comparison of demographic groups: gender, age categories (18 to 24 years, 25 to 34 years, 35 to 44 years, 45 to 54 years and 55 to 64 years), regions (Belgrade region, Vojvodina, Šumadija and Western Serbia region and Southern and Eastern Serbia region), and type of settlement (urban and rural settlements).

The z-test was used to analyze the statistical significance of the differences between the proportions in the above groups, with a significance level of $p=0.05$. The z-test with the stated significance level of $p=0.05$ was used for all analyses of the statistical significance of the differences between the compared groups. The orientation of respondents in Serbia is in line with expectations based on the theory of two-factor satisfaction: when asked about satisfaction with loyalty programs, respondents first list sources of motivation, followed by “hygiene factors” related to comfort (**Figure 2**).

Figure 2. Preferred rewards and functionalities in loyalty programs



Source: Authors' calculations

The first significant insight from the analyzed data is that women are statistically significantly more supportive of each of the rewards and functionalities of the loyalty program. Furthermore, all of the aforementioned functionalities and rewards record average ratings of 4 or close to 4 (on a scale of 1 to 5). Customers overwhelmingly rate all tested rewards and functionalities positively, except for collecting points, which is preferred by only 41.% of respondents (20.9%+20.8%). Other ways of exercising the right to a reward are much more desirable: instant discounts at the checkout (61.5%) and occasional larger rewards (54.5).

Men are skeptical of all forms of earning rewards through loyalty programs, and as many as 25.2% of them have a negative attitude towards collecting points. The most desirable loyalty program functionality for as many as 67.5% is the mobile phone application, followed by 64.1% of respondents, the updated status of the customer's profile in the loyalty program, and personalization of rewards with 55.3%.

However, some aspects of these programs cause ambivalent consumer attitudes and such attributes of loyalty programs are presented in the following section as disadvantages (Figure 3).

Figure 3. Importance of different LP dissatisfaction factors



Source: Authors' calculations

The homogeneity of all respondents is a key characteristic of the answers to the question about dissatisfaction with the components of the loyalty program. No statistically significant differences were observed between the groups of respondents who differ in gender, age, regional distribution of respondents, or even the type of settlement in which they live, except in one specific case. The urban population is more critical when it comes to the attitude that "Rewards can be uninteresting" (z-test, $p=0.05$).

When it comes to directly measured aspects of dissatisfaction with loyalty programs, rewards and financial aspects cause more frequent dissatisfaction. It is interesting to note that the respondents are not very critical of the possibility that too much communication is achieved through the loyalty program. In the discussions conducted in focus groups, opinions about customer fatigue caused by frequent notifications emerged, but these

assumptions were not confirmed and even the slightly greater dissatisfaction of men with this phenomenon, which was suggested, was not statistically significant.

Also, the suspicion expressed by business people towards loyalty programs that being held at the checkout because of the loyalty program causes great dissatisfaction, was not confirmed in this case. Slowing down checkouts due to loyalty programs was noted by a number of respondents (11.9%), but this source of dissatisfaction is relatively minor compared to most other sources of dissatisfaction (especially economic ones such as rewards and required spending).

Conclusions

The key takeaway of this research is that the competitiveness of a loyalty program depends on differentiating from other competing loyalty programs, both in terms of the type and relevance of the rewards it provides to members, as well as in terms of the functionality of the loyalty program itself.

For a loyalty program to be desirable, it must, in addition to standard functionalities (collecting points), also contain some attractive differentiating features such as personalization of rewards, gamification (moving to a higher level), constant insight into earned points and possible savings, a clear overview of available rewards, etc. Also, for a loyalty program to be desirable, in addition to regular collection of points, it must also contain some positive surprises in the form of rewards directly at the checkout, combining spending and group collection of points, etc.

Loyalty program users undergo a kind of benefit “learning” program, so that they value rewards and benefits more than those who do not participate in these programs. Any facilitation for customers to reach the reward, combined with the comfort of using the loyalty program (easy to activate, no waiting at the checkout, etc.), positively differentiates the loyalty program from the existing “bunch” of impersonal and boring programs that become failed marketing investments.

This study has certain limitations that should be acknowledged. The data were collected through an online survey, which may have introduced coverage and self-selection biases, as individuals without stable internet access or interest in online participation were less likely to respond. In addition, all constructs were self-evaluated, which may have led to subjective bias and social desirability effects. Finally, the research sample was limited to consumers in Serbia, restricting the generalizability of the findings to other cultural and market contexts. Future studies could validate these results using mixed-mode data collection and comparative cross-country samples. Additionally, future research avenues could further analyze the effects of additional customer behavioral patterns and psychographic profiles on customer preferences of loyalty program rewards and functionalities.

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Conflict of interests

The authors declare no conflict of interest.

References

1. Alshmemri, M., Shahwan-Akl, L., & Maude, P. (2017). Herzberg's Two-Factor Theory. *Life Science Journal*, 14(5). <https://doi.org/10.7537/marslsj140517.03>
2. Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, 16(1), 74–94. <https://doi.org/10.1007/BF02723327>
3. Belli, A., O'Rourke, A.-M., Carrillat, F. A., Pupovac, L., Melnyk, V., & Napolova, E. (2022). 40 years of loyalty programs: How effective are they? Generalizations from a meta-analysis. *Journal of the Academy of Marketing Science*, 50(1), 147–173. <https://doi.org/10.1007/s11747-021-00804-z>
4. Bergkvist, L., & Rossiter, J. R. (2007). The Predictive Validity of Multiple-Item versus Single-Item Measures of the Same Constructs. *Journal of Marketing Research*, 44(2), 175–184. <https://doi.org/10.1509/jmkr.44.2.175>
5. Bergkvist, L., & Rossiter, J. R. (2009). Tailor-made single-item measures of doubly concrete constructs. *International Journal of Advertising*, 28(4), 607–621. <https://doi.org/10.2501/S0265048709200783>
6. Blau, P. (1986). *Exchange and Power in Social Life* (2nd ed.). Routledge. <https://doi.org/10.4324/9780203792643>
7. Bombajj, N. J. F., & Dekimpe, M. G. (2020). When do loyalty programs work? The moderating role of design, retailer-strategy, and country characteristics. *International Journal of Research in Marketing*, 37(1), 175–195. <https://doi.org/10.1016/j.ijresmar.2019.07.003>
8. Bruneau, V., Swaen, V., & Zidda, P. (2018). Are loyalty program members really engaged? Measuring customer engagement with loyalty programs. *Journal of Business Research*, 91, 144–158. <https://doi.org/10.1016/j.jbusres.2018.06.002>
9. Casper Ferm, L.-E., & Thaichon, P. (2021). Customer pre-participatory social media drivers and their influence on attitudinal loyalty within the retail banking industry: A multi-group analysis utilizing social exchange theory. *Journal of Retailing and Consumer Services*, 61, 102584. <https://doi.org/10.1016/j.jretconser.2021.102584>
10. Chang, H. H., Tsai, Y.-C., Chen, S.-H., Huang, G.-H., & Tseng, Y. H. (2015). Building long-term partnerships by certificate implementation: A social exchange theory perspective. *Journal of Business & Industrial Marketing*, 30(7), 867–879. <https://doi.org/10.1108/JBIM-08-2013-0190>

11. Cortiñas, M., Elorz, M., & Múgica, J. M. (2008). The use of loyalty-cards databases: Differences in regular price and discount sensitivity in the brand choice decision between card and non-card holders. *Journal of Retailing and Consumer Services*, 15(1), 52–62. <https://doi.org/10.1016/j.jretconser.2007.03.006>
12. Cropanzano, R., Anthony, E. L., Daniels, S. R., & Hall, A. V. (2017). Social Exchange Theory: A Critical Review with Theoretical Remedies. *Academy of Management Annals*, 11(1), 479–516. <https://doi.org/10.5465/annals.2015.0099>
13. Danaher, P. J., Sajtos, L., & Danaher, T. S. (2016). Does the reward match the effort for loyalty program members? *Journal of Retailing and Consumer Services*, 32, 23–31. <https://doi.org/10.1016/j.jretconser.2016.05.015>
14. Das, G. (2014). Linkages of retailer personality, perceived quality and purchase intention with retailer loyalty: A study of Indian non-food retailing. *Journal of Retailing and Consumer Services*, 21(3), 407–414. <https://doi.org/10.1016/j.jretconser.2013.11.001>
15. Emerson, R. M. (1976). Social Exchange Theory. *Annual Review of Sociology*, 2(Volume2, 1976), 335–362. <https://doi.org/10.1146/annurev.so.02.080176.002003>
16. Fan, X., Li, J., Mao, Z. (Eddie), & Lu, Z. (2021). Can ethical leadership inspire employee loyalty in hotels in China? -From the perspective of the social exchange theory. *Journal of Hospitality and Tourism Management*, 49, 538–547. <https://doi.org/10.1016/j.jhtm.2021.11.006>
17. Filipe, S., Marques, S. H., & Salgueiro, M. D. F. (2017). Customers' relationship with their grocery store: Direct and moderating effects from store format and loyalty programs. *Journal of Retailing and Consumer Services*, 37, 78–88. <https://doi.org/10.1016/j.jretconser.2017.03.002>
18. García Gómez, B., Gutiérrez Arranz, A. M., & Gutiérrez Cillán, J. (2012). Drivers of customer likelihood to join grocery retail loyalty programs. An analysis of reward programs and loyalty cards. *Journal of Retailing and Consumer Services*, 19(5), 492–500. <https://doi.org/10.1016/j.jretconser.2012.06.004>
19. Huang, C.-T., & Chen, P.-T. (2010). Do reward programs truly build loyalty for lodging industry? *International Journal of Hospitality Management*, 29(1), 128–135.
20. Hwang, J., & Choi, L. (2020). Having fun while receiving rewards?: Exploration of gamification in loyalty programs for consumer loyalty. *Journal of Business Research*, 106, 365–376. <https://doi.org/10.1016/j.jbusres.2019.01.031>
21. Hwang, Y., & Mattila, A. S. (2018). Is It My Luck or Loyalty? The Role of Culture on Customer Preferences for Loyalty Reward Types. *Journal of Travel Research*, 57(6), 769–778. <https://doi.org/10.1177/0047287517718353>
22. Jang, D., & Mattila, A. S. (2005). An examination of restaurant loyalty programs: What kinds of rewards do customers prefer? *International Journal of Contemporary Hospitality Management*, 17(5), 402–408.

23. Jensen, L. A. (2011). Navigating Local and Global Worlds: Opportunities and Risks for Adolescent Cultural Identity Development. *Psychological Studies*, 56(1), 62–70. <https://doi.org/10.1007/s12646-011-0069-y>
24. Jones, T. O., & Sasser, W. E. (1995). Why satisfied customers defect. *Harvard Business Review*, 73(6), 88.
25. Kim, E., Park, M.-C., & Lee, J. (2017). Determinants of the intention to use Buy-Online, Pickup In-Store (BOPS): The moderating effects of situational factors and product type. *Telematics and Informatics*, 34(8), 1721–1735. <https://doi.org/10.1016/j.tele.2017.08.006>
26. Kim, J. J., Steinhoff, L., & Palmatier, R. W. (2021). An emerging theory of loyalty program dynamics. *Journal of the Academy of Marketing Science*, 49(1), 71–95. <https://doi.org/10.1007/s11747-020-00719-1>
27. Klopotan, I., Vrhovec-Žohar, K., & Mahič, E. (2016). Impact of Income on Customers' Loyalty: Are Customers with Higher Income more Loyal? *Business Systems Research Journal*, 7(1), 81–88. <https://doi.org/10.1515/bsrj-2016-0006>
28. Lee, J. J., Capella, M. L., Taylor, C. R., Luo, M. (Meg), & Gabler, C. B. (2014). The financial impact of loyalty programs in the hotel industry: A social exchange theory perspective. *Journal of Business Research*, 67(10), 2139–2146. <https://doi.org/10.1016/j.jbusres.2014.04.023>
29. Mainardes, E. W., Rosa, C. A. de M., & Nossa, S. N. (2020). Omnichannel strategy and customer loyalty in banking. *International Journal of Bank Marketing*, 38(4), 799–822. <https://doi.org/10.1108/IJBM-07-2019-0272>
30. Meyer-Waarden, L. (2015). Effects of loyalty program rewards on store loyalty. *Journal of Retailing and Consumer Services*, 24, 22–32. <https://doi.org/10.1016/j.jretconser.2015.01.001>
31. Meyer-Waarden, L., & Benavent, C. (2009). Grocery retail loyalty program effects: Self-selection or purchase behavior change? *Journal of the Academy of Marketing Science*, 37(3), 345–358. <https://doi.org/10.1007/s11747-008-0123-z>
32. Meyer-Waarden, L., Bruwer, J., & Galan, J.-P. (2023). Loyalty programs, loyalty engagement and customer engagement with the company brand: Consumer-centric behavioral psychology insights from three industries. *Journal of Retailing and Consumer Services*, 71, 103212. <https://doi.org/10.1016/j.jretconser.2022.103212>
33. Nahalkova Tesarova, E., & Krizanova, A. (2023). How Shopping was Transformed from Offline to Online Space—A Case Study within the Slovak Republic. *Management Dynamics in the Knowledge Economy*, 11(2), 128–137. <https://doi.org/10.2478/mdke-2023-0009>
34. Nettet, E., Bergem, O., Nervik, B., Schiøll Sørli, E., & Helgesen, Ø. (2021). Building chain loyalty in grocery retailing by means of loyalty programs – A study of ‘the Norwegian case.’ *Journal of Retailing and Consumer Services*, 60, 102450. <https://doi.org/10.1016/j.jretconser.2021.102450>

35. Rehnen, L.-M., Bartsch, S., Kull, M., & Meyer, A. (2017). Exploring the impact of rewarded social media engagement in loyalty programs. *Journal of Service Management*, 28(2), 305–328.
36. Rothschild, M. L., & Gaidis, W. C. (1981). Behavioral Learning Theory: Its Relevance to Marketing and Promotions. *Journal of Marketing*, 45(2), 70–78. <https://doi.org/10.2307/1251666>
37. Söderlund, M., & Colliander, J. (2015). Loyalty program rewards and their impact on perceived justice, customer satisfaction, and repatronize intentions. *Journal of Retailing and Consumer Services*, 25, 47–57. <https://doi.org/10.1016/j.jretconser.2015.03.005>
38. SORS. (2022). *Census of Population, Households and Dwellings—Age and Sex, Data by settlements*. Statistical Office of the Republic of Serbia. <https://www.stat.gov.rs/en-US/publikacije/publication/?p=15204>
39. Taylor, G. A., & Neslin, S. A. (2005). The current and future sales impact of a retail frequency reward program. *Journal of Retailing*, 81(4), 293–305.
40. Tomczak, M., & Tomczak, E. (2014). The need to report effect size estimates revisited. An overview of some recommended measures of effect size. *Trends in Sport Sciences*, 1, 19–25.
41. White, C. J., & Tong, E. (2019). On linking socioeconomic status to consumer loyalty behaviour. *Journal of Retailing and Consumer Services*, 50, 60–65. <https://doi.org/10.1016/j.jretconser.2019.05.001>
42. Youngblut, J. M., & Casper, G. R. (1993). Focus on psychometrics single-item indicators in nursing research. *Research in Nursing & Health*, 16(6), 459–465. <https://doi.org/10.1002/nur.4770160610>

ADOPTION OF AI-POWERED FOOD DELIVERY PLATFORMS IN THE REPUBLIC OF SERBIA

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ABSTRACT

With the rapid growth of AI technologies, understanding factors driving user adoption of AI-powered platforms is increasingly important. This study investigates factors influencing the adoption of AI-powered food delivery platforms by integrating the Stimulus–Organism–Response framework with Task–Technology Fit theory. Primary research was conducted through a structured questionnaire in May 2024 in the Republic of Serbia, collecting data on communicative competence, technology and task characteristics, perceived intelligence, social influence, anthropomorphism, emotional trust, and task–technology fit. Structural equation modeling tested the hypothesized relationships. Results indicate that both task–technology fit and emotional trust significantly influence adoption intention. The findings highlight the critical roles of emotional trust and effective alignment between technology and user tasks in facilitating adoption of AI platforms in emerging markets. It is recommended that platform providers enhance AI transparency and build user trust. Additional descriptive data reveal moderate AI familiarity among respondents, indicating potential for further user education.

Introduction

The increasing prominence of AI-powered service platforms in the contemporary era has stimulated innovative practices designed to satisfy existing needs and anticipate emerging demands, thereby redefining service delivery and business–customer interactions (Ameen et al., 2021). The retail and food delivery sectors, in particular, are undergoing rapid transformation driven by emerging digital technologies, growing competition, and evolving consumer expectations (Su, 2022; Zhang et al., 2021).

Consumers increasingly interact across multiple channels, prompting service providers to adopt seamless omnichannel strategies and personalized experiences (Cortinas et

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al., 2019; Rodrigues & Brandão, 2020). AI-powered food delivery platforms further support businesses through customer segmentation, targeted marketing, and content optimization, while successful adoption depends on technical expertise, organizational resources, and strategic digital marketing (Yum et al., 2022; Cho et al., 2019; Jia et al., 2020; Sandeep et al., 2022).

In agricultural and food economics, digital transformation drives competitiveness and efficiency across the agri-food value chain (Schroeder et al., 2021). AI-powered food delivery platforms form a growing segment of the digital food economy, connecting producers, restaurants, and consumers through data-driven decision-making (Min et al., 2023). Understanding user adoption is crucial, as technological innovation reshapes distribution, consumer behavior, and market organization, particularly in emerging economies (Trabelsi et al., 2023). This transformation creates opportunities to increase value added, facilitate trade, meet evolving consumer demand, and improve food supply chain efficiency, traceability, and resilience (Schroeder et al., 2021; Ghag et al., 2024).

Despite these advantages, understanding the factors influencing consumer adoption of AI-powered food delivery platforms remains limited. This study examines adoption determinants in the Republic of Serbia, focusing on Task-Technology Fit and Emotional Trust, with the aim of empirically validating the research model and identifying key factors that drive or hinder user acceptance.

Literature Review

Artificial Intelligence (AI) has transformed service industries by extending capabilities for reasoning, problem-solving, and automation (Joiner, 2018). In food delivery, AI-powered platforms use intelligent algorithms, mobile applications, chatbots, and real-time data analysis to optimize operations, personalize services, enhance customer interactions, foster emotional trust, and increase satisfaction and repurchase intentions (Prentice et al., 2020; Adam et al., 2021; Van Esch & Stewart Black, 2021; Ljepava, 2022; Pelau et al., 2021; Maduku et al., 2024; Ameen et al., 2021). Driven by changing consumer behavior and digital reliance, these platforms have transformed meal access through personalized recommendations, tailored menus, and on-demand delivery (Chai & Yat, 2019).

The Stimulus–Organism–Response (S–O–R) framework, originally proposed by Mehrabian and Russell (1974) and later expanded by Jacoby (2002), provides a comprehensive theoretical lens for understanding how external and internal factors shape human behavior through mediating psychological processes. Unlike the traditional Stimulus–Response (S–R) model, which assumes a direct causal link between stimuli and behavior, the S–O–R approach emphasizes the critical role of the organism, representing cognitive and affective evaluations, in translating stimuli into observable behavioral responses (Goi et al., 2014; Alcántara-Pilar et al., 2024).

The Task–Technology Fit (TTF) model, developed by Goodhue and Thompson (1995), complements the S–O–R framework by emphasizing that users are more likely to adopt

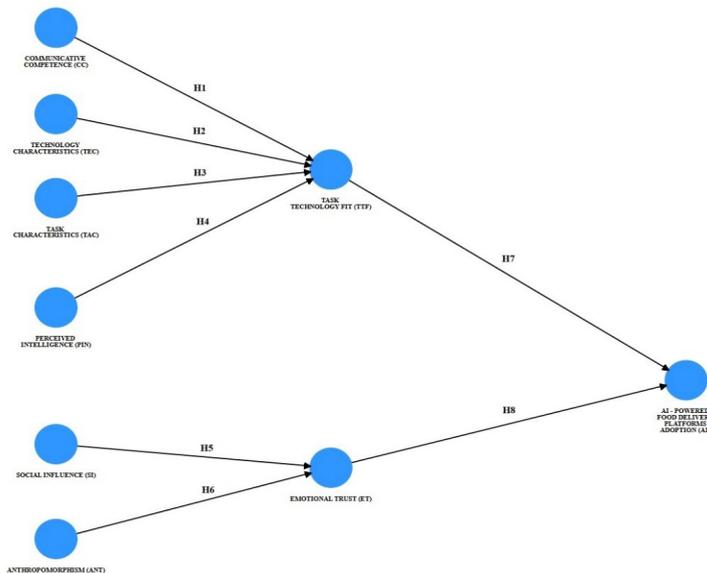
technology when its features align effectively with the tasks they need to accomplish. TTF posits that technology adoption is facilitated when users perceive that a system enhances their ability to complete tasks efficiently and achieve desired outcomes. This perspective has been widely applied in diverse IT contexts, demonstrating that both task characteristics and technology features are significant predictors of user engagement and intention to adopt digital innovations (Vafaei-Zadeh et al., 2023).

Previous research has examined factors influencing the adoption of AI-powered and technology-mediated food delivery platforms. Vafaei-Zadeh et al. (2023) integrated the SOR and TTF frameworks for AI customer service adoption, while other studies explored gamification in mobile delivery (Liao & Ahn, 2025), drone-based delivery (Abbasi et al., 2024), and customer inspiration via the SOR paradigm (Malik et al., 2024). Additionally, Saygıner (2024) studied customer satisfaction and loyalty during and after COVID-19, Shorbaji et al. (2025) reviewed AI-enabled food-ordering apps, and Leung et al. (2025) analyzed young adults' consumption behavior, collectively highlighting technological, psychological, and contextual factors in AI-driven food delivery adoption.

Research model

In this study, the S–O–R model from Vafaei-Zadeh et al. (2023), originally used for AI customer service adoption, is applied to AI-powered food delivery platforms in the Republic of Serbia. The focus is on how external stimuli, such as communicative competence, technology and task characteristics, perceived intelligence, social influence, and anthropomorphism, affect internal evaluations, including task-technology fit and emotional trust, which in turn influence adoption. The conceptual model is shown in Figure 1.

Figure 1. Conceptual Model of AI-Powered Food Delivery Platforms Adoption



Source: Author (2025)

Based on the S–O–R model and TTF theory, eight hypotheses were formulated to investigate platforms adoption, each grounded in theoretical rationale (Vafaei-Zadeh et al., 2023). Together, these hypotheses provide a comprehensive framework for understanding the factors shaping user perceptions, emotional trust, and adoption of AI-powered food delivery platforms.

H1: *Communicative competence positively influences task-technology fit in AI-powered food delivery platforms.*

Communicative competence in AI chatbots refers to their ability to provide clear, timely, and relevant responses that resemble human communication. Such competence enhances user satisfaction and task–technology fit, thereby strengthening acceptance of AI solutions.

H2: *Technology characteristics positively influence task-technology fit in AI-powered food delivery platforms.*

Technology characteristics refer to key attributes of AI tools, including personalization, real-time information, availability, and ease of use. When these features align with user needs, task–technology fit improves, enhancing effectiveness and acceptance of AI services and promoting user adoption.

H3: *Task characteristics positively influence task-technology fit in AI-powered food delivery platforms.*

Task characteristics refer to the nature and complexity of activities users perform when interacting with a service. When these requirements align with the technology’s features, task–technology fit improves, enhancing ease of use and promoting user acceptance of AI-based solutions.

H4: *Perceived intelligence positively influences task-technology fit in AI-powered food delivery platforms.*

Perceived intelligence refers to a system’s ability to perform tasks effectively, learn from interactions, and respond appropriately to user needs. In AI-powered services, higher perceived intelligence, demonstrated through responsiveness, problem-solving, and adaptability, enhances task-technology fit and encourages user adoption.

H5: *Social influence positively influences emotional trust in AI-powered food delivery platforms.*

Social influence reflects the extent to which individuals perceive that important others expect them to adopt new technology. Recommendations from family, friends, or colleagues are often seen as more trustworthy, and social influence helps build emotional trust in human-AI interactions.

H6: *Anthropomorphism positively influences emotional trust in AI-powered food delivery platforms.*

Anthropomorphism involves attributing human-like characteristics, emotions, or behaviors to AI systems. This can make interactions feel more natural and strengthen emotional connections, though research shows mixed effects on emotional trust, ranging from positive to limited or negative.

H7: *Task-technology fit positively influences AI-powered food delivery platform adoption.*

Task-technology fit refers to how well a technology’s capabilities align with the requirements of a specific task, affecting its perceived usefulness. Strong alignment enhances performance and efficiency, increasing the likelihood of adoption, while poor alignment reduces it, emphasizing the need to match technology features with task demands.

H8: *Emotional trust positively influences AI-powered food delivery platform adoption.*

Emotional trust reflects a user’s confidence and comfort in relying on a technology, influencing their willingness to adopt it. In AI-powered services, users are more likely to engage with systems that provide emotional security and positive experiences, which strongly drive adoption intentions.

Methodology

The primary research employed a convenience sample and was conducted through a structured questionnaire in May 2024 in the Republic of Serbia, encompassing a total of 392 respondents—users of food delivery platforms who are aware that the platform employs artificial intelligence. The questionnaire was distributed online through various channels to reach a diverse group of participants. The questionnaire was structured in two sections. The first section collected respondents’ demographic and background information, including age, gender, education level, platforms usage frequency, ordering frequency, self-assessed AI knowledge, and perception of whether food delivery platforms use AI (Table 1). The second section assessed participants’ perceptions across multiple items for each research construct, using a five-point Likert scale (1 - “strongly disagree” to 5 - “strongly agree”).

Table 1. Demographic and Background Characteristics of Sample

Category	Percentage (%)
Age	
18-24	24.5
25-34	38.0
35-44	22.2
45-54	10.7
55 and above	4.6
Gender	
Male	40.8
Female	59.2

Category	Percentage (%)
Education Level	
High School Diploma	16.6
College of Applied Studies Diploma	12.2
Bachelor's Degree	37.2
Master's Degree	32.9
Doctoral Degree (PhD)	1.0
Platforms Usage Frequency	
Regularly	23.5
Occasionally	76.5
Ordering Frequency	
Daily	10.5
Weekly	20.9
Monthly	28.8
Less often	39.8
Self-Assessed AI Knowledge	
Very low	1.5
Low	23.7
Moderate	37.2
High	33.7
Very high	3.8
Belief That Food Delivery Platforms Use AI	
Certain	54.1
Believes so but unsure	45.9

Source: Author (2025)

Platforms used included Wolt, Glovo, Mister D, restaurant websites/apps, and Office Bite, with Wolt and Glovo most popular. Most respondents identified AI use for predicting delivery times, personalized promotions and discounts, and automated meal recommendations, while fewer recognized AI in image recognition and visual food search or voice interaction and chatbots.

The statistical model comprises eight constructs: Communicative Competence (CC), Technology Characteristics (TEC), Task Characteristics (TAC), Perceived Intelligence (PIN), Social Influence (SI), Anthropomorphism (ANT), Task-Technology Fit (TTF), and AI-powered Food Delivery Platforms Adoption (AD). All indicators were adapted from Vafaei-Zadeh et al. (2024) to fit the context of AI-powered food delivery platforms (Table 2).

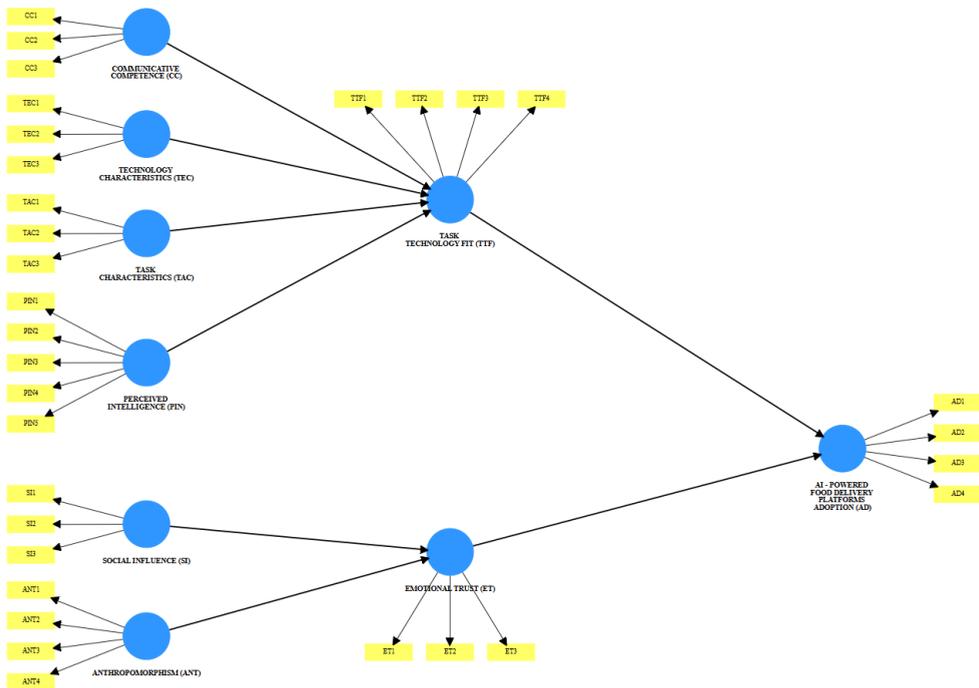
Table 2. Constructs and Indicators (Items)

CONSTRUCTS		INDICATORS (ITEMS)
COMMUNICATION COMPETENCE (CC)	CC1	AI-powered food delivery platforms will be more productive than face-to-face interactions with in-store agents.
	CC2	Communication through AI-powered food delivery platforms will be more efficient than other forms of communication for ordering food.
	CC3	AI-powered food delivery platforms will save a tremendous amount of time.
TECHNOLOGY CHARACTERISTICS (TEC)	TEC1	AI-powered food delivery platforms will provide ubiquitous service.
	TEC2	AI-powered food delivery platforms will provide real-time service.
	TEC3	AI-powered food delivery platforms will provide secure service.
TASK CHARACTERISTICS (TAC)	TAC1	I will need to access my food delivery inquiries anytime, anywhere.
	TAC2	I will need to send my food delivery inquiries anytime, anywhere.
	TAC3	I will need to receive my food delivery inquiry responses in real-time.
PERCEIVED INTELLIGENCE (PIN)	PIN1	AI-powered food delivery platforms will be able to complete tasks quickly.
	PIN2	AI-powered food delivery platforms will understand my commands.
	PIN3	AI-powered food delivery platforms will be able to communicate with me in an understandable manner.
	PIN4	AI-powered food delivery platforms will be able to find and process the necessary information for completing their tasks.
	PIN5	AI-powered food delivery platforms will provide useful answers.
TASK-TECHNOLOGY FIT (TTF)	TTF1	The functionalities of AI-powered food delivery platforms will be very adequate.
	TTF2	The functionalities of AI-powered food delivery platforms will be very appropriate.
	TTF3	The functionalities of AI-powered food delivery platforms will be very sufficient.
	TTF4	The functions of AI-powered food delivery platforms will fully meet my ordering and support needs.

CONSTRUCTS		INDICATORS (ITEMS)
SOCIAL INFLUENCE (SI)	SI1	Many people I know will use AI-powered food delivery services.
	SI2	People who influence my behavior will use AI-powered food delivery services.
	SI3	People whose opinions I value will use AI-powered food delivery services.
ANTHROPOMORPHISM (ANT)	ANT1	It is important that the conversation with AI-powered food delivery platforms resembles one with a human being.
	ANT2	Conversations with AI-powered food delivery platforms should be natural.
	ANT3	AI-powered food delivery platforms should seem as if they understand the person with whom they are interacting.
	ANT4	Conversation with the AI-powered food delivery platforms should not be artificial.
EMOTIONAL TRUST (ET)	ET1	I will feel secure relying on AI-powered food delivery platforms for inquiries.
	ET2	I will feel comfortable trusting AI-powered food delivery platforms for assistance.
	ET3	I will be satisfied relying on AI-powered food delivery platforms for support.
AI – POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	AD1	I will be interested in using AI-powered food delivery platforms.
	AD2	AI-powered food delivery platforms will increase my willingness to use it.
	AD3	I will recommend AI-powered food delivery platforms to others.
	AD4	I will use this AI-powered food delivery platforms for ordering and assistance.

Source: Author (2025)

Each variable was modeled as a reflective construct (Figure 2), meaning the individual items are highly similar. Given the latent nature of the variables, Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test the hypotheses. PLS-SEM combines regression and factor analysis techniques, making it suitable for analyzing latent constructs measured indirectly through indicators (Sarstedt, Ringle, & Hair, 2021).

Figure 2. Statistical Model of AI-Powered Food Delivery Platforms Adoption

Source: Author (2025)

The questionnaire was pretested, and given the reflective nature of all constructs, reliability, convergent validity, and discriminant validity were assessed. Reliability was evaluated using Cronbach's alpha and composite reliability (CR), convergent validity with average variance extracted (AVE), and discriminant validity using the Fornell–Larcker criterion and the HTMT ratio (Grubor et al., 2021). Following Hair, Risher, Sarstedt, and Ringle (2019), reflective constructs were assessed by:

- Outer loadings – values above 0,7 indicating indicator reliability;
- Internal consistency – Cronbach's α , CR, and ρ_A between 0,70 and 0,95 considered satisfactory;
- Convergent validity – $AVE \geq 0,50$; and
- Discriminant validity – HTMT ratios below 0,85.

The structural model was then analyzed, examining path coefficients and their significance levels. All analyses were conducted using SmartPLS 4 (Grubor et al., 2021).

Results and Discussions

Measurement Model

Reliability of the indicators in the AI-powered food delivery platforms adoption model was first assessed through outer loadings (Table 3). All first-order reflective construct indicators exceeded the 0,70 threshold, except for PIN4 (AI-powered food delivery platforms will be able to find and process the necessary information for completing their tasks) and TTF3 (The functionalities of AI-powered food delivery platforms will be very sufficient), which were excluded, leading to a revised model for subsequent analysis.

Table 3. Indicator Reliability – Outer Loadings

	AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	ANTHROPOMORPHISM (ANT)	COMMUNICATIVE COMPETENCE (CC)	EMOTIONAL TRUST (ET)	PERCEIVED INTELLIGENCE (PIN)	SOCIAL INFLUENCE (SI)	TASK CHARACTERISTICS (TAC)	TASK-TECHNOLOGY FIT (TTF)	TECHNOLOGY CHARACTERISTICS (TEC)
AD1	0,839								
AD2	0,884								
AD3	0,922								
AD4	0,870								
ANT1		0,798							
ANT2		0,773							
ANT3		0,829							
ANT4		0,773							
CC1			0,867						
CC2			0,758						
CC3			0,829						
ET1				0,876					
ET2				0,899					
ET3				0,836					
PIN1					0,721				
PIN2					0,808				
PIN3					0,794				
PIN4					0,605				
PIN5					0,778				
SI1						0,838			
SI2						0,893			
SI3						0,884			
TAC1							0,868		

	AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	ANTHROPOMORPHISM (ANT)	COMMUNICATIVE COMPETENCE (CC)	EMOTIONAL TRUST (ET)	PERCEIVED INTELLIGENCE (PIN)	SOCIAL INFLUENCE (SI)	TASK CHARACTERISTICS (TAC)	TASK-TECHNOLOGY FIT (TTF)	TECHNOLOGY CHARACTERISTICS (TEC)
TAC2							0,924		
TAC3							0,830		
TEC1									0,824
TEC2									0,828
TEC3									0,865
TTF1								0,840	
TTF2								0,849	
TTF3								0,690	
TTF4								0,759	

Source: Author (2025)

The results of testing internal consistency and convergent validity are presented in Table 4. All constructs showed Cronbach's alpha values above 0,7, with CR values ranging from 0,7 to 0,95, indicating satisfactory reliability and internal consistency. AVE values exceeded the recommended threshold of 0,5, and all indicator outer loadings surpassed 0,7, confirming the convergent validity of the constructs.

Table 4. Outer Loadings of Indicators

Constructs and Items	Outer Loadings	Cronbach's Alpha Coefficients	CR	AVE
COMMUNICATION COMPETENCE - CC		0,754	0,774	0,671
CC1	0,867			
CC2	0,758			
CC3	0,829			
TECHNOLOGY CHARACTERISTICS - TEC		0,793	0,813	0,704
TEC1	0,824			
TEC2	0,828			
TEC3	0,865			
TASK CHARACTERISTICS - TAC		0,846	0,849	0,765
TAC1	0,868			
TAC2	0,924			
TAC3	0,830			

Constructs and Items	Outer Loadings	Cronbach's Alpha Coefficients	CR	AVE
PERCEIVED INTELLIGENCE - PIN		0,797	0,803	0,622
PIN1	0,721			
PIN2	0,808			
PIN3	0,794			
PIN5	0,778			
TASK-TECHNOLOGY FIT - TTF		0,792	0,798	0,708
TTF1	0,840			
TTF2	0,849			
TTF4	0,759			
SOCIAL INFLUENCE - SI		0,842	0,851	0,760
SI1	0,838			
SI2	0,893			
SI3	0,884			
ANTHROPOMORPHISM - ANT		0,806	0,821	0,630
ANT1	0,798			
ANT2	0,773			
ANT3	0,829			
ANT4	0,773			
EMOTIONAL TRUST - ET		0,841	0,851	0,759
ET1	0,876			
ET2	0,899			
ET3	0,836			
AI – POWERED FOOD DELIVERY PLATFORMS ADOPTION - AD		0,902	0,904	0,773
AD1	0,839			
AD2	0,884			
AD3	0,922			
AD4	0,870			

Source: Author (2025)

Discriminant validity was assessed using the results presented in Table 5. The square root of the AVE for each construct exceeded its correlations with other constructs, providing clear evidence of discriminant validity. The Fornell–Larcker criterion showed no issues, further confirming the constructs' discriminant validity.

Table 5. Discriminant Validity of Constructs – Fornell–Larcker Criterion

	AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	ANTHROPOMORPHISM (ANT)	COMMUNICATIVE COMPETENCE (CC)	EMOTIONAL TRUST (ET)	PERCEIVED INTELLIGENCE (PIN)	SOCIAL INFLUENCE (SI)	TASK CHARACTERISTICS (TAC)	TASK-TECHNOLOGY FIT (TTF)	TECHNOLOGY CHARACTERISTICS (TEC)
AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	0,879								
ANTHROPOMORPHISM (ANT)	0,369	0,794							
COMMUNICATIVE COMPETENCE (CC)	0,519	0,315	0,819						
EMOTIONAL TRUST (ET)	0,587	0,427	0,630	0,871					
PERCEIVED INTELLIGENCE (PIN)	0,619	0,529	0,436	0,615	0,789				
SOCIAL INFLUENCE (SI)	0,262	0,296	0,365	0,332	0,243	0,872			
TASK CHARACTERISTICS (TAC)	0,360	0,372	0,444	0,434	0,358	0,336	0,875		
TASK-TECHNOLOGY FIT (TTF)	0,690	0,401	0,590	0,595	0,668	0,387	0,441	0,841	
TECHNOLOGY CHARACTERISTICS (TEC)	0,601	0,401	0,640	0,664	0,572	0,290	0,478	0,644	0,839

Source: Author (2025)

The establishment of discriminant validity was further confirmed using the HTMT approach, where the HTMT ratio for each pair of constructs was below the threshold of 0,85 (Table 6), indicating the absence of multicollinearity and confirming discriminant validity among the constructs.

Table 6. Discriminant Validity of Constructs – HTMT Criterion

	AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)	ANTHROPOMORPHISM (ANT)	COMMUNICATIVE COMPETENCE (CC)	EMOTIONAL TRUST (ET)	PERCEIVED INTELLIGENCE (PIN)	SOCIAL INFLUENCE (SI)	TASK CHARACTERISTICS (TAC)	TASK-TECHNOLOGY FIT (TTF)	TECHNOLOGY CHARACTERISTICS (TEC)
AI - POWERED FOOD DELIVERY PLATFORMS ADOPTION (AD)									
ANTHROPOMORPHISM (ANT)	0,417								
COMMUNICATIVE COMPETENCE (CC)	0,629	0,399							
EMOTIONAL TRUST (ET)	0,665	0,508	0,793						
PERCEIVED INTELLIGENCE (PIN)	0,729	0,664	0,571	0,753					
SOCIAL INFLUENCE (SI)	0,297	0,340	0,437	0,387	0,301				
TASK CHARACTERISTICS (TAC)	0,414	0,454	0,546	0,521	0,437	0,389			
TASK-TECHNOLOGY FIT (TTF)	0,818	0,495	0,755	0,723	0,835	0,476	0,537		
TECHNOLOGY CHARACTERISTICS (TEC)	0,691	0,500	0,830	0,806	0,705	0,347	0,587	0,793	

Source: Author (2025)

These findings, confirming the reliability and validity of the measurement indicators, provide the foundation for structural model analysis. This analysis tests the hypothesized relationships among latent constructs, identifies key factors influencing the phenomenon, and quantitatively assesses the strength of these effects.

Structural Model

To assess the path coefficients in the study, the bootstrapping procedure with 10.000 subsamples was applied, as presented in Table 7, all obtained path coefficients were statistically significant with p-values below 0,05, indicating a positive influence of the analyzed factors on the adoption of AI-powered food delivery platforms.

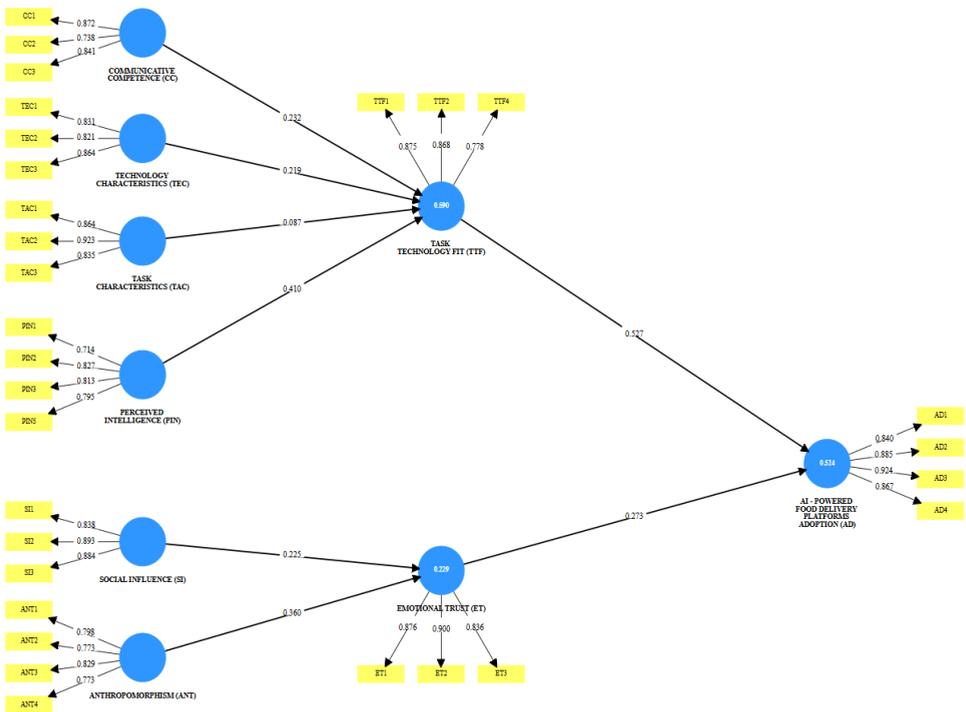
Table 7. Testing of Second-Order Constructs

Relationships	Path Coefficients	Standard Deviation	T Statistics	P Value	VIF Value
Communicative Competence → Task-Technology Fit	0,232	0,044	5,265	0,000	1,781
Technology Characteristics → Task-Technology Fit	0,219	0,052	4,249	0,000	2,168
Task Characteristics → Task-Technology Fit	0,087	0,041	2,107	0,035	1,365
Perceived Intelligence → Task-Technology Fit	0,410	0,040	10,220	0,000	1,520
Social Influence → Emotional Trust	0,225	0,055	4,124	0,000	1,096
Anthropomorphism → Emotional Trust	0,360	0,056	6,476	0,000	1,096
Task-Technology Fit → AI – Powered Food Delivery Platforms Adoption	0,527	0,043	12,321	0,000	1,549
Emotional Trust → AI – Powered Food Delivery Platforms Adoption	0,273	0,046	5,897	0,000	1,549

Source: Author (2025)

The structural model (Figure 3) indicates that all lower-order constructs significantly contribute to higher-order constructs. Perceived Intelligence has the largest impact on Task-Technology Fit (0,410), followed by Communicative Competence (0,232), Technology Characteristics (0,219), and Task Characteristics (0,087). For Emotional Trust, Anthropomorphism (0,360) and Social Influence (0,225) are significant. Task-Technology Fit (0,527) and Emotional Trust (0,273) strongly influence the adoption of AI-powered food delivery platforms. The results show no multicollinearity among the factors, as all VIF values are below 5. Perceived Intelligence (1,520), Communicative Competence (1,781), Technology Characteristics (2,168), and Task Characteristics (1,365) significantly affect Task-Technology Fit ($p < 0,05$), while Social Influence (1,096) and Anthropomorphism (1,096) significantly affect Emotional Trust ($p < 0,05$), supporting the applicability of the S–O–R framework in explaining the adoption of AI-powered food delivery platforms.

Figure 3. Structural Model



Source: Authors' calculations (2025)

The results are generally consistent with previous empirical findings, including the research of Vafaei-Zadeh et al. (2023), which demonstrated that social influence and anthropomorphism substantially affect emotional trust. Similar to their conclusions, the positive role of social networks can be interpreted through social proof and peer endorsement mechanisms that strengthen affective confidence in AI technologies (Chi et al., 2021; Shi et al., 2021). The identified impact of anthropomorphism confirms that human-like attributes of AI interfaces enhance user comfort and the perception of natural interaction (Lee & Chen, 2022).

Communicative competence and perceived intelligence are revealed as essential determinants of perceived task–technology fit, supporting earlier evidence that natural communication and adaptive learning capabilities increase the perceived adequacy of AI systems for user tasks (Song et al., 2022; Pillai & Sivathanu, 2020). In this context, effective interpretation of informal dialogue and the ability to provide personalized recommendations are perceived as key aspects of technological fit. Although task characteristics show a weaker direct effect, the strong relationship between task–technology fit and adoption differs slightly from the results of Vafaei-Zadeh et al. (2023), where this path was not always significant. This discrepancy may stem from the specific context of food delivery services, in which functional efficiency and perceived usefulness have a more immediate impact on behavioral intention.

The obtained results indicate that both task–technology fit and emotional trust play a significant role in the intention to adopt AI-powered food delivery platforms. All indicators showed a positive and statistically significant effect on adoption intention, confirming support for all eight proposed hypotheses. This highlights that Task-Technology Fit and Emotional Trust strongly drive adoption, while Communicative Competence, Technology Characteristics, Task Characteristics, Perceived Intelligence, Social Influence, and Anthropomorphism act as key antecedents.

These findings extend the understanding of AI adoption in the context of agricultural and food economics in the Republic of Serbia. Greater alignment between task and technology, along with emotional trust, can reduce transaction costs, improve supply-chain coordination, and expand market access for small producers (Schroeder et al., 2021; Min et al., 2023). For sustainable digital transformation, platform developers should prioritize intelligent, adaptive, and transparent AI functions that enhance user confidence and operational efficiency. Public policy and educational initiatives that promote digital literacy and trust in AI can further support equitable technological adoption in agricultural and food service markets. By providing evidence from an emerging market, this study offers practical insights for policymakers and platform developers seeking to optimize AI adoption and strengthen competitiveness in the regional agri-food sector.

Conclusions

This study combines the Stimulus–Organism–Response framework with Task–Technology Fit theory to examine AI-powered food delivery platforms adoption in the Republic of Serbia. It shows how stimuli such as Communicative Competence, Technology and Task Characteristics, Perceived Intelligence, Social Influence, and Anthropomorphism affect Task-Technology Fit and Emotional Trust, which in turn drive adoption, highlighting the importance of aligning technology with tasks and fostering emotional trust.

Empirical findings show that Perceived Intelligence is the strongest determinant of Task-Technology Fit, with Communicative Competence, Technology Characteristics, and Task Characteristics also contributing positively. Anthropomorphism and Social Influence enhance Emotional Trust, and together, Task-Technology Fit and Emotional Trust significantly influence adoption intentions, highlighting the importance of both cognitive and emotional factors in AI service platform acceptance. These results have practical implications for service providers seeking to optimize AI-powered food delivery platforms. Prioritizing AI systems that balance efficiency, task alignment, and human-like interaction can increase user satisfaction, trust, and engagement. Features such as real-time updates, personalized recommendations, intuitive conversational interfaces, and socially endorsed functionalities can strengthen both task efficacy and emotional connection, ultimately driving sustained adoption. From the perspective of agricultural and food economics, these insights suggest that well-designed AI platforms can enhance operational efficiency, improve supply chain coordination, and expand market access, supporting the broader goals of competitiveness and innovation in the agri-food sector.

Future research could expand the proposed model to capture additional dimensions of consumer behavior and further validate its applicability in different contexts. Longitudinal designs may also be employed to observe how adoption intentions evolve over time as AI technologies advance. In addition, qualitative approaches could complement survey-based methods by offering deeper insights into consumer perceptions and trust in AI-powered services.

Conflict of interests

The author declares no conflict of interest.

References

1. Abbasi, G. A., Rodriguez-López, M. E., Higuera-Castillo, E., & Liébana-Cabanillas, F. (2024). Drones in food delivery: an analysis of consumer values and perspectives. *International Journal of Logistics Research and Applications*, 1-21. doi:[10.1080/13675567.2024.2407496](https://doi.org/10.1080/13675567.2024.2407496).
2. Adam, M., Wessel, M., & Benlian, A. (2021). AI-based chatbots in customer service and their effects on user compliance. *Electronic markets*, 31(2), 427-445. doi:10.1007/s12525-020-00414-7.
3. Alcántara-Pilar, J. M., Rodriguez-López, M. E., Kalinić, Z., & Liébana-Cabanillas, F. (2024). From likes to loyalty: Exploring the impact of influencer credibility on purchase intentions in tiktok. *Journal of Retailing and Consumer Services*, 78(C). doi:10.1016/j.jretconser.2024.103709.
4. Ameen, N., Hosany, S., & Tarhini, A. (2021). Consumer interaction with cutting-edge technologies: Implications for future research. *Computers in Human Behavior*, 120, 106761. doi:10.1016/j.chb.2020.106548.
5. Chai, L. T., & Yat, D. N. C. (2019). Online food delivery services: Making food delivery the new normal. *Journal of Marketing advances and Practices*, 1(1), 62-77. Retrieved August, 25, 2025 from: https://www.researchgate.net/profile/Teck-Chai-Lau-2/publication/334050513_Online_Food_Delivery_Services_Making_Food_Delivery_the_New_Normal/links/5d148043458515c11cfb6d5e/Online-Food-Delivery-Services-Making-Food-Delivery-the-New-Normal.pdf.
6. Chi, O. H., Jia, S., Li, Y., & Gursoy, D. (2021). Developing a formative scale to measure consumers' trust toward interaction with artificially intelligent (AI) social robots in service delivery. *Computers in Human Behavior*, 118, 106700. doi:10.1016/j.chb.2021.106700.
7. Cho, M., Bonn, M. A., & Li, J. J. (2019). Differences in perceptions about food delivery apps between single-person and multi-person households. *International Journal of Hospitality Management*, 77, 108-116. doi:10.1016/j.ijhm.2018.06.019.
8. Cortiñas, M., Chocarro, R., & Elorz, M. (2019). Omni-channel users and omni-channel customers: a segmentation analysis using distribution services. *Spanish Journal of Marketing-ESIC*, 23(3), 415-436. doi:10.1108/sjme-06-2019-0031.
9. Ghag, N., Sonar, H., Jagtap, S., & Trollman, H. (2024). Unlocking AI's potential in the food supply chain: A novel approach to overcoming barriers. *Journal of*

- Agriculture and Food Research*, 18, 101349. doi:10.1016/j.jafr.2024.101349.
10. Goi, M. T., Kalidas, V., & Zeeshan, M. (2014). Comparison of stimulus-organism-response framework between international and local retailer. *Procedia-Social and Behavioral Sciences*, 130, 461-468. doi:10.1016/j.sbspro.2014.04.054.
 11. Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS quarterly*, 213-236. doi:10.2307/249689.
 12. Grubor, A., Đokić, N., Milicević, N., & Đokić, I. (2021). Marketing istraživanje (Prvo izdanje). Ekonomski fakultet u Subotici, Univerzitet u Novom Sadu
 13. Jacoby, J. (2002). Stimulus-organism-response reconsidered: an evolutionary step in modeling (consumer) behavior. *Journal of consumer psychology*, 12(1), 51-57. doi:10.1207/S15327663JCP1201_05.
 14. Jia, X., Ren, L., & Cai, J. (2020). Clinical implementation of AI technologies will require interpretable AI models. *Medical physics*, (1), 1-4. doi:10.1002/mp.13891.
 15. Joiner, I. A. (2018). Chapter 1-Artificial intelligence: AI is nearby. *Emerging library technologies*, 1-22. doi:10.1016/B978-0-08-102253-5.00002-2.
 16. Krivorotov, G. (2023). Machine learning-based profit modeling for credit card underwriting-implications for credit risk. *Journal of Banking & Finance*, 149, 106785. doi:10.1016/j.jbankfin.2023.106785.
 17. Lee, J. C., & Chen, X. (2022). Exploring users' adoption intentions in the evolution of artificial intelligence mobile banking applications: the intelligent and anthropomorphic perspectives. *International Journal of Bank Marketing*, 40(4), 631-658. doi: 10.1108/IJBM-08- 2021-0394.
 18. Leung, Y. L., Chan, R. L., Chiu, D. K., & Ruwen, T. (2025). Investigating the consumption behavior of young adults using online food delivery platforms during the COVID-19 pandemic. *Aslib Journal of Information Management*, 77(2), 330-353. doi:10.1108/AJIM-05-2023-0177.
 19. Liao, Y. J., & Ahn, J. (2025). The Role of Gamification Attributes in Customer Behavior in Mobile Food Delivery. *International Journal of Human-Computer Interaction*, 1-12. doi:[10.1080/10447318.2025.2520940](https://doi.org/10.1080/10447318.2025.2520940).
 20. Ljepava, N. (2022). AI-enabled marketing solutions in marketing decision making: AI application in different stages of marketing process. *Tem Journal*, 11(3), 1308-1315. doi:10.18421/tem113-40.
 21. Maduku, D. K., Rana, N. P., Mpinganjira, M., Thusi, P., Mkhize, N. H. B., & Ledikwe, A. (2024). Do AI-powered digital assistants influence customer emotions, engagement and loyalty? An empirical investigation. *Asia Pacific Journal of Marketing and Logistics*, 36(11), 2849-2868. doi:10.1108/APJML-09-2023-0935.
 22. Malik, N., Abbasi, A. Z., Sohail, M. S., Abbasi, G. A., & Ting, D. H. (2024). How “inspired” are customers to order from mobile food delivery apps? Soliciting the stimulus-organism-response (SOR) paradigm. *Aslib Journal of Information Management*, (ahead-of-print). doi:[10.1108/AJIM-10-2023-0417](https://doi.org/10.1108/AJIM-10-2023-0417).
 23. Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. Cambridge, MA: Massachusetts Institute of Technology, 8.

24. Min, W., Zhou, P., Xu, L., Liu, T., Li, T., Huang, M., ... & Jain, R. (2023). From plate to production: Artificial intelligence in modern consumer-driven food systems. arXiv preprint arXiv:2311.02400. doi:10.48550/arXiv.2311.02400.
25. Nabavi, E. (2019). Why the huge growth in AI spells a big opportunity for transdisciplinary researchers. *Nature*, 429, 429. doi:10.1038/d41586-019-01251-1.
26. Pelau, C., Dabija, D. C., & Ene, I. (2021). What makes an AI device human-like? The role of interaction quality, empathy and perceived psychological anthropomorphic characteristics in the acceptance of artificial intelligence in the service industry. *Computers in Human Behavior*, 122, 106855. doi: 10.1016/j.chb.2021.106855.
27. Pillai, R., & Sivathanu, B. (2020). Adoption of AI-based chatbots for hospitality and tourism. *International Journal of Contemporary Hospitality Management*, 32(10), 3199-3226. doi:10.1108/IJCHM-04-2020-0259.
28. Prentice, C., Dominique Lopes, S., & Wang, X. (2020). The impact of artificial intelligence and employee service quality on customer satisfaction and loyalty. *Journal of Hospitality Marketing & Management*, 29(7), 739-756. doi: 10.1080/19368623.2020.1722304.
29. Rodrigues, C., & Brandão, A. (2021). Measuring the effects of retail brand experiences and brand love on word of mouth: a cross-country study of IKEA brand. *The International Review of Retail, Distribution and Consumer Research*, 31(1), 78-105. doi:10.1080/09593969.2020.1768577.
30. Sandeep, S. R., Ahamad, S., Saxena, D., Srivastava, K., Jaiswal, S., & Bora, A. (2022). To understand the relationship between Machine learning and Artificial intelligence in large and diversified business organisations. *Materials Today: Proceedings*, 56, 2082-2086. doi:10.1016/j.matpr.2021.11.40.
31. Sayginer, C. (2024). Factors influencing customer satisfaction and loyalty in Artificial Intelligence (AI)-driven food delivery systems during and post COVID-19. *Business & Management Studies: An International Journal*, 12(4), 674-692. doi:[10.15295/bmij.v12i4.2398](https://doi.org/10.15295/bmij.v12i4.2398).
32. Schroeder, K., Lampietti, J., & Elabed, G. (2021). What's cooking: Digital transformation of the agrifood system. World bank publications. Retrieved October, 29, 2025 from: <https://openknowledge.worldbank.org/bitstreams/938f9612-f772-5a2d-980b-ab3f67497adf/download>.
33. Shi, S., Gong, Y., & Gursoy, D. (2021). Antecedents of trust and adoption intention toward artificially intelligent recommendation systems in travel planning: a heuristic-systematic model. *Journal of Travel Research*, 60(8), 1714-1734. doi:10.1177/0047287520966395.
34. Shorbaji, M. F., Alalwan, A. A., & Algharabat, R. (2025). AI-Enabled Mobile Food-Ordering Apps and Customer Experience: A Systematic Review and Future Research Agenda. *Journal of Theoretical and Applied Electronic Commerce Research*, 20(3), 156. doi:[10.3390/jtaer20030156](https://doi.org/10.3390/jtaer20030156).
35. Song, M., Xing, X., Duan, Y., Cohen, J., & Mou, J. (2022). Will artificial intelligence replace human customer service? The impact of communication quality and privacy risks on adoption intention. *Journal of Retailing and Consumer Services*, 66, 102900. doi:10.1016/j.jretconser. 2021.102900.

36. Su, H. T. (2022). Strategic management of the application of information technology in the retail market. *Journal of Management Scholarship*, 1(1), 1-5. doi:10.38198/jms/1.1.2022.1.
37. Talwar, S., Dhir, A., Scuotto, V., & Kaur, P. (2021). Barriers and paradoxical recommendation behaviour in online to offline (O2O) services. A convergent mixed-method study. *Journal of Business Research*, 131, 25-39. doi:10.1016/j.jbusres.2021.03.049.
38. Trabelsi, M., Casprini, E., Fiorini, N., & Zanni, L. (2023). Unleashing the value of artificial intelligence in the agri-food sector: where are we? *British Food Journal*, 125(13), 482-515. doi:10.1108/BFJ-11-2022-1014.
39. Vafaei-Zadeh, A., Nikbin, D., Wong, S. L., & Hanifah, H. (2025). Investigating factors influencing AI customer service adoption: An integrated model of stimulus–organism–response (SOR) and task-technology fit (TTF) theory. *Asia Pacific Journal of Marketing and Logistics*, 37(6), 1465-1502. doi:10.1108/APJML-05-2024-0570.
40. Van Esch, P., & Stewart Black, J. (2021). Artificial intelligence (AI): revolutionizing digital marketing. *Australasian Marketing Journal*, 29(3), 199-203. doi:10.1177/183933492111037684.
41. Yum, K., Yoo, B., & Lee, J. (2022). Application of AI-based customer segmentation in the insurance industry. *Asia pacific journal of information systems*, 32(3), 496-513. doi:10.14329/APJIS.2022.32.3.496.
42. Zhang, Z., Ren, D., Lan, Y., & Yang, S. (2022). Price competition and blockchain adoption in retailing markets. *European Journal of Operational Research*, 300(2), 647-660. doi:10.1016/j.ejor.2021.08.027.

GROSS MARGIN ANALYSIS OF RASPBERRY PRODUCTION ON SELECTED FAMILY HOLDINGS IN SERBIA

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ABSTRACT

This study analyzes the economic performance and risk exposure of raspberry production on selected family farms in Serbia, identified by agricultural advisory services as regional leaders. Using gross margin calculations for the period 2020–2024, the results show that an average gross margin was €14,546/ha or €1.57/kg. Strong year-to-year fluctuations in gross margin were observed, ranging from €0.53/kg in 2023 to €2.97/kg in 2022. These variations were primarily attributable to volatility in raspberry market prices and escalating labor costs, which together accounted for more than 80% of total variable expenses. Sensitivity analysis indicated that most simulated scenarios yielded positive gross margins, suggesting a favorable outlook for the selected Serbian farms. The findings underscore the sector's dependence on labor and unstable markets, highlighting the need for technological modernization, labor-saving innovations, and targeted institutional support to sustain competitiveness in the global raspberry market.

Introduction

Raspberry production is organized in different culture systems under various natural, social, business, etc., conditions all over the world. Raspberries are produced in different intensity systems, from very extensive to super intensive. Various risks and

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uncertainties are connected with raspberry production, which can have a decisive role in the success or failure of investments in raspberry plantations. Those risks and uncertainties depend on many factors, such as intensity level, natural conditions for production, subsidies policy in the country, export and import rules, etc.

In the Republic of Serbia, raspberries are produced in different production systems, which include production on field and production in protected environments. Raspberry production on fields can be organized in very different intensity levels which under the influence of risks can lead to very different economic results.

Table 1. Raspberry production systems and varieties according to use and ripening

Cultivation system	Varieties (examples)	Main characteristics	Ripening time	Main use
Extensive	Willamette, Meeker, Lloyd George, Fertödi zamatos, Polka, Heritage, Autumn Bliss	Hardy varieties, low input, lower planting density, stable but lower yield, suitable for traditional/organic farming	Early–mid (summer), remontant	Processing, fresh (limited)
Semi-intensive	Willamette, Meeker, Glen Ample, Tulameen, Polka, Heritage	Moderate agronomy, stable yield, suitable both for processing and fresh market	Early–mid (summer), remontant	Fresh market + processing
Intensive	Glen Ample, Tulameen, Lashka, Fertödi zamatos, Polka, Imara, Kwanza, Willamette	High yield per hectare, large high-quality fruit, requires irrigation, trellis system, regular crop management	Mid–late summer, remontant	Fresh market (export) + processing
Super-intensive	Kwanza, Imara, Enrosadira, Amira, Maligna selections (Adriana, Loretta, Sofia...), Tulameen, Glen Ample	Grown in tunnels/ greenhouses, fertigation, extended harvest season, premium fruit quality, maximum yield per m ²	Remontant (long harvest season)	Premium fresh consumption, export

Source: authors's presentation

All factors influencing the production and economic parameters of raspberry production could be seen as certain, risky or uncertain. Apart from the certain factors which are constant, it is very important to be aware of the potential impact of risky and uncertain factors, especially when the decision about investing is about to be made. Distinguishing between risk and uncertainty is crucial in agricultural decision-making. Risk involves situations where outcome probabilities are known or can be estimated statistically, while uncertainty refers to cases where such probabilities are indeterminable (Knight, 1921; Jakovljević et al., 2025; Andrei & Darvasi, 2012). Risk assessments are often subjective, shaped by individual perspectives (Popescu & Andrei, 2011; Hardaker, 2016). According to ISO 31000, risk is “the effect of uncertainty on objectives,” encompassing both positive and negative outcomes. In agriculture, risk is

typically categorized into five types: production, market, institutional, personal, and financial (Komarek et al., 2020; Erokhin et al., 2022), each reflecting distinct sources of variability and vulnerability.

From the past research and experiences, a need occurred to investigate the nature of risks and uncertainties in raspberry production in more detail. This paper is part of the authors' research that should bring new insights into factors affecting production results and profitability of raspberry production in the Republic of Serbia and in general. This research mainly aims to identify risks in raspberry production in Serbia, detect their origin and differences in risk occurrence and to measure its possible effects on economic performance on the level of variable costs.

Production risks include factors that could affect the growth and production results of raspberry in quantitative and qualitative terms. Production risks could be roughly subdivided into natural and technological-technical risks.

In this category fall the following risks: risks related to raspberry cultivars and the quality of planting material, risks that originate from natural (agroecological) conditions for raspberry production, production systems and intensity, presence of diseases at the national, regional, or farm level, risks of technical and constructional failure, extreme weather events, etc.

Natural condition-related risks include a range of adverse climatic and meteorological events that may significantly affect agricultural production outcomes. These commonly include storm winds, early autumn frosts, late spring frosts, drought, hail, extreme temperatures, and intense solar radiation.

Market risks include price and cost changes and market access. In the last few years, there have been considerable changes in the raspberry industry in general. Those changes were caused mainly by the Coronavirus pandemic and the war in Ukraine, which can be seen as uncertain and unpredictable events. The usual and biggest market risks in the raspberry industry in Serbia are price changes of raspberries and human labour.

Institutional risks come from changes in the policies and regulations that affect agricultural production, e.g., raspberry production. Institutional risks are mostly not under farmers' control, and farmers have minimal influence. This risk category includes changes in subsidy policies, export and import regulations, and fitosanitary, agricultural and ecological regulations that affect raspberry production.

Personal (human) risks are specific to an individual and include factors like health, relations, motivation, qualification level, working ethics, etc., which could influence farm results.

The shortage of external labor is an increasingly prevalent issue and risk, both in raspberry production and in agriculture more broadly. Manual operations include the removal of young shoots, tying of canes and wire tensioning, pruning of old canes, in-row fertilization, and harvesting. Additionally, plant protection treatments are often carried

out manually. The engagement of manual labor is also required for operations involving mechanization, such as irrigation, spraying, transport, and other auxiliary tasks.

Financial risks refer to all aspects of financing the investment and operation of raspberry production. There is the risk that the financial means for financing the operation wouldn't be sufficient. Changes in bank interest rates for long-term and short-term credits also fall in this category.

Materials and methods

In this research authors used the data from structured interview, data from the Institute for science application in agriculture (IPN) data base and information from previous researches and literature.

Data gathered from structured questionnaire originate from State funded advisory services from the cities of Kraljevo, Užice, Valjevo, Čačak and Šabac. Those data include information about most frequent risks in raspberry production in Serbia such as the risk type, frequency of occurrence, negative effects to plants and fruits and risk mitigation measures.

The IPN base dataset was compiled from a selection of agricultural farms whose principal economic activity is the cultivation of raspberries (hereinafter referred to as "selected family holdings"). These farms were identified in accordance with the provisions outlined in the Rulebook on the Methodology for Conducting Advisory Services in Agriculture (Official Gazette No. 65/2014), which constitutes an integral component of the Regulation on the Annual Program for the Development of Agricultural Advisory Services, adopted individually for each calendar year.

Using data from the IPN dataset spanning the 2020–2024 production years, gross margin analysis was employed to assess the economic viability of raspberry cultivation among selected family farms. The dataset encompassed detailed records on cultivated area, yield levels, and variable input costs associated with field-based raspberry production. The data includes the quantity of external work (working days) for each manual operation. On the other hand, family labor costs are a significant factor that influences the overall cost of agricultural production but is often overlooked. Usual methods for evaluation of family labor costs are called market wage substitution method (Picazo-Tadeo et al., 2005) or opportunity cost method (Folbre, 2015). This method assigns a local market wage to the hours worked by family members, treating them as if they were hired labor. Quantity of family labor was calculated by subtracting external working days from total working days, for each operation separately. Quantity of total labor in working days per manual operation was estimated to 95 (w.day/ha) for plantation maintenance, transportation and other operations and with 50kg/w.day for fruit harvest, using various sources (Veljković et al., 2006; Miljković & Arsić, 2025; Apáti, F., 2014; Institut za voćarstvo, Čačak, 2015; Kljajić et al., 2017) and author's consultations with experts from State funded advisory services from the cities of Belgrade, Kraljevo, Užice, Valjevo and Čačak. The daily wage rates vary depending on the type of agricultural operation, as well as the geographical

location of the farm. The cost of family labor was evaluated based on the wage rate paid by the farm to external labor for the corresponding operation. In cases where no external labor was hired for a specific task, the average daily wage rate of external labor on that farm was used as the valuation basis.

To evaluate the resilience of economic outcomes under uncertainty, a sensitivity analysis was conducted. This involved simulating variations in key parameters—such as working day cost and production value volatility—and quantifying their respective impacts on gross margins. The findings provide insight into the economic performance and risk exposure of selected family raspberry producers, offering a basis for informed decision-making and policy support in the sector. The adopted unit of observation for the analysis is 1 hectare.

Results

Raspberry production in Serbia is conducted under different natural and organizational-economic conditions, with very different variable costs expenditures, which leads to different production and economic results. Table 2 provides an overview of average yields recorded on selected family holdings as well as across Serbia as a whole over the examined five-year period.

Table 2. Average yield of raspberry production in Serbia on selected holdings and in general (2020-2024.)

Yield / Year	2020	2021	2022	2023	2024	2020-2024
Average Yield – Serbia* (kg/ha)	4,939	5,315	5,892	5,189	5,048	5,266
Average Yield – selected holdings (kg/ha)	8,839	9,209	9,831	8,002	10,402	9,240

Source: author's calculation; *SORS data.

There is a marked discrepancy between the average raspberry yield at the national level in Serbia and the yields recorded on selected family farms. Selected family holdings are deliberately chosen based on criteria such as productivity, technological advancement, and their capacity to serve as demonstrative models for best practices. Furthermore, substantial yield variation exists among individual selected family farms themselves, primarily due to mentioned differences in production conditions and cost expenditures. Key contributing factors include agroecological characteristics, access to irrigation, mechanization levels, labor availability, and the degree of adoption of modern cultivation techniques. These disparities underscore the importance of targeted support and knowledge transfer to enhance productivity across the broader sector (Kljajić & Subić, 2022; Mihajlović & Todorov, 2024; Veljković et al., 2024; Grčak et al., 2019).

For the purpose of easier and more detailed explanation of the detected risks in raspberry production in Serbia, the previously mentioned division of risks into five categories will be employed.

Production risks: The selection of raspberry cultivars under specific production conditions significantly influences their resilience to environmental stressors and disease pressure, as well as the yield quantity and fruit quality. Moreover, choosing an appropriate cultivar for a given location affects the timing of ripening and the potential for market placement at higher purchase prices. Based on criteria such as market demand, yield potential, and adaptability to local growing conditions, certain raspberry cultivars are recommended for cultivation in Serbia (Leposavić, 2023).

The risk of disease occurrence and the severity of its impact on yield and plantation—both in terms of production and economic outcomes—depend on a range of factors, some of which are related to production systems, while others stem from human-related risks. Natural conditions for raspberry cultivation represent a critical determinant of production success. Certain natural risk factors can be mitigated or eliminated entirely, while the severity of others can be reduced through the careful selection of an appropriate cultivation site and cultivar.

Market risks in raspberry production in Serbia can be easily depicted with variations in material costs, labour prices for working day (€/w.day), and raspberry prices for chosen time period.

Table 3. Average Raspberry price and external labor daily allowance (2020-2024)

Indicator / Year	2020	2021	2022	2023	2024
Raspberry price (€/kg)	1.82	3.49	4.24	1.80	2.12
Index (2020 = 100%)	100%	192%	249%	97%	128%
Daily allowance (€/working day)	25	30	39	38	42
Index (2020 = 100%)	100%	119%	155%	152%	165%

Source: author's calculation based on IPN database data

Table 3 reveals that, over the observed five-year period, both the purchase price of raspberries and the daily wage rates for external labor were subject to substantial fluctuations. Notably, in 2024, the average daily wage increased by 165%, while the purchase price of raspberries rose by 128%, compared to the baseline year of 2020. These price variations highlight the extent of volatility, which must be considered when conducting risk assessments and sensitivity analyses. During the same period, there were no significant changes in the exchange rate of the Serbian dinar against the euro, with monthly average values ranging between 116.973 RSD/€ and 117.728 RSD/€.

Institutional risks: in raspberry production in Serbia, there are government measures aimed at encouraging the establishment and maintenance of raspberry plantations. These measures include subsidies for the procurement of high-quality planting material, support structures such as poles and wire, irrigation systems, hail protection systems, shading nets, deep soil cultivation, soil analysis, diesel fuel acquisition, as well as basic incentives for crop production. The amount of support depends on the geographical location of the farm and may cover 50% or up to 65% of the purchase

value of the primary input. It is evident that government subsidies play a crucial role in the establishment of plantations, whereas production-related, such as subsidies for incentives are of lesser economic impact.

The most important regulations that define the conditions and levels of agricultural subsidies in raspberry production include: the Rulebook on Defining Areas with Difficult Working Conditions in Agriculture (“Official Gazette of the Republic of Serbia”, No. 132/21); the Rulebook on Incentive Programs for Enhancing Competitiveness through Investments in Physical Assets of Agricultural Holdings, supporting the establishment of perennial fruit and hop plantations (“Official Gazette RS”, No. 17/23); the Rulebook on Incentives for Investments in Physical Assets of Agricultural Holdings for the Procurement of New Machinery and Equipment to Improve Primary Crop Production (“Official Gazette RS”, Nos. 48/18, 29/19, 78/20, and 119/21); the Rulebook on Conditions, Procedures, and Application Forms for Exercising the Right to Insurance Premium Subsidies for Crops, Fruits, Perennial Plantations, Nurseries, and Livestock (“Official Gazette RS”, Nos. 61/17 and 44/18 – amended law).

Personal (human) risks are specific to an individual and include factors like health, relations, motivation, qualification level, working ethics, etc., which could influence farm results.

Worker motivation and training are of critical importance in raspberry production, as errors in performing operational tasks can have adverse effects on plant health and vigor, fruit quantity and quality, labor productivity, and overall production costs. Certain tasks are more sensitive than others, and improper execution may lead to more pronounced consequences and elevated risk levels.

Financial risks: in Serbia, various financing mechanisms are available for raspberry production on family farms. These include self-financing, subsidized loans provided by the Ministry of Agriculture, Forestry and Water Management and local municipalities, commercial bank loans, as well as financing from cold storage operators for the procurement of fertilizers, plant protection products, and occasionally planting material. Survey results indicate that raspberry producers rarely utilize commercial loans due to high interest rates. Subsidized loans are used when available. On mixed farms with multiple production lines, self-financing is commonly practiced, often without proper cost tracking. Family holdings frequently rely on financing from cold storage operators, with debt repayment made in the form of agricultural products.

Table 4. Some frequent risks in raspberry production in Serbia

Risk	Frequency of occurrence	Damage	Possible losses (%)	Method of reducing risk
Hail occurrence	Occasional, depends on geographical area	Damage to shoots and berries	Damage to 20% shoots, yield reduction 40% - 80%	Anti-hail nets
Sunburn / sunscald	Every year	Fruits and leaves damage, reduced fruit quality	Yield reduction of up to 20%, increase in the share of II Class fruit	Shade nets
Drought	Every year	Drying of shoots, reduction in fruit mass and quantity	Yield reduction of up to 50%	Introduction of an irrigation system
Excessive rainfall	Occasional	Drying of shoots, weaker shoot growth, risk of root disease, fruit rot	Yield reduction of 30% - 80%	Selection of orchard location and soil, soil preparation before planting, raising orchards on berms / beds on flatter terrain
Labor: availability, lack of motivation, lack of training, absenteeism	Every year	Yield reduction via a decrease in the quantity of harvested fruit	Yield reduction of up to 25%	Establish orchards on smaller areas or introduce mechanized harvesting where possible
Labor: religious holidays	Every year, in some areas	Harvest delay, irregular harvesting	Yield reduction of up to 20%	?
Risk of making incompetent decisions, failure to follow expert advice (inadequate and excessive fertilizing and irrigation, etc.)	Every year	Drying of shoots	Yield reduction of 10% - 30%, or more in unfavorable years	Continuous education of agricultural producers
Raspberry price unpredictability	Every year	Negative economic results	Change in family holding income $>\pm 50\%$	Product and production diversification

Source: Questionnaire, 2025.

The survey, conducted through questionnaires among selected Serbian agricultural advisory services, enabled the identification of the predominant risks associated with raspberry production, which are summarized in Table 4. Analysis of Table 1 and 4 further

indicates that risk factors are not uniformly distributed across production systems. Risks arising from natural conditions for raspberry cultivation are more pronounced in extensive systems, whereas price fluctuations exert a stronger impact on economic outcomes in intensive systems, reflecting the larger production scale per unit area.

Drawing on the compiled data regarding variable costs and the estimated value of family labor, the gross margin was calculated for the examined period, with results presented in Table 5.

Table 5. Gross margin calculation for selected family holdings (2020-2024)

Indicator / Year	2020	2021	2022	2023	2024	2020-2024
Number of family holdings	285	221	193	139	181	1019
Production area (ha)	201.9	139.0	110.7	82.2	104.5	638.4
Average Yield (kg/ha)	8,839.6	9,209.0	9,831.5	8,001.6	10,401.9	9,239.9
Average Income (€/ha)	16,078.5	32,136.9	41,714.0	14,439.3	22,037.1	24,785.3
Average incentives (€/ha)	192.2	110.5	61.9	160.5	236.7	155.0
Average income with incentives (€/ha)	16,270.7	32,247.5	41,775.9	14,599.8	22,273.8	24,940.3
Material Costs (€/ha)	1,303.4	2,166.2	2,001.2	1,674.4	1,244.0	1,650.3
External labour costs (€/ha)	4,092.9	4,973.6	5,651.7	4,629.2	7,039.5	5,106.5
Family labor costs (€/ha)	2,337.2	2,897.9	4,855.2	4,052.7	4,740.9	3,510.5
Mechanization services (€/ha)	9.5	-	22.9	11.6	93.2	23.7
Other variable costs (€/ha)	178.6	124.4	28.6	3.6	84.3	102.8
Variable costs without family labour (€/ha)	5,584.3	7,264.2	7,704.4	6,318.8	8,460.9	6,883.4
Variable costs - Total (€/ha)	7,921.5	10,162.1	12,559.6	10,371.5	13,201.9	10,393.8
Gross Margin - without family labor (€/ha)	10,686.4	24,983.3	34,071.5	8,281.0	13,812.9	18,056.9
Gross Margin without family labor (€/kg)	1.21	2.71	3.47	1.03	1.33	1.95
Gross Margin -Total (€/ha)	8,349.2	22,085.4	29,216.3	4,228.2	9,071.9	14,546.4
Gross Margin - Total (€/kg)	0.94	2.40	2.97	0.53	0.87	1.57

Source: author's calculation

Variable costs excluding family labor expenses ranged from €5,584.3/ha in 2020 to €8,460.9/ha in 2024. Total variable costs during the same period ranged from €7,921.5/ha (2020) to €13,201.9/ha (2024), with a five-year average of €10,393.8/ha. The gross margin excluding family labor costs was lowest in 2023, amounting to €8,281.0/ha, equivalent to €1.03/kg of raspberries, and highest in 2022, amounting to €34,071.5/ha, or €3.47/kg of produced raspberries. When family labor costs are included, the lowest coverage margin was €4,228.2/ha, or €0.53/kg in 2023, and the highest was €29,216.3/ha, or €2.97/kg in 2022. The five-year average gross margin, including family labor costs, amounted to €18,056.9/ha, or €1.57/kg of produced raspberries.

When observing the share of individual cost components within total variable costs, it is evident that labor expenses accounted for the largest proportion, ranging from 77.5% to 89.2%, with an average of 82.9% over the five-year period under analysis. On the other hand, when examining the factors that determined the production value, it is evident that price fluctuations were significantly more pronounced than yield variations.

The preceding analysis indicates that labor costs and raspberry prices represent the most volatile variables, exerting the greatest influence on gross margin outcomes. For the sensitivity analysis, a baseline scenario was established with labor costs of €12,000€ per hectare and a raspberry price of €2.70 per kilogram. The average yield was set at 9 t/ha, while other variable costs were assumed to amount to €1,700 per hectare. This baseline reflects recent production conditions and is considered representative for projections in the near future.

Table 6. Sensitivity analysis of gross margin in raspberry production (€/kg)

Raspberry price (€/kg) / Labour Costs (€/ha)		-60%	-40%	-20%	Base price	20%	40%	60%
		1.08	1.62	2.16	2.7	3.24	3.78	4.32
-30%	8,400	-0.01	0.50	1.04	1.58	2.12	2.66	3.20
-20%	9,600	-0.14	0.36	0.90	1.44	1.98	2.52	3.06
-10%	10,800	-0.28	0.23	0.77	1.31	1.85	2.39	2.93
Base cost	12,000	-0.41	0.10	0.64	1.18	1.72	2.26	2.80
10%	13,200	-0.54	-0.04	0.50	1.04	1.58	2.12	2.66
20%	14,400	-0.68	-0.17	0.37	0.91	1.45	1.99	2.53
30%	15,600	-0.81	-0.30	0.24	0.78	1.32	1.86	2.40

Source: author's calculation

As presented in Table 6, gross margin remains positive across a broad range of feasible parameter combinations, reaching 1.18€/kg under the reference scenario with labor costs of 12,000 €/ha and a raspberry price of 2.70 €/kg. In contrast, a 60% reduction in the raspberry price under baseline labor costs results in a negative gross margin of -0.41 €/kg. When the baseline price of 2.70 €/kg is combined with a 30% increase in labor costs, the gross margin remains positive at 0.78 €/kg. Conversely, a 40% decline in raspberry price coupled with a 10% increase in labor costs drives the gross margin slightly below zero (-0.04 €/kg).

Discussions

The results of the present study demonstrate that raspberry production on selected family farms in Serbia can generate a positive gross margin over the observed five-year period, averaging €14,546/ha or €1.57/kg of raspberries. Nevertheless, significant inter-annual fluctuations were recorded, with margins ranging from as low as €0.53/kg in 2023 to €2.97/kg in 2022. These variations confirm the high sensitivity of profitability to changes in labor costs and raspberry purchase prices. Labor costs alone accounted for more than 80% of total variable costs, highlighting their critical role in the economic performance of farms. Sensitivity analysis showed that even moderate changes in key

parameters—such as a 20–30% decline in farm-gate price or increase in labor costs—could shift gross margins into negative values.

When compared to international research, similar patterns emerge. Wróblewska, Pawlak, and Paszko (2019) reported that in Poland, Serbia, and Ukraine, the main drivers of profitability were fluctuations in the farm-gate price of raspberries and the high share of manual labor in total costs. However, Poland benefits from somewhat lower labor costs and higher mechanization, which partially offsets price volatility. In Hungary, Apáti (2014) emphasized that profitability is strongly dependent on the intensity of the production system, with high-input plantations achieving above-average yields but simultaneously being more exposed to climatic and market risks. These findings correspond closely to the present results, where higher yields on selected family holdings secured higher margins, but only under favorable price and labor cost conditions.

The differences between extensive, semi-intensive, intensive, and super-intensive systems, as outlined in Serbian and regional studies (Veljković et al., 2008; Kljajić & Subić, 2022), further confirm that production intensity is a double-edged sword: while it increases potential yields (up to 20–25 t/ha under optimal agro-technical measures), it also amplifies exposure to risk due to higher fixed and variable costs. The average yield of 8.9 t/ha reported in this study is above the Serbian national average of around 5.3 t/ha (SORS data), which is logical given that these holdings were selected by agricultural advisors as leaders in their specific region, indicating that they are more technologically advanced and better organized.

Several studies emphasize that the appropriate application of agrotechnical measures and the choice of suitable cultivars significantly improve profitability. Radosavljević (2016) demonstrated that proper agronomic practices can double yields from 7 t/ha to 13 t/ha on family farms, while Milić et al. (2019) confirmed the profitability of raspberry production in Vojvodina, where mechanized harvesting reduced labor costs and allowed profits of around €5,940/ha. These findings highlight the critical role of technology adoption in improving gross margins, especially in regions outside the traditional raspberry-producing areas of Western Serbia.

Risk analysis also shows strong alignment with earlier studies. Jirgena et al. (2013) documented that climatic and market shocks are the most destabilizing factors in berry production across Europe. In Serbia, drought, hail, and sunburn remain frequent and damaging risks (Veljković et al., 2006; Laposavić, 2023). The present study confirms that climate variability significantly impacts production results, while institutional risks—such as subsidy changes and unstable policy frameworks—continue to create additional uncertainty.

Institutional support, in the form of subsidies and regulatory frameworks, plays an important stabilizing role. Radosavljević (2016) emphasized the need for targeted policy measures to support small family farms, while recent analyses (Official Gazette RS, 2017–2023) show that subsidies for planting material, anti-hail nets, irrigation systems, and basic crop incentives are crucial for reducing establishment costs. Without such instruments, the economic viability of raspberry production would be significantly threatened, particularly under rising labor costs.

Overall, this study contributes to the literature by quantifying the gross margins and demonstrating, through sensitivity analysis, just how fragile profitability can be under realistic variations of key parameters. Compared with the international and domestic literature, the results highlight both the strengths (relatively high yields on advanced family farms) and weaknesses (overdependence on labor and volatile farm-gate prices) of the Serbian raspberry sector.

Conclusions

The analysis of gross margins in raspberry production on selected family farms in Serbia confirms that this sector remains profitable on average, but it is highly sensitive to changes in prices and labor costs. The dominance of labor expenses—exceeding 80% of total variable costs—makes the system particularly vulnerable to rising wages and labor shortages. When compared to studies from Poland, Hungary, and Ukraine, it is evident that Serbian producers face similar structural challenges but with higher exposure to risk due to limited mechanization and high labor intensity (Wróblewska et al., 2019; Apáti, 2014). Domestic research further confirms that profitability can be ensured only through the consistent application of advanced agro-technical practices, adoption of mechanization where possible, and adequate institutional support (Radosavljević, 2016; Milić et al., 2019; Kljajić & Subić, 2022).

The sensitivity analysis revealed a wide range of practically attainable values for the gross margin. Most of the simulated scenarios yielded positive outcomes, while a smaller portion resulted in negative or near-zero margins. These findings suggest a potentially favorable position for the selected agricultural holdings in Serbia. However, for more precise conclusions, it is essential to consider farm size, total production costs, and investment calculations.

For long-term sustainability, it is necessary to develop systemic instruments for risk management, such as crop insurance schemes, producer cooperatives, and stabilization funds, while simultaneously promoting technological modernization and labor-saving innovations. Only through such measures can the Serbian raspberry sector maintain competitiveness in an increasingly volatile global market.

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Conflict of interests

The authors declare no conflict of interest.

References

1. Andrei, J. V., & Darvasi, D. (2012). Perspectives and challenges in financing the new Common Agricultural Policy, a new paradigm. *Journal of Food, Agriculture & Environment*, 10 (1) No. 1 part 2, 904-907.
2. Apáti, F. (2014). Economic Evaluation of Hungarian Raspberry Production. *International Journal of Horticultural Science* 2014, 20(3-4): 53-56. Doi: <https://doi.org/10.31421/IJHS/20/3-4/1135>
3. Erokhin, V., Tianming, G., Chivu, L., & Andrei, J. V. (2022). Food security in a food self-sufficient economy: A review of China's ongoing transition to a zero hunger state. *Agricultural Economics/Zemědělská Ekonomika*, 68(12).
4. Folbre, N. (2015). Valuing non-market work. UNDP Human Development Report Office, Think Piece. Retrieved from <https://hdr.undp.org/system/files/documents/folbrehdr2015final.pdf>
5. Grčak D., Grčak M., Grčak D., Đekić V., Aksić M., Nikolić K., Gudžić S. (2019): The raspberry: An analysis of production in the Republic of Serbia from 2006 to 2016. *Acta agriculturae Serbica*, 24(47), 19-25. Doi: <https://doi.org/10.5937/AASer1947019G>.
6. Hardaker, B. (2016). Comment 2 on 'Risk and uncertainty' by Quiggin and Anderson. *Australian Journal of Agricultural and Resource Economics*, 60(4), 552-553. Doi: <https://doi.org/10.1111/1467-8489.12184>
7. Institut za voćarstvo, Čačak. (2015). Elaborat zasnivanja i održavanja zasada maline (Izveštaj projekta: Tehničko-tehnološki modeli intenzivnih zasada voćaka i jačanje ljudskih kapaciteta u funkciji unapređenja voćarske proizvodnje Republike Srbije). Ministarstvo poljoprivrede i zaštite životne sredine Republike Srbije. [in English: Institute of Fruit Growing, Čačak. (2015). Establishment and maintenance of raspberry orchards (Project report: Technical-technological models of intensive fruit orchards and strengthening human capacities for the improvement of fruit production in the Republic of Serbia). Ministry of Agriculture and Environmental Protection of the Republic of Serbia].
8. Jakovljević, N., Dmitrović, V., & Jeremić, N. . (2025). Triple materiality: concept, structure and perspective. *BizInfo Blace*, 16(2), 93-98. <https://doi.org/10.71159/bizinfo250022J>
9. Jirgena, H., Hazners, J., Kaufmane, E., Strautina, S., Feldmane, D., & Skrivele, M. (2013). "Risks and Returns in Strawberry, Raspberry and Cherry Production with Various Methods." *Economics and Rural Development* 9(2): 16-26. Retrieved from <https://portalcris.vdu.lt/server/api/core/bitstreams/f7c7d222-3000-4d6b-ad2c-95299ea1b4de/content>.
10. Kljajić, N. & Subić, J. (2022). Economic Effects of Raspberry Production on the Family Farm. In *Agrarian Economy and Rural Development – Trends and Challenges*. International Symposium, 13th Edition, edited by Steliana Rodino and Vili Dragomir: 31-39. Bucharest: ICEADR. Retrieved from <https://symposium.iceadr.ro/archive/archive/>

11. Kljajić, N., Subić, J., & Sredojević, Z. (2017). Profitability of raspberry production on holdings in the territory of Arilje. *Economics of Agriculture*, 64(1), 57–68. Doi: <https://doi.org/10.5937/ekoPolj1701057K>
12. Knight, F. H. (1921). *Risk, uncertainty and profit* (Vol. 31). Houghton Mifflin. Retrieved from: https://oll-resources.s3.us-east-2.amazonaws.com/oll3/store/titles/306/Knight_0192_EBk_v6.0.pdf
13. Komarek, A. M., De Pinto, A. & Smith, V. H. (2020). A review of types of risks in agriculture: What we know and what we need to know. *Agricultural Systems*, 178, 102738. Doi: <https://doi.org/10.1016/j.agsy.2019.102738>
14. Leposavić, A. (2023). *Savremena proizvodnja maline*. Institut za voćarstvo, Čačak, Poljoprivredni fakultet, Kruševac. [in English: Leposavić, A. (2023). *Modern Raspberry Production*. Institute of Fruit Growing, Čačak, Faculty of Agriculture, Kruševac]. ISBN: 978-86-920869-3.
15. Mihajlović, M., & Todorov, J. (2024). Analiza uticaja nedostatka resursa i satisfakcija stanovništva. *Održivi razvoj*, 6(1), 47-62. <https://doi.org/10.5937/OdrRaz2401047M>
16. Milić, D., Užar, D., Radojević, V., Đajić, S. & Zekić, V. (2019). Ekonomski efekti proizvodnje maline na porodičnom gazdinstvu na teritoriji AP Vojvodine. *Agroekonomika* 85, 43–53. [in English: Milić, D., Užar, D., Radojević, V., Đajić, S., & Zekić, V. (2019). Economic effects of raspberry production on family farms in the territory of AP Vojvodina. *Agroekonomika*, 85, 43–53.] Retrieved from https://agroekonomika.rs/images/Brojevi/ae85/Agroekonomika_85.pdf
17. Miljković, M., & Arsić, I. (2025). Determinisanje promena organizaciono-upravljačkih procesa u sistemu upravljanja. *Finansijski Savetnik*, 30(1), 55-74. <https://fa-journal.com/index.php/fa/article/view/3>
18. Picazo-Tadeo, A., J. & Reig-Martínez, E. (2005). Calculation of shadow wages for family labour in agriculture: An application to citrus farming in Spain. *Cahiers d'Economie et de Sociologie Rurales*, 75, 5-21. Doi: <https://doi.org/10.22004/ag.econ.201781>
19. Popescu, G., & Andrei, J. (2011). From industrial holdings to subsistence farms in Romanian agriculture. Analyzing the subsistence components of CAP. *Agricultural Economics*, 57(11), 555.
20. Radosavljević, K. (2016). Enhancing agri-competitiveness: A cost-benefit analysis of raspberry production on a family farm. *Economics of Enterprise*, 64(7-8), 492-498. Doi: <https://doi.org/10.5937/ekoprel1608492R>
21. Republic of Serbia. (2017). Rulebook on Conditions, Procedures, and Application Forms for Exercising the Right to Insurance Premium Subsidies for Crops, Fruits, Perennial Plantations, Nurseries, and Livestock. Official Gazette RS, No. 61/17.
22. Republic of Serbia. (2018). Rulebook on Conditions, Procedures, and Application Forms for Exercising the Right to Insurance Premium Subsidies for Crops, Fruits, Perennial Plantations, Nurseries, and Livestock (Amended). Official Gazette RS, No. 44/18.

23. Republic of Serbia. (2018). Rulebook on Incentives for Investments in Physical Assets of Agricultural Holdings for the Procurement of New Machinery and Equipment to Improve Primary Crop Production. Official Gazette RS, No. 48/18.
24. Republic of Serbia. (2019). Rulebook on Incentives for Investments in Physical Assets of Agricultural Holdings for the Procurement of New Machinery and Equipment to Improve Primary Crop Production. Official Gazette RS, No. 29/19.
25. Republic of Serbia. (2020). Rulebook on Incentives for Investments in Physical Assets of Agricultural Holdings for the Procurement of New Machinery and Equipment to Improve Primary Crop Production. Official Gazette RS, No. 78/20.
26. Republic of Serbia. (2021). Rulebook on Defining Areas with Difficult Working Conditions in Agriculture. Official Gazette RS, No. 132/21.
27. Republic of Serbia. (2021). Rulebook on Incentives for Investments in Physical Assets of Agricultural Holdings for the Procurement of New Machinery and Equipment to Improve Primary Crop Production. Official Gazette RS, No. 119/21.
28. Republic of Serbia. (2023). Rulebook on Incentive Programs for Enhancing Competitiveness through Investments in Physical Assets of Agricultural Holdings, Supporting the Establishment of Perennial Fruit and Hop Plantations. Official Gazette RS, No. 17/23.
29. Veljković, B., Glišić, I., & Laposavić, A. (2008). An analysis of raspberry production conditions in Serbia. *Acta Agriculturae Serbica*, 13(25), 9–16. Retrieved from https://www.researchgate.net/publication/268409685_An_Analysis_of_Raspberry_Production_Conditions_in_Serbia
30. Veljković, B., Marković D., Koprivica R. & Gavrilović M. (2024). Calculations in raspberry production on family farms in Western Serbia. In *Proceedings of the 2nd International Symposium on Biotechnology*: 175–181. Doi: <https://doi.org/10.46793/sbt29.23bv>
31. Wróblewska, W., Pawlak, J. & Paszko, D. (2019). Economic Aspects in the Raspberry Production on the Example of Farms from Poland, Serbia and Ukraine. *Journal of Horticultural Research*, 27(2), 71-80. Doi: <https://doi.org/10.2478/johr-2019-0019>
32. Вељковић, Б., Петровић, С., Лепосавић, А. & Глишић, И. (2006). Профитабилност производње малине на подручју Србије. *Економика пољопривреде*, 53(4), 1013-1022. [in English: Veljković, B., Petrović, S., Laposavić, A., & Glišić, I. (2006). Profitability in raspberry production in Serbia. *Economics of Agriculture*, 53(4), 1013–1022.] Retrieved from <https://ea.bg.ac.rs/index.php/EA/article/view/1415/1202>

CLASSIFICATION OF DISTRICTS IN SERBIA BASED ON THE AGRICULTURAL PRODUCTION DEVELOPMENT INDICATORS

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ABSTRACT

The purpose of this paper is to analyze regional differences in agricultural production development at district level in the Republic of Serbia. For the realization of defined objectives a multivariate statistical methodology was employed, based on the combined application of hierarchical and non-hierarchical cluster analysis methods, using following four indicators: employment in agriculture, average farm size, land productivity, and agricultural gross value added per farm. The research results indicate the existence of five distinct clusters of districts, which differ significantly in production structure, resource utilization, and economic efficiency. The findings confirm pronounced regional disparities and emphasize the need for differentiated agricultural development measures. The recommendations arising from results relate to the creation of targeted institutional and financial support tailored to the specific characteristics of individual clusters. This research contributes to the enrichment of existing literature and provides a suitable analytical basis for creation of future agricultural and rural development strategy.

Introduction

Agriculture is one of the key economic sectors of the Republic of Serbia (RS) and the backbone of national economy (Government of the RS, 2022). Although the agriculture, forestry, and fisheries sector accounts for only 4.4% of gross value added (GVA) in 2023, employing around 27,552 persons in domain-specific legal entities and 53,633 registered individual farmers (SORS, 2024; 2025) within the total of 2,360,588 employed

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persons in the RS it still retains strategic importance for the country. This is particularly evident in rural areas, where it often represents the dominant economic activity, thereby contributing to their economic growth, poverty reduction, improved living conditions, and the mitigation of rural-to-urban migration (Jankowska & Hlavsa, 2025). Besides its economic role, agriculture in the RS also has an important social role, as it relies heavily on small and family farms (nearly 508,325 recorded in 2023), which form the basis of the country's agrarian structure. Furthermore, based on the well-known fact that agricultural production plays a critical role in ensuring food security by supplying essential crops and livestock to feed the country's population, as well as in providing raw materials and foundation for related industries (i.e., food processing, manufacturing of agricultural machinery, and agrochemicals), and in creating jobs and income opportunities across the value chain (Jankowska & Hlavsa, 2025), it is not surprising that agriculture is perceived as strategically important for sustainable development of the country and its regions, and, to a larger extent, for its independence and self-sufficiency (Lubova et al., 2023). However, the development potential of agriculture in the RS faces numerous constraints, including low productivity levels, fragmented land holdings, insufficient technical and technological equipment, and pronounced regional differences in the intensity and structure of production. These challenges have also been recognized in the Agriculture and Rural Development Strategy of the RS for the period 2014–2024 (MAEP, 2014), which highlights enhancing competitiveness, sustainable resource management, and reducing regional disparities as key development priorities. In parallel, the process of European integration and alignment with the Common Agricultural Policy of the European Union imposes additional requirements aimed at improving the agricultural sector's productivity and efficiency, while emphasizing the need for differentiated development measures customized to the traits of individual regions (Radenović et al., 2022).

The spatial differences in agricultural development, along with the necessity of creating targeted and more effective development support policies, create the need for analytical (mainly multivariate statistical) approaches that enable a deeper understanding of internal disparities and the grouping of territories according to their agricultural characteristics. In other words, the existence of regional disparities in agricultural structures and performance raises important questions not only for policymakers but also for researchers (Fanelli, 2019). Consequently, the relevant literature includes numerous studies analyzing various issues related to agricultural development across different level territorial units, defined by the Nomenclature of Territorial Units for Statistics (NUTS), within specific country or group of countries, such as: Fanelli (2019) analyzes the agricultural features of 228 NUTS 2 level areas across 28 EU countries; Némethová & Cíván (2017) examine regional differences in Slovakia, using selected agricultural production indicators at 79 districts (LAU I level territories); Harizanova-Metodieva (2024) develops a classification of 28 districts (NUTS 3 level territories) in Bulgaria based on the livestock sector development indicators; and Romantseva & Kolomeeva (2021) conduct a multivariate evaluation of agriculture competitiveness across 77 NUTS 2 regions in the Russian Federation.

Consequently, this paper analyzes regional agricultural production and development disparities at the NUTS 3 level territories (districts) in the RS, based on the selected agricultural production development indicators in 2023. In this context, the following objectives have been formulated: (1) a detailed and statistically valid demonstration of application possibilities of cluster analysis in the domain of regional agricultural production development researching; and (2) the creation of a statistically optimal and practically meaningful classification of districts in the RS into mutually exclusive, internally-similar and externally-dissimilar groups, based on the values of selected agricultural production development indicators. The research hypothesis is defined as follows: pronounced disparities still exist among the 25 districts in the RS, in terms of the intensity and structure of their agricultural production, measured by representative indicators.

The practical contribution of this research is reflected in providing a comprehensive snapshot of the spatial differentiation of agricultural production in terms of its structure, productivity, and intensity at the district level in the RS. The proposed categorization can offer valuable insights to policymakers in preparing future national agricultural and rural development strategies, specifically adapted to the identified agricultural characteristics of each cluster of districts. The originality of the conducted research lies in the fact that, to the best of the authors' knowledge, the applied combination of temporal-spatial data coverage, methodology used, and selected agricultural production development indicators has not been exploited in the existing literature so far. Therefore, addressing this research gap will undoubtedly contribute to the enrichment of the existing knowledge and literature, but also to the creation of a suitable analytical basis for the formulation of targeted agricultural development policies at the district level in the RS.

After the Introduction, the rest of the paper is structured as follows. A detailed elaboration of the applied methodological framework, along with a description of the selected variables, used sources and spatial-temporal coverage of data, is presented in section named *Materials and methods*. The obtained cluster analysis results are given in the next section (*Results*), followed by the interpretation and discussion of the proposed classification of districts. The final considerations, limitations of the study, and recommendations for future research, are stated in the last section.

Materials and methods

Starting from the defined research objectives and official (NUTS-based) territorial organization of the RS, secondary (latest available) data, used to calculate the values of selected four indicators of agricultural production (*Table 1*), were collected for 24 districts and Belgrade area (i.e. NUTS 3 level territories). All data were sourced from the complex publication of the Statistical Office of the RS (acronym, SORS), entitled *Municipalities and Regions in the RS* (SORS, 2024), and working document – *Regional gross domestic product* (SORS, 2025) and refer to 2023. Districts within the Autonomous Province of Kosovo and Metohija were not used as observation units, due to SORS's inability to conduct data collection in their territories since 1999.

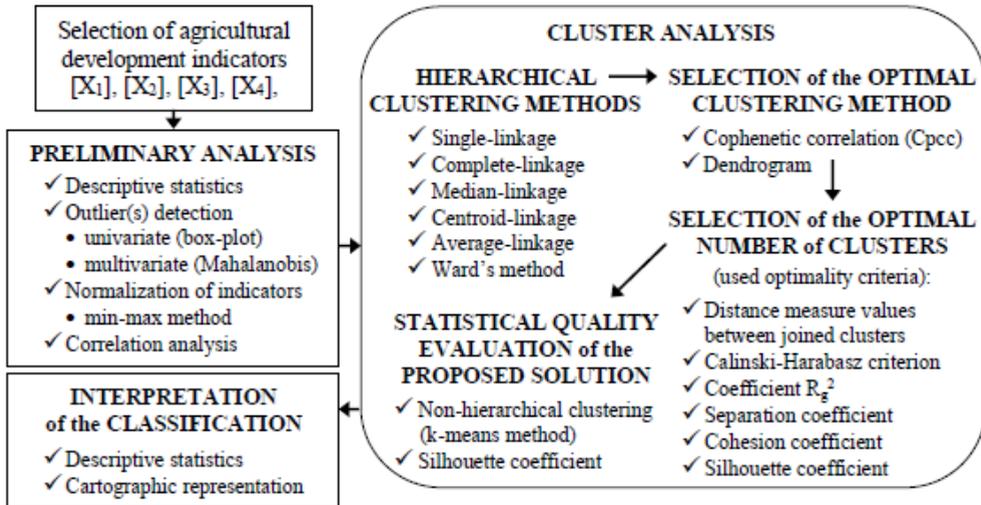
Table 1. List of selected agricultural production development indicators

Symbol	Agricultural production development indicators	Measurement units
X_1	Employment in agriculture, forestry and fishing	% of total employment
X_2	Utilized agricultural area per agricultural farm	ha / farm
X_3	Productivity of agricultural land	thousands of RSD / ha
X_4	Agriculture, forestry & fishing, GVA per farm	millions of RSD / farm
Notes on calculating indicators' values:		
$X_1 = (\text{Number of employees in agriculture, forestry \& fishing} / \text{Total number of employees}) \times 100$		
$X_2 = (\text{Utilized agricultural area (UAA)} / \text{Number of farms})$		
$X_3 = (\text{Agriculture, forestry \& fishing, GVA} / \text{UAA}) / 1000$		
$X_4 = (\text{Agriculture, forestry \& fishing, GVA} / \text{Number of farms})$		

Source: Authors' representation

The construction of presented indicators was conditioned by the availability of data at district level in the RS and supported by the guidelines provided by the OECD (2001) and numerous authors in research studies of a similar nature. More precisely, listed as one of the most relevant indicators in the OECD comprehensive agricultural study (2001), the share of agricultural employment in overall employment has been used in research conducted by Špirkova et al. (2017), Némethová & Civiň (2017) and Fanelli (2019). Utilized agricultural area, expressed in hectares or as a percentage of a total land area, is also a frequently used indicator of agricultural production potential, in numerous studies (e.g. Soóki et al., 2024; Rakhmetova et al., 2020; OECD, 2001). On the other hand, Fanelli (2019) combined this variable with the number of farms in order to create a ratio indicator that provides information about the average farm size. His idea was applied in this research, in the form of X_2 indicator. Finally, based on its wide use in relevant literature (e.g. OECD, 2001; Apostolidou et al., 2014; Reiff et al., 2016; Špirkova et al., 2017; Rađenović et al., 2022; Lubova et al., 2023; Soóki et al., 2024), as a key indicator of the efficiency of harvesting the agricultural economic potential, gross value added (GVA) of the agricultural industry was used to calculate agricultural land and labor productivity indicators, following the approach presented by Grotkiewicz (2017), Romantseva & Kolomeeva (2021) and Bocean (2024).

A schematic representation of the methodological framework used, supplemented by detailed explanations of the applied statistical methods and their key determinations, is given in Figure 1. In the proposed methodological framework, a central analytical role is assigned to the cluster analysis (CA), as one of the most frequently used (non-parametric) multivariate statistical methods, intended and designed for simultaneous examination of interdependencies between a set of selected numerical variables. In fact, cluster analysis is a generic term used to describe a wide range of multivariate statistical procedures specifically designed to reveal “natural” structure, i.e. classification of observation units, within complex and heterogeneous data sets (Gore Jr., 2000). The common primary goal of these numerous procedures, mainly based on the principles of proximity concept, is to “divide” a given set of multivariate observations into a certain number (as a rule, a priori unknown and small) number of mutually exclusive and, to the greatest extent possible, internally–homogeneous and externally–heterogeneous, meaningful groups, so-called clusters (Stamenković, 2024).

Figure 1. Schematic representation of the applied research methodology framework

Source: Authors' representation

Compared to the published studies of a similar research character and methodological approach, the application of CA in this research is distinguished by the following (threefold) methodological advantages. First, in contrast to the default application of Ward's method, primarily conditioned by the researcher's subjective assessment, the cophenetic-based approach for statistically objective evaluation of the individual clustering solutions' quality, obtained by six different CA methods and, consequently, selection of the optimal hierarchical clustering (HCA) method, was applied. Second, subjectivity in selecting the optimal number of clusters within the obtained HCA tree-classification structure was eliminated by comparing the calculated values of the entire spectrum of optimality criteria. The identification of the "optimal division" of observation units into groups was carried out on the basis of 6 different optimality criteria. Finally, since the non-hierarchical clustering procedure (Non-HCA) allows reallocation of observation units during the clustering process, a comparison and comprehensive evaluation of statistical quality of the obtained HCA and Non-HCA classifications was conducted based on the silhouette coefficient values, in order to identify the final classification of districts in the RS according to selected agricultural production development indicators (*Table 1*). Given the fact that agricultural indicators, used as CA input variables, are expressed in different measurement units, a modified *min-max* method of normalization of their original values was implemented, via the following expression (Stamenković, 2024: 24):

$$x_j^* = 9 \times \frac{x_j - x_j^{\min}}{x_j^{\max} - x_j^{\min}} + 1. \quad (1)$$

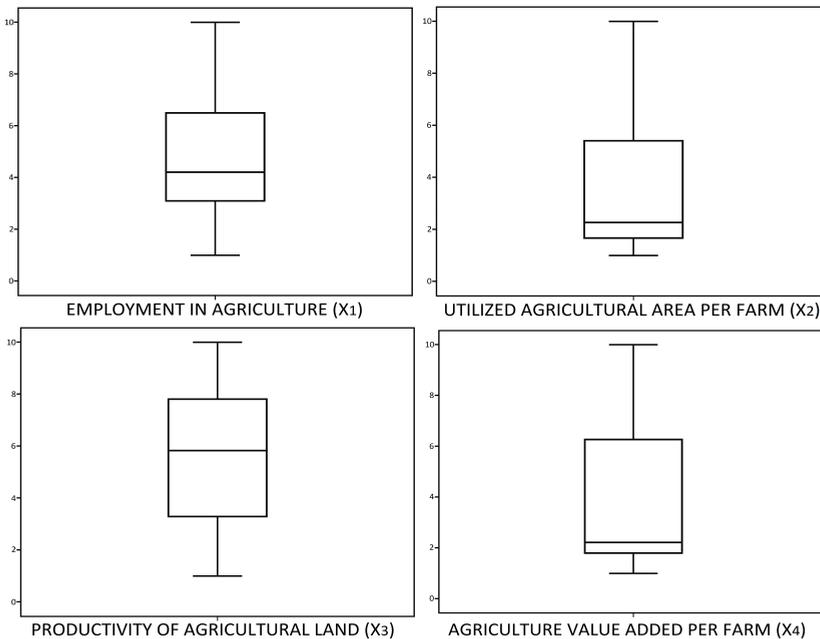
Within this expression, symbol x_{ij}^* denote normalized and x_{ij} original value of the j^{th} agricultural indicator for i^{th} district (for $i = 1, 2, \dots, 25$, and $j = 1, 2, 3, 4$), while x_j^{\max} and x_j^{\min}

represent the largest and smallest original value of j^{th} indicator, respectively. The mentioned modification of the *min-max* method is reflected in the expansion of the initial range (i.e. from 0 to 1) to an interval ranging from 1 to 10, and was implemented primarily to create a more precise comparative basis. The analysis of collected data and all necessary statistical calculations were carried out using statistical software package *IBM-SPSS Statistics* version 21, and *Microsoft Office Excel*. The interpretation of the obtained research results was carried out using the adequate tabular, cartographic and graphical representations.

Results

Starting from the well-known sensitivity of CA results and distance measure used to the presence of univariate / multivariate outliers, multicollinearity, but also different measurement units of input variables, before conducting classification of 25 districts, as observation units, a preliminary analysis of four input variables was carried out. The analyzed indicators are not highly correlated, as the corresponding correlation coefficient values range from $r_{x_3x_4} = 0.165$ to $r_{x_2x_4} = 0.902$, with only one pair of variables (i.e. $X_2 \leftrightarrow X_4$) for which the value of this coefficient is greater than 0.80. Due to different measurement units in which they are expressed, the transformation of the indicators' original values to a comparable scale from 1 to 10 was carried out by the *min-max* normalization, using expression (1). Regardless of the observed differences between the arithmetic mean and median values (*Table 2*), especially present in the case of indicators X_1 , X_2 and X_4 , the box-plots constructed for each indicator (*Figure 2*), unequivocally confirmed the absence of one-dimensional outliers.

Figure 2. Box-plots for individual agricultural production development indicators



Source: Authors' representation

Apostrophized differences between central tendency measures, as a frequently used signal of atypical observations' presence, are evidently the result of high variability of the variables, taking into account the ranges between the minimum and maximum, but also individual values of the coefficient of variation, which are (for three out of four indicators) above 30%. In addition, by comparing the *Mahalanobis distance values* calculated for each district (ranging from 0.85 to 10.80), with the 97.5 percentile of Chi-square distribution ($\chi^2_{4, 0.975} = 11.14$), as a threshold value, the presence of multivariate outliers was not detected.

Table 2. Descriptive statistics for agricultural production development indicators

Agricultural indicators	mean	median	min	max	coefficient of variation
X_1	5.21	4.74	0.54	12.30	56.15 %
X_2	7.10	4.87	2.76	17.77	63.76 %
X_3	103.37	107.15	61.95	146.13	22.74 %
X_4	0.71	0.48	0.28	1.75	63.71 %

Source: Authors' calculations

After the preprocessing phase, six different HCA methods were applied on the normalized values of agricultural indicators, using the squared Euclidean distance as an adequate proximity measure. In order to identify the HCA method that best fits empirical data, the cophenetic coefficient values (*Cpcc*), as a specific (but rarely used) statistical measure of the quality of individual clustering solutions, were calculated and presented in *Table 3*.

Table 3. Cophenetic correlation coefficient values for different HCA solutions

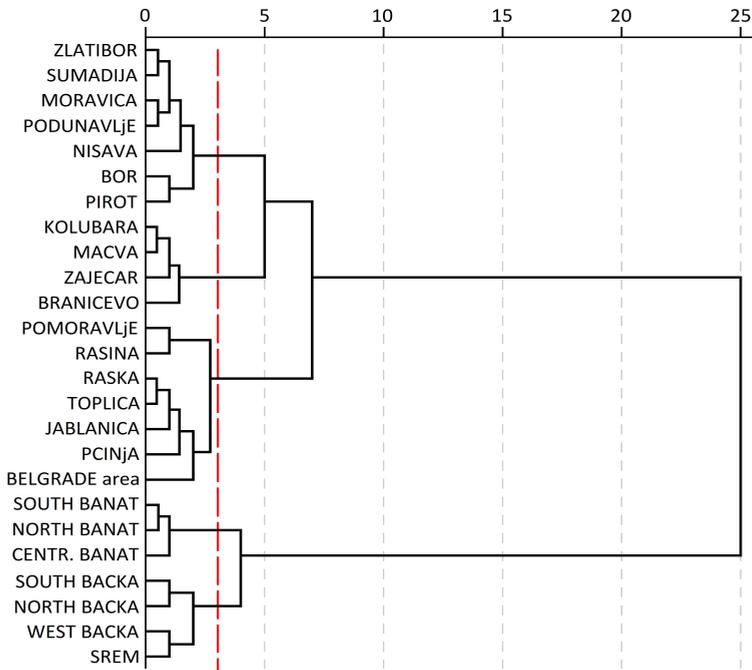
HCA methods →	Single-linkage	Complete-linkage	Median-linkage	Centroid-linkage	Average-linkage	Ward's method
<i>Cpcc</i> values	0.785	0.779	0.821	0.838	0.852	0.853

Source: Authors' calculations

The highest *Cpcc* value (0.853), but also the most visually acceptable classification structure of the solution, singled out *Ward's method* as optimal. The complete tree-structure classification obtained as a solution to its application is given in *Figure 3*. The presented dendrogram contains 24 different clustering solutions (i.e. possible classifications), created in each step of the irreversible agglomeration process for 25 districts in the RS according to the used indicators of agricultural production. The decision regarding the selection of a specific classification solution that can be considered optimal in terms of the number of clusters within which the observed districts are allocated was made based on a thorough comparative analysis of the values of six different optimality criteria, as listed in the methodology framework. By analyzing the graphical representation in *Figure 4* and the series of optimality criteria given in *Table 4*, with a help of a trained "statistical eye", a sudden change in the values of all six criteria, which occurred at the moment of creating classification solution with four clusters, can be clearly noticed. The observed "drastic" change, occurred as a result of merging two very dissimilar (distant) clusters, unequivocally suggests the selection of a 5-cluster classification as the optimal

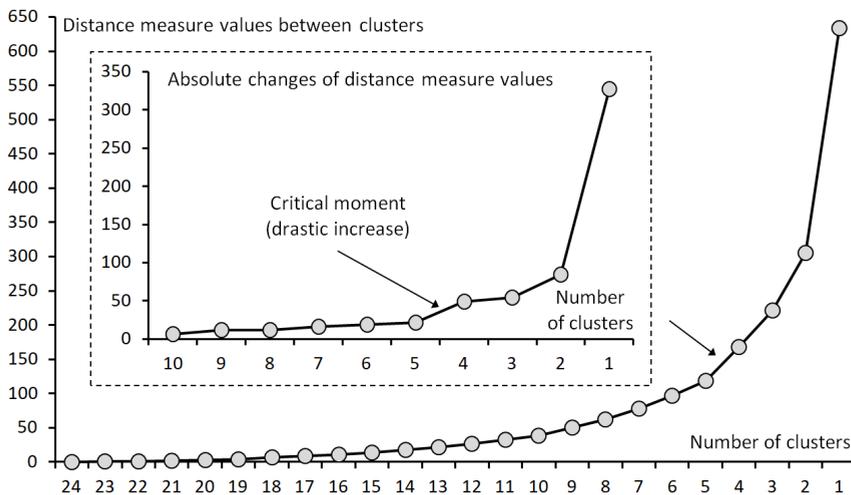
solution, since it was created in the agglomeration step that immediately precedes it. From a graphical perspective, the moment of achieving the optimal HCA solution is marked on the dendrogram with a red dashed line.

Figure 3. Dendrogram



Source: Authors' representation

Figure 4. Changes of distance measure values between clusters for different CA solutions



Source: Authors' representation

Table 4. The optimality criteria values for different clustering solutions

Optimality criteria values	Number of clusters							
	9	8	7	6	5	4	3	2
Pseudo- F	23.21	22.33	21.19	21.00	21.71	19.42	20.42	24.62
Coefficient R_g^2	0.92	0.90	0.88	0.85	0.81	0.73	0.65	0.52
Separation coefficient	583.1	571.3	554.8	536.3	514.8	465.6	411.6	327.4
Cohesion coefficient	50.3	62.2	78.6	97.0	118.6	167.8	221.8	305.9
Silhouette coefficient	0.59	0.53	0.52	0.55	0.54	0.50	0.51	0.69

Source: Authors' calculations

Finally, the evaluation of statistical quality of the obtained HCA classification, but in terms of the structure of districts within the five formed clusters, was carried out based on a comparison with the Non-HCA reversible classification obtained by applying the *k-means* method for the same number of clusters. For this purpose, the silhouette coefficient values, calculated for both clustering alternatives, at the level of the overall solution as well as individual clusters, were used (Table 5).

Table 5. Silhouette coefficient values

Cluster codes	Number of districts		Silhouette values	
	HCA	Non-HCA	HCA	Non-HCA
C-1	4	3	0.403	0.537
C-2	3	4	0.899	0.675
C-3	4	3	0.475	0.684
C-4	7	9	0.488	0.516
C-5	7	6	0.417	0.542
Overall	25		0.536	0.591

Source: Authors' calculations

Based on the comparison of the silhouette values for the two clustering alternatives, it can be concluded that the resulting Non-HCA classification has higher quality, in terms of the structure of districts allocated within the extracted 5 clusters. The drawn conclusion is supported by the following facts: (1) higher overall silhouette value obtained for the complete Non-HCA classification (0.59); (2) due to the possibility of district reallocation during the clustering process, the Non-HCA solution contributed to an increase in the silhouette values of 4 groups and thus their internal-homogeneity and external heterogeneity, compared to the HCA alternative; and (3) negative values of the silhouette coefficient of individual districts, as indicators of their misallocation within a particular cluster, were not present in the proposed Non-HCA classification, in contrast to the HCA alternative in which 4 such cases were recorded.

Interpretation and Discussion

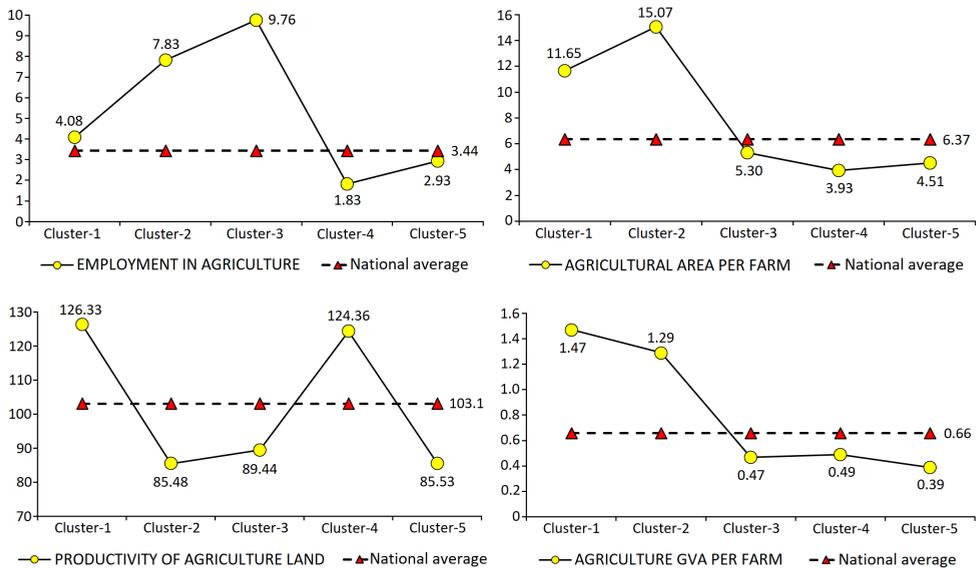
The Non-HCA results reveal pronounced district-level differences in the development of agriculture in the RS. The five identified distinct types of districts are characterized by specific combinations of the four agricultural production indicators used (Figure 5), reflecting diverse production structures, efficiency levels, and development potentials.

The discussion of results is enriched by additional indicators regarding the livestock fund and different types of land used (Table 6), which help confirm and specify the structural and development differences observed. The spatial distribution of clusters is illustrated in a cartographic representation (Figure 6), which provides a clear understanding of the geographical patterns of agricultural production in the RS.

Cluster C-1, labeled as “*Very high level of agricultural production development*”

This cluster, comprising three districts, represents the core of intensive agriculture in the RS. Although the average share of agricultural employment is only 4.08% of their total employment, the average farm size (11.65 ha) and productivity of agricultural land (126.33 thousand RSD/ha) are among the highest, resulting in the highest agricultural GVA per farm (1.47 million RSD), thus indicating not only productive but also economically efficient agricultural operations on their territories. It accounts for almost 20% of country’s total agricultural employment, nearly one-fifth of utilized agricultural area (19.7%) and as much as 24% of arable land, indicating a strong dominance of crop farming in agricultural production. In addition to crop farming, specialized plant production is also developed → 6.7% of the country’s orchards and more than 12% of vineyards are located within the districts belonging to this cluster. Livestock farming is strongly dominated by pig breeding (29% of country’s pig stock) and poultry farming (18%), while a cattle breeding, with 14% of the national herd, plays a complementary role. These characteristics indicate an intensive and diversified production model characterized by strong commercial orientation, where large-scale farms and high productivity are the key drivers of competitiveness.

Figure 5. Graphical representations of agricultural indicators’ averages per clusters



Source: Authors’ representation

Cluster C-2, labeled as “*High level of agricultural production development*”

Although it comprises only four districts, this cluster occupies a highly significant position within the country's agricultural sector. Its relative importance derives from fact that it concentrates a disproportionately large share of agricultural employment and land resources, compared to the number of districts covered. It accounts for 19% of country's total agricultural employment, and 11.23% of agricultural farms, while encompassing as much as 26.56% of the UAA and 32.28% of arable land in the RS. The average UAA per farm is around 15.07 ha which is more than twice the national average (6.37 ha), and the highest among all clusters, indicating a strong consolidation of agricultural holdings. The substantial difference confirms the cluster's specialization in crop production, particularly cereals and industrial crops. Agricultural employment reaches 7.83% of total employment in these districts, considerably higher than in C-1, indicating that agriculture retains a stronger role in local labor markets and that diversification of economic activities is more limited. Despite its substantial land base, this cluster achieves relatively modest agricultural land productivity, below both the country's average and C-1. Nevertheless, agriculture GVA per farm reaches 1.29 million RSD, which is almost double the national average. This imbalance demonstrates that larger farm size compensates for lower land productivity, ensuring relatively high economic outcomes at the level of individual holdings while still underscoring the extensive nature of production systems. Agricultural production is predominantly land-oriented, while perennial crops play only a marginal role. The share of orchards and vineyards is the lowest among all clusters. Regarding livestock production, C-2 is characterized by highly developed poultry farming, constituting a leading area of this branch in the RS with more than $\frac{1}{4}$ of the national poultry stock.

Figure 6. Cartographic display of districts in the RS by agricultural production classification



Source: Authors' representation

Cluster C-3, labeled as “*Average level of agricultural production development*”

This cluster includes three districts, and with 9.76% of total employment engaged in agriculture, it stands markedly above the national average (3.44%) and higher than C-1 and C-2, indicating the considerable reliance of local economies on agriculture. At the same time, the average farm size remains below the national average and far smaller than in C-2 (*Figure 5*), revealing pronounced fragmentation of holdings. Land productivity also lags behind the national average, while agricultural GVA per farm is distinctly below both the national level and the leading clusters C-1 and C-2, which points to limited economic efficiency. Although it accounts for over one-fifth of national agricultural employment and 16% of farms, it uses only 13.3% of UAA and 12.9% of arable land, underscoring the imbalance between abundant labor and scarce land resources. Livestock production is a defining feature of C-3: it concentrates nearly $\frac{1}{4}$ of the national sheep stock, but also holds substantial shares of pigs (23%) and cattle (18.6%). Together, these branches form a diverse and relatively balanced livestock sector, in which mixed farming systems prevail. This cluster is an example of traditional, labor-intensive, but lower-profit agriculture.

Cluster C-4, labeled as “*Below average level of agricultural production development*”

This cluster represents a modal group, comprising 9 out of the 25 districts. Despite the small average farm size (3.93 ha), land productivity is exceptionally high due to production specialization. These districts dominate in fruit growing (46.1% of the country’s orchards) and viticulture (50.6% of vineyards), confirming a clear orientation towards high value-added branches of agriculture. Nevertheless, agricultural GVA per farm remains low as a result of land fragmentation and limited scale of production. Livestock farming is well developed, with considerable shares of poultry (31.8%), cattle (29.4%) and sheep (29.1%) in the national livestock fund, which are the highest among all clusters. The average share of agricultural employment in these districts is very low (1.83%), mainly due to the inclusion of Belgrade area. However, this cluster still accounts for more than $\frac{1}{4}$ of national agriculture employment (28.1%), primarily as a result of its large territorial coverage and number of districts it encompasses. The dominance of perennial crops and livestock production points to labor-intensive systems, with limited economic efficiency due to land fragmentation.

Table 6. Additional agricultural indicators’ values (as % in the country’s total) per clusters

Additional indicators	Cluster codes				
	C-1	C-2	C-3	C-4	C-5
Number of employees in agriculture	19.8	19.0	20.4	28.1	12.7
Number of farms	10.8	11.2	16.0	37.6	24.4
Utilized agricultural area, UAA (ha)	19.7	26.6	13.3	23.1	17.3
Arable land and gardens (ha)	24.4	32.3	12.9	18.5	11.9
Fruit orchards (ha)	6.7	4.9	15.1	46.1	27.2
Vineyards (ha)	12.1	6.1	4.7	50.6	26.5
Cattle	14.2	17.5	18.6	29.4	20.3
Pigs	29.0	16.4	23.0	20.6	11.0
Sheep	7.5	10.7	24.7	29.1	28.0
Poultry	18.3	26.5	15.0	31.8	8.4

Source: Authors’ calculations based on the data from SORS (2024)

Cluster C-5, labeled as “*Low level of agricultural production development*”

This cluster, composed of six districts, encompasses nearly $\frac{1}{4}$ of all farms in the country, yet accounts for only 12.7% of total agricultural employment. It consists of small, fragmented family agricultural farms, with an average size of 4.51 ha. Crop production is diversified, but with a more pronounced share of perennial plantations (orchards and vineyards), which account for over $\frac{1}{4}$ of national area under such crops, compared to approximately 12% of arable land. Since this cluster encompasses 41% of the national pastures, it is not surprising that sheep (28% of the national herd) and cattle farming (20.3%) constitute the dominant segment of livestock production. Despite relatively high shares in certain agricultural branches, C-5 shows low economic efficiency, as GVA per farm is the lowest among all clusters. This combination of perennial crops and livestock production reflects labor-intensive systems with relatively modest economic performance due to fragmentation and small production scale.

The analysis of the obtained five-cluster classification reveals pronounced agricultural production disparities, ranging from highly productive, market-oriented systems in clusters C-1 and C-2 to fragmented, labor-intensive, and economically less efficient production in other three, confirming the validity of formulated research hypothesis.

Conclusions

The results of the combined application of HCA and Non-HCA methods to the values of four selected agricultural production development indicators in 2023 unequivocally confirm that agriculture production at the district level in the RS is characterized by profound structural and spatial inequalities. These disparities are reflected in substantial differences in production orientation, farm size and structure, land productivity, and economic efficiency. The proposed classification, consisting of five groups, clearly reveals that districts with larger and more consolidated farms (clusters C-1 and C-2) exhibit higher levels of productivity and economic efficiency, while areas dominated by fragmented holdings and labor-intensive production systems remain at a disadvantage. These differences confirm the dual nature of agricultural production in the RS and the pronounced polarization between modernized, growth-oriented districts and those constrained by persistent structural limitations that hinder their development potential.

These findings underline the importance of formulating targeted and territorially differentiated agricultural policies that acknowledge the specific profiles of individual clusters of districts, shaped primarily by the geographical, natural, socio-economic, and other distinctive characteristics of rural areas. Instead of applying uniform measures, institutional and financial support should be specifically tailored, aimed at strengthening competitive districts while providing targeted support to less developed areas to help them overcome systemic limitations. Such an approach could contribute not only to a more effective allocation of available resources and the enhancement of competitiveness, but also to the reduction of regional inequalities in the agricultural sector and, consequently, to the development of the national economy as a whole.

Therefore, the methodological approach employed in this study may serve as a useful tool, while the obtained snapshot of spatial differentiation of agricultural production at the district level can provide valuable insights for policymakers in designing future strategy and support policies aimed at achieving balanced and sustainable agricultural development in the RS.

Some of the key limitations of this research include the absence of a time dimension in the analysis and the relatively limited possibility of direct comparability of the obtained results with previously published studies with similar objectives. Expanding the proposed analytical framework by incorporating additional statistical methods (e.g., panel data regression analysis or factor analysis) could represent an effective way to overcome the aforementioned limitations. Future research could also focus on including new agricultural input indicators and/or modifying the spatial and temporal scope of the analysis.

Conflict of interests

The authors declare no conflict of interest.

References

1. Apostolidou, I., Kontogeorgos, A., Michailidis, A. & Loizou, E. (2014). The role of agriculture in economic growth: A comparison of Mediterranean and Northern views in Europe. *International Journal of Business & Economic Sciences Applied Research*, 7(3), 81–102.
2. Bocean, C.G. (2024). A cross-sectional analysis of the relationship between digital technology use and agricultural productivity in EU countries. *Agriculture*, 14(4), Article No. 519. <https://doi.org/10.3390/agriculture14040519>.
3. Fanelli, R.M. (2019). A new classification of European Union regions: A decision support tool for policymakers. *Spanish Journal of Agricultural Research*, 17(1), Article No. e0102. <https://doi.org/10.5424/sjar/2019171-13481>.
4. Gore, P.A. Jr. (2000). Cluster Analysis. In: Tinsley, H. & Brown, S. (Editors), *Handbook of Applied Multivariate Statistics & Mathematical Modeling*, pp. 297–321. Academic Press, Massachusetts.
5. Влада Републике Србије (2022). *Национални програм руралног развоја за период 2022-2024. године*. Службени гласник РС, Београд. [in English: Government of the Republic of Serbia (2022). *National program of rural development for the period 2022-2024*. Official Gazette of the RS, Belgrade.].
6. Grotkiewicz, K. (2017). Analysis of economic and agricultural indicators under sustainable agriculture conditions with the use of Bayesian modeling. *Technical Sciences*, 20(3), 209–225.

7. Harizanova-Metodieva, T. (2024). Cluster analysis of districts in Bulgaria according to the development of the livestock sector. *Scientific papers series management, economic engineering in agriculture & rural development*, 24(3), 423–427.
8. Jankowska, A. & Hlavsa, T. (2025). A comparative analysis of diversification of agricultural production among EU candidate countries and Eastern Partnership countries: An international perspective. *PLoS ONE*, 20(3), Article No. e0314471.
9. Lubova, T., Salimova, G., Nigmatullina, G., Islamgulov, D. & Araslanbayev, I. (2023). Solving problems of agricultural production development by modeling using the cluster analysis method. *BIO Web of Conferences*, Vol. 66, Article 14002.
10. Министарство пољопривреде и заштите животне средине (МПЗЖС), (2014). *Стратегија пољопривреде и руралног развоја Републике Србије за период 2014-2024. године*. Службени гласник РС, Београд. [in English: Ministry of Agriculture and Environmental Protection (MAEP), (2014). *Agriculture and rural development strategy of the Republic of Serbia for the period 2014-2024*. Official Gazette of the RS, Belgrade.].
11. Némethová, J. & Cíván, M. (2017). Regional differences in agriculture in Slovakia after its accession to the European Union. *Quaestiones Geographicae*, 36(2), 9-21.
12. OECD (2001). *Environmental Indicators for Agriculture – Methods and Results, Volume 3*. OECD, Paris.
13. Rađenović, Ž., Krstić, B. & Marković, M. (2022). Economic performance of agriculture in the EU countries. *Problems in agricultural economics*, 370(1), 5-21
14. Rakhmetova, R.U., Cheirkhanova, A.A. & Maldynova, A.V. (2020). Comparative cluster analysis of Kazakhstan's agricultural potential with world countries. *Central Asian Economic Review*, 133(4), 45–53.
15. Reiff, M., Surmanová, K., Balcerzak, A.P. & Pietrzak, M.B. (2016). Multiple criteria analysis of EU agriculture. *Journal of international studies*, 9(3), 62–74.
16. Romantseva, Y. & Kolomeeva, E. (2021). Statistical evaluation of competitiveness of agriculture in the regions. *IOP Conference Series: Earth and Environmental science*, 699, Article No. 012004. <https://doi.org/10.1088/1755-1315/699/1/012004>.
17. Soóki, M., Poláková, Z., Palkovič, J. & Beňovičová, K. (2024). Multivariate analysis of food security and its driving factors, *AGRIS on-line Papers in economics & informatics*, 16(1), 91–103. <https://doi.org/10.7160/aol.2024.160108>.
18. Републички завод за статистику (РЗС), (2024). *Општине и региони у Републици Србији, 2024*. РЗС, Београд. [in English: Statistical Office of the RS (SORS), (2024). *Municipalities and regions in the RS, 2024*. SORS, Belgrade.].
19. Републички завод за статистику (РЗС), (2025). *Регионални бруто домаћи производ – Региони и области Републике Србије, 2023*. РЗС, Београд. [in English: Statistical Office of the RS (SORS), (2025). *Regional gross domestic product–Regions and areas of the Republic of Serbia, 2023*. SORS, Belgrade.].

20. Стаменковић, М. (2024). *Анализа груписања: Методолошка одређења и примена у економским истраживањима*. Економски факултет Универзитета у Крагујевцу, Крагујевац. [*in English: Stamenković, M. (2024). Cluster analysis: Methodological determinations and application in economic research*. Faculty of Economics University of Kragujevac, Kragujevac.].
21. Špírková, D., Stehliková, B., Zubkova, M., Ševela, M. & Stiglic, D. (2017). Evaluation of agriculture's economic role in EU countries. *Ekonomický časopis*, 65(8), 763-779.

THE PATHWAY TO THE RESILIENT AND SUSTAINABLE FUTURES: THE GREEN TRANSFORMATION OF TOURISM DESTINATIONS

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ABSTRACT

Global development in recent decades has been characterized by increased resource consumption and growing environmental pressures, highlighting the need for sustainable economic and social progress. Tourism, despite its significant contribution to economic growth, often puts pressure on natural resources and ecosystems, underscoring the need for sustainable development in territories with substantial rural characteristics, such as islands. This paper examines the role of green transformation as a driver of economic resilience and sustainable development of Croatian island economies. Research was conducted among stakeholders in island destinations who are involved in tourism planning, development and management, using a structured questionnaire survey. The results from Partial Least Squares Structural Equation Modeling (PLS-SEM) show that green transformation of tourism positively influences all four sustainability dimensions of destination development, with the strongest effect on environmental sustainability. These findings support decision-makers in shaping development strategies for island destinations.

Introduction

Contemporary economic development is marked by a continuous increase in resource demand, resulting in intensified environmental pressures, declining biodiversity, and the destabilisation of local communities. These trends encourage the search for development models that simultaneously ensure economic progress and preserve ecosystems. At the centre of debates on new development trajectories is the concept

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of sustainable development, defined in the Brundtland Report (WCED, 1987) and in Barbier's work (1987), which has become a cornerstone of modern development policies and academic discourse. Sustainable development entails balancing the needs of present generations with the ability of future generations to meet their own needs, relying on the integration of economic, environmental, social, and cultural dimensions (UCLG, n.d.; Vornholz, 1994; Hawkes, 2001; Du Pisani, 2006; Zaccai, 2012; Barbier & Burgess, 2017). Despite its wide acceptance, the concept is often criticised for its ambiguity and normative flexibility (Lélé, 1991; Sharpley, 2009; Dernbach & Cheever, 2015). Nevertheless, global challenges such as climate change, resource depletion, and widening inequalities (Hopwood et al., 2005; Hoffman & Bazerman, 2007) further reinforce the need for an integrative approach that aligns economic, environmental, and social objectives (Bäckstrand, 2006; Kanie et al., 2019).

Several analytical frameworks have been developed to structure the multidimensional concept of sustainability. The Triple Bottom Line (TBL) (Elkington, 1994) and the Quadruple Bottom Line (QBL) (Mohd Zawawi & Abd Wahab, 2019; Tiller et al., 2022) frameworks decompose sustainability into three or four interconnected dimensions. The TBL encompasses economic, social, and environmental components (Norman & MacDonald, 2004; Fauzi et al., 2010), while the QBL additionally incorporates the cultural dimension as an essential element of sustainable destination development. In island destinations, this framework supports a holistic understanding of sustainability by integrating economic stability, social cohesion, cultural integrity, and environmental resilience.

Building on the abovementioned theoretical foundation, tourism emerges as a field in which the application of sustainability principles is especially imperative. The tourism industry accounts for more than 10% of global GDP. It employs one in ten people worldwide (World Bank, 2025), generating strong multiplier effects on innovation, investment, and regional development (Tang et al., 2023; Sastri et al., 2024). At the same time, it exerts significant pressure on the environment, ranging from greenhouse gas emissions to high energy and water consumption and increased pressure on infrastructure and local resources (Gössling, 2002). The observed dynamics underscore the need to reframe tourism growth in alignment with sustainability and low-carbon development pathways.

Growing pressures on natural and social resources further encourage the search for development models that transcend linear patterns of growth. In this context, the green transformation of tourism is increasingly recognised as a key instrument for aligning economic development with the principles of environmental responsibility and long-term sustainability (OECD, 2022; UN Tourism, 2025). This process goes beyond isolated technical interventions and involves profound changes in production, organisational, and consumption patterns, to create more resilient economies (OECD, 2013; Wang & Luo, 2023).

At the European Union level, the green transition is reinforced by a strong institutional framework. The European Green Deal (Fetting, 2020), the EU Industrial Strategy (Krpata, 2022), the Circular Economy Action Plan (European Commission, 2020), and the Clean Energy for EU Islands (European Commission, 2021) and Smart Islands initiatives (2017) steer the economy towards climate neutrality and resource efficiency. The European Agricultural Fund for Rural Development plays an important role in strengthening territorial cohesion in rural areas, including island communities facing specific structural constraints. Programs financed through the fund support increased competitiveness, more efficient resource use, and the mitigation of climate change impacts (European Commission, n.d.). Rural development measures under the Common Agricultural Policy (CAP) further contribute to building a low-carbon and climate-resilient economy, thereby creating conditions for the sustainable transformation of island areas.

These development instruments are further supported by a broader European framework relevant for island territories, including the Barcelona Convention on Integrated Coastal Zone Management (UNEP/MAP, 2011). Additional momentum for the green-digital transition is provided by the Green Digital Action Declaration, adopted at COP29 (International Telecommunication Union, 2024), which emphasises climate-positive digitalisation and the reduction of the environmental footprint of technological systems. Taken together, this institutional framework demonstrates the strong interconnection between rural and island development policies and their contribution to the European green transition.

Within the existing institutional framework, tourism stands out as a sector with high environmental pressures but significant potential for adopting green solutions. In island areas, the green transformation represents both an opportunity and a necessity, i.e., an opportunity to strengthen local economies and increase added value, and a necessity arising from ecological and economic vulnerability. Due to these characteristics, some authors describe island destinations as “laboratories of sustainable development” (e.g., Pathirana, 2025). The adoption of green technologies, the development of circular models, the establishment of sustainable energy systems, efficient waste management, and the promotion of local production and cultural heritage can generate multiplier effects, including cost reductions, increased competitiveness, and employment growth.

Despite strong institutional support, empirical research on the green transformation in island zones remains limited and methodologically fragmented. Although sustainable tourism indicators are conceptually multidimensional, existing approaches lack standardisation and show considerable variability in capturing ecological, economic, social, and cultural aspects (Law et al., 2017). Furthermore, previous studies on sustainable tourism policy have tended to prioritise environmental elements, while social issues have received less attention (Guo et al., 2019). Consequently, there remains a research gap in understanding how ecological efficiency interacts with social cohesion, cultural valorisation, and the economic prosperity of island destinations.

Due to the abovementioned shortcomings in existing measurement practices, sustainable destination management requires high-quality, comparable, and adaptable indicator systems. Indicator frameworks (Meadows, 1998; OECD, 2000; Pintér et al., 2005) facilitate monitoring progress towards sustainability goals and timely policy adjustments. In the tourism sector, UNWTO (2004) emphasises the importance of comparable and flexible indicators, while the Croatian CROSTO system, based on the ETIS framework, enables monitoring of economic, social, and environmental impacts at the destination level (Pavlinović Mršić & Čale, 2020). Such indicator systems provide the analytical basis for evaluating and guiding the green transformation in tourism.

Drawing on this theoretical and normative foundation, the green transformation acquires a clear development-economic rationale. In the literature, it is defined as the restructuring of the economy toward low-carbon growth models, supported by innovation and sustainable resource management (UNEP, n.d.; OECD, 2011). Achieving such systemic change typically requires coordinated institutional action and broad stakeholder engagement. Empirical studies (Apostu et al., 2023; Kozar & Sulich, 2023) further confirm positive effects on competitiveness, productivity, and long-term economic resilience. Stern (2007) argues that the costs of inaction on climate change far exceed the costs of investing in sustainable measures, providing the green transition with a strong economic justification.

Linking the green transformation with the concept of resilience is particularly important in island economies. Resilience is defined as the capacity of a system to absorb disturbances, adapt to change, and maintain essential functions (Folke et al., 2010; Biggs et al., 2012). In island contexts, the principles of the green transformation naturally align with the blue economy, which promotes sustainable use of marine resources and synergies between tourism, fisheries, and renewable energy (OECD, 2020). The integration of green and blue practices can contribute to the development of circular value chains, increase local added value, and reduce dependence on external resources, thereby strengthening the foundation for greater self-sufficiency of small island economies.

Building on this EU framework, recent policy initiatives, such as the Transition Pathway for Tourism, further strengthen the development of sustainable energy and tourism practices. In this context, the green transformation of tourism entails transitioning to renewable energy, sustainable resource management, circular business models, and the active participation of local communities (European Commission, 2023). Resulting impacts include economic gains through efficiency and innovation, social benefits such as inclusion and equity, cultural benefits linked to the preservation of identity and heritage, and environmental benefits through reduced emissions and resource use.

Within this broader policy and conceptual setting, the paper examines how green transformation in tourism affects the four dimensions of sustainability in Croatian island destinations and explores its implications for their economic resilience and long-term development.

Materials and methods

The research employs a quantitative approach to examine the relationships between green transformation in tourism and four dimensions of sustainability. The study relies on the conceptual framework of the Quadruple Bottom Line (QBL) model, which provides an integrated understanding of sustainability by balancing economic, social, cultural, and environmental effects.

The research model consists of five latent constructs: green transformation (GRT) and four sustainability constructs: economic (ECS), social (SOS), cultural (CUS), and environmental sustainability (ENS). All constructs were operationalised using multiple indicators based on relevant literature (UNWTO, 2004; OECD, 2011; Geissdoerfer et al., 2018; Tiller et al., 2022).

The independent variable, green transformation in tourism (GRT), was operationalised through five indicators capturing: community involvement in the green transformation of tourism (GRT1), the development of green products, services, and business models (GRT2), the preservation and promotion of cultural–ecological practices (GRT3), the development of green tourism infrastructure and spatial planning (GRT4), and resource conservation and energy efficiency (GRT5).

Economic sustainability (ECS), as a dependent variable, was measured using indicators of innovation and revenue growth (ECS1), employment (ECS2), the competitiveness of local products (ECS3), and entrepreneurship development (ECS4).

The dependent variable social sustainability (SOS) was measured through indicators capturing: increased social cohesion and inclusion within the community (SOS1), improvements in the quality of life of local residents (SOS2), greater involvement of the local community in planning and decision-making regarding destination development (SOS3), and a more active social life through event organisation and extended tourism seasons (SOS4).

Cultural sustainability (CUS) included indicators related to: the growth in organised activities and services managing the destination’s cultural resources (CUS1), increased cultural and intercultural exchange and the strengthening of local customs and traditions (CUS2), an increase in cultural landmarks and the visibility of the local cultural identity (CUS3), and the development of cultural offerings and promotion of authentic culture to the wider public (CUS4).

Environmental sustainability (ENS) was measured through indicators related to: the reduction of uncontrolled waste and other forms of environmental pollution (ENS1), the increase in activities and services that sustainably manage the destination’s natural resources (ENS2), improved management and quality of water resources (ENS3), and the growth of environmental awareness and biodiversity protection within the local community (ENS4). All indicators were measured using a five-point Likert scale (1 – “strongly disagree” to 5 – “strongly agree”), enabling the standardised evaluation of respondents’ perceptions and attitudes.

Data were collected in 2024 through an online questionnaire (survey method) distributed to stakeholders in Croatian island destinations involved in planning, managing, and developing tourism activities. The total number of valid responses was $N = 303$, which ensures adequate statistical power in line with PLS-SEM methodological criteria (Hair et al., 2021). The sample includes diverse island destinations of different sizes and levels of tourism development, enabling the generalisation of results within the context of Croatian islands.

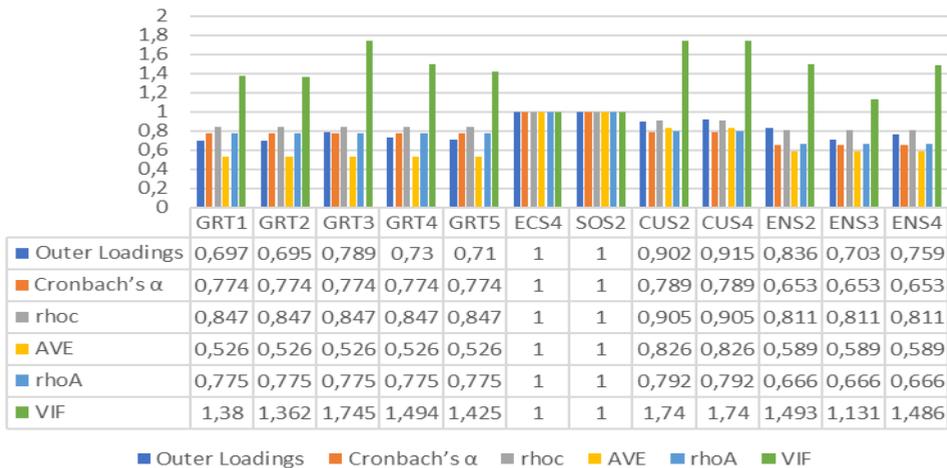
The Partial Least Squares Structural Equation Modeling (PLS-SEM) method was applied, as it is well-suited for examining complex relationships among latent variables and for analyses based on relatively small sample sizes (Hair et al., 2021). This method allows simultaneous testing of both the measurement and structural models, ensuring the assessment of reliability, validity, and the strength of relationships among constructs. The analysis aimed to quantify the effects of green transformation across four sustainability dimensions in island destinations and to determine the direction and strength of relationships among the observed constructs.

In line with the PLS-SEM approach, data analysis was conducted in RStudio and followed a two-phase procedure. First, the measurement model was assessed, including the examination of construct reliability (Cronbach’s alpha and composite reliability), convergent validity (Average Variance Extracted – AVE), and discriminant validity (Fornell–Larcker criterion and HTMT ratios). Second, the structural model was assessed, including testing the effects of green transformation on each sustainability dimension using standardised coefficients (β), p-values, and the coefficient of determination (R^2). Bootstrapping with 1,000 iterations was performed to assess the robustness of the results.

Results and discussions

To ensure methodological robustness, an assessment of the reliability and validity of the constructs included in the model was conducted (*Figure 1*).

Figure 1. Reliability and validity of the measurement models



Source: author’s calculations in RStudio using the SEMinR package

The results in Figure 1 indicate satisfactory values across all evaluated indicators. Cronbach's alpha and composite reliability (CR) exceed the recommended threshold of 0.70, demonstrating the internal consistency of the measurement instruments. Furthermore, all Average Variance Extracted (AVE) values are above 0.50, confirming convergent validity and indicating that the constructs explain a sufficient proportion of variance in their corresponding indicators. Thus, the measurement model meets the criteria of internal consistency and convergent validity. The composite reliability values for the ECS and SOS constructs equal 1, which does not indicate perfect reliability but results from their single-indicator specification; this specification is considered methodologically acceptable within the PLS-SEM approach. Accordingly, the selected indicators reliably and validly represent the constructs included in the measurement model.

Discriminant validity was then assessed using the Fornell–Larcker (FL) criterion (*Table 1*) and the Heterotrait–Monotrait ratio of correlations (HTMT) (*Table 2*).

Table 1. Fornell–Larcker criterion

	GRT	ECS	SOS	CUS	ENS
GRT	0.725				
ECS	0.359	1			
SOS	0.300	0.533	1		
CUS	0.350	0.522	0.557	0.909	
ENS	0.403	0.515	0.527	0.635	0.768

Source: author's calculations in RStudio using the SEMinR package

According to the Fornell–Larcker criterion, the square root of each construct's AVE value should exceed its correlations with all other constructs in the model. The results confirm that the constructs GRT (0.725), CUS (0.909), and ENS (0.768) meet this requirement, indicating clear construct separation and an adequate level of discriminant validity.

Given that the Fornell–Larcker criterion may be limited in detecting issues of discriminant validity, the HTMT ratio was additionally examined. All HTMT values fall below the conservative threshold of 0.85, thereby providing further support for the discriminant validity of the measurement model (*Table 2*). The highest recorded value refers to the relationship between ENS and CUS (0.881), which slightly exceeds the conservative threshold but remains within the bounds of the less restrictive interpretation (≤ 0.90). Therefore, it can be concluded that the model as a whole satisfies the criteria for discriminant validity.

Table 2. HTMT criterion

	GRT	ECS	SOS	CUS	ENS
GRT					
ECS	0.408				
SOS	0.342	0.533			
CUS	0.447	0.589	0.627		
ENS	0.555	0.638	0.653	0.881	

Source: author's calculations in RStudio using the SEMinR package

Given that all reliability and validity criteria have been met, the reflective measurement model can be considered appropriate for further PLS-SEM analysis. In the next stage of the research, the structural model is assessed to examine the relationships among the latent variables. The model comprises five constructs, with green transformation in tourism (GRT) defined as the exogenous construct, while economic (ECS), social (SOS), cultural (CUS), and environmental sustainability (ENS) are specified as endogenous constructs. To evaluate the significance and stability of the path coefficients, a bootstrap resampling procedure was conducted. The results indicate that all constructs retain satisfactory measurement quality, and all coefficients are statistically significant at the 1% level (*Table 3*).

Table 3. Structural paths obtained through the bootstrap procedure

Assumed relationship	Structural coefficients	t-test	Effect size
GRT →ECS	0.359***	5.959	0.148
GRT →SOS	0.300***	5.098	0.099
GRT →CUS	0.350***	5.663	0.139
GRT →ENS	0.403***	7.961	0.194

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: author's calculations in RStudio using the SEMinR package

The explanatory power of the examined relationships was assessed using the coefficients of determination (R^2). The obtained values show varying levels of explained variance across the sustainability dimensions: environmental ($R^2 = 0.163$), economic ($R^2 = 0.129$), cultural ($R^2 = 0.122$), and social ($R^2 = 0.090$). The highest explained variance is observed in the environmental dimension, which aligns with the nature of the analysed phenomenon.

The research findings show that green transformation in tourism exerts a statistically significant and positive effect on all analysed dimensions of sustainability in island destinations, confirming its multidimensional developmental role. The strongest effect is observed in the ecological dimension, indicating that environmental benefits and ecosystem resilience manifest most rapidly through measures that involve more efficient resource management, reduced negative impacts, and improved efficiency.

At the same time, the positive effects identified across the economic, social, and cultural components demonstrate that green transformation is not limited to environmental outcomes but also functions as an integrated development framework that supports economic activity, social inclusion, and the preservation of local community identity. From an economic perspective, the results suggest that sustainable practices can stimulate entrepreneurial activity, increase local revenues, and contribute to job creation. Social effects are linked to greater community participation, strengthened cohesion, and improved quality of life, while the cultural dimension confirms the importance of sustainable approaches in safeguarding local identity, traditions, and heritage.

Overall, the findings indicate that green transformation serves as a fundamental

mechanism for long-term sustainability in island economies, enabling the alignment of ecological, economic, social, and cultural objectives. Such an integrated effect is particularly important for island destinations, which, due to limited resources, seasonality, and structural vulnerabilities, require development models that strengthen both resilience and competitiveness. Taken together with the existing literature, the results suggest that green transformation in tourism represents a meaningful and evidence-based pathway that can support the sustainable development of island destinations when implemented through targeted, systematic and long-term measures.

Conclusions

The conducted research confirms that the green transformation in tourism represents an important development mechanism for enhancing the sustainability of island destinations, with positive effects evident across all examined dimensions – economic, social, cultural, and environmental. The findings indicate that sustainable practices not only help reduce environmental pressures but also lay the foundations for diversifying the local economy, strengthening social cohesion, and ensuring the long-term preservation of cultural identity. The greatest impact is observed in the environmental dimension, confirming that green transition processes on islands primarily manifest through improved resource management and reduced ecological footprints. At the same time, positive effects across the remaining dimensions highlight the multidimensional nature of sustainable development.

Island areas, as specific and often vulnerable forms of rural space, require development models that account for the spatial, economic, demographic, and cultural characteristics of each local community. The results show that uniform policies, although useful as a strategic framework, have limited reach if they fail to recognise the heterogeneity of island and rural contexts. Therefore, implementing the green transformation on islands requires an approach grounded in local capacities, the involvement of community stakeholders, and the adaptation of objectives to local development realities.

From a practical perspective, the findings point to the need to strengthen institutional and financial instruments targeting rural economies, particularly in the fields of renewable energy, sustainable mobility, circular economy models, and the valorisation of local resources. The importance of developing participatory governance structures, continuous stakeholder education, and local partnerships is likewise emphasised, as these elements are crucial for ensuring long-term resilience and competitiveness.

From a theoretical standpoint, the research contributes to a deeper understanding of the interrelations between green transformation and the multidimensional sustainability of rural and island areas. At the same time, at the policy level, it opens space for differentiated development approaches that integrate economic, social, cultural, and environmental objectives.

However, the research conducted for this paper is subject to several methodological limitations. It relies on a questionnaire survey as the primary data collection method,

which may introduce response bias related to the subjective interpretation of individual items. In addition, the empirical analysis focuses exclusively on stakeholders involved in tourism planning, development, and management in island destinations. Although these actors are important for the implementation of sustainable strategies, their perceptions do not necessarily reflect the views of other relevant groups, such as local residents. These limitations should be considered when interpreting the findings and point to the need for complementary research designs that incorporate additional stakeholder perspectives and data sources.

In conclusion, the sustainable development of island destinations requires strategic thinking that simultaneously incorporates the specificities of rural areas, the potential of the green transition, and the needs of local communities. Future research should further explore these processes by analysing long-term effects and identifying governance models that support resilient, equitable, and ecologically grounded development of island tourism economies.

Conflict of interests

The authors declare no conflict of interest.

References

1. Apostu, S. A., Gigauri, I., Panait, M., & Martín-Cervantes, P. A. (2023). Is Europe on the Way to Sustainable Development? Compatibility of Green Environment, Economic Growth, and Circular Economy Issues. *International Journal of Environmental Research and Public Health*, 20(2), 1078. <https://doi.org/10.3390/ijerph20021078>
2. Bäckstrand, K. (2006). Multi-stakeholder partnerships for sustainable development: rethinking legitimacy, accountability and effectiveness. *European Environment*, 16(5), 290–306. Portico. <https://doi.org/10.1002/eet.425>
3. Barbier, E. B. (1987). The concept of sustainable economic development. *Environmental Conservation*, 14(2), 101–110. <https://doi.org/10.1017/S0376892900011449>.
4. Barbier, E. B., & Burgess, J. C. (2017). The sustainable development goals and the systems approach to sustainability. *Economics*, 11(2017-28), 1–22. <https://doi.org/10.5018/economics-ejournal.ja.2017-28>
5. Biggs, R., Schlüter, M., Biggs, D., Bohensky, E. L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T. M., Evans, L. S., Kotschy, K., Leitch, A. M., Meeck, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M. D., Schoon, M. L., Schultz, L., & West, P. C. (2012). Toward principles for enhancing the resilience of ecosystem services. *Annual Review of Environment and Resources*, 37, 421–448. <https://doi.org/10.1146/annurev-environ-051211-123836>

6. Dernbach, J. C., & Cheever, F. (2015). Sustainable development and its discontents. *Transnational Environmental Law*, 4(2), 247–287. <https://doi.org/10.1017/S2047102515000163>
7. Du Pisani, J. A. (2006). Sustainable development: Historical roots of the concept. *Environmental Sciences*, 3(2), 83–96. <https://doi.org/10.1080/15693430600688831>
8. Elkington, J. (1994). Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review*, 36(2), 90–100. <https://doi.org/10.2307/41165746>
9. European Commission. (n.d.). *European Agricultural Fund for Rural Development (EAFRD)*, Retrieved from https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/european-agricultural-fund-rural-development-eafrd_en (October 17, 2025)
10. European Commission. (2020). A new circular economy action plan for a cleaner and more competitive Europe (COM/2020/98 final), Retrieved from https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF (October 10, 2025)
11. European Commission. (2021). Clean energy for EU islands: Technology solutions booklet. Publications Office of the European Union, Retrieved from <https://data.europa.eu/doi/10.2833/03574> (October 1, 2025)
12. European Commission. (2024). Transition pathway for tourism: Taking stock of progress by 2023. Publications Office of the European Union, Retrieved from <https://data.europa.eu/doi/10.2873/775069> (October 1, 2025)
13. Fauzi, H., Svensson, G., & Rahman, A. (2010). “Triple Bottom Line” as “Sustainable Corporate Performance”: A Proposition for the Future. *Sustainability*, 2, 1345-1360, <https://doi.org/10.3390/su2051345>
14. Fetting, C. (2020). The European Green Deal, ESDN Report, December 2020, ESDN Office, Retrieved from Vienna. https://www.esdn.eu/fileadmin/ESDN_Reports/ESDN_Report_2_2020.pdf (October 1, 2025)
15. Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, 15(4). <http://www.jstor.org/stable/26268226>
16. Gössling, S. (2002). Global environmental consequences of tourism. *Global Environmental Change*, 12, 283-302, [https://doi.org/10.1016/s0959-3780\(02\)00044-4](https://doi.org/10.1016/s0959-3780(02)00044-4)
17. Guo, Y., Jiang, J., & Li, S. (2019). A Sustainable Tourism Policy Research Review. *Sustainability*, 11(11), 3187. <https://doi.org/10.3390/su11113187>
18. Hair Jr., J. F, Hult, G. Tomas M, Ringle, C. M, Sarstedt, M., Danks, N. P, Ray, S. (2021). Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook.

19. Hawkes, J. (2001). The fourth pillar of sustainability: Culture's essential role in public planning. Common Ground.
20. Hoffman, A. J., & Bazerman, M. H. (2007). Changing Practice on Sustainability: Understanding and Overcoming the Organizational and Psychological Barriers to Action. *Organizations and the Sustainability Mosaic*. <https://doi.org/10.4337/9781847205544.00012>
21. Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: mapping different approaches. *Sustainable Development*, 13, 38-52. <https://doi.org/10.1002/sd.244>
22. International Telecommunication Union (2024). COP29 Declaration on Green Digital Action, Retrieved from <https://cop29.az/en/pages/cop29-declaration-on-green-digital-action> (October 1, 2025)
23. Kanie, N., Griggs, D., Young, O., Waddell, S., Shrivastava, P., Haas, P. M., Broadgate, W., Gaffney, O., & Körösi, C. (2019). Rules to goals: Emergence of new governance strategies for sustainable development. *Sustainability Science*, 14(6), 1745–1749. <https://doi.org/10.1007/s11625-019-00729-1>
24. Kozar, Ł. J. i Sulich, A. (2023). Energy Sector's Green Transformation towards Sustainable Development: A Review and Future Directions. *Sustainability*, 15(15), <https://doi.org/10.3390/su151511628>
25. Krpata, M. (2022). The European Union Industrial Strategy: Reconciling Competition and Geoeconomic Challenges. Notes du Cerfa, No. 172. Ifri, Paris.
26. Law, A., DeLacy, T., & McGrath, G. M. (2017). A green economy indicator framework for tourism destinations. *Journal of Sustainable Tourism*, 25(10), 1434–1455, <https://doi.org/10.1080/09669582.2017.1284857>
27. Lélé, S. M. (1991). Sustainable development: A critical review. *World Development*, 19(6), 607–621. [https://doi.org/10.1016/0305-750x\(91\)90197-p](https://doi.org/10.1016/0305-750x(91)90197-p)
28. Meadows, D. H. (1998). Indicators and Information Systems for Sustainable Development: A Report to the Balaton Group, September 1998. The Sustainability Institute, Hartland VT
29. Mohd Zawawi, N. F., & Abd Wahab, S. (2019). Organizational sustainability: a redefinition? *Journal of Strategy and Management*, 12(3), 397–408, <https://doi.org/10.1108/jsma-08-2018-0077>
30. Norman, W., & MacDonald, C. (2004). Getting to the Bottom of "Triple Bottom Line." *Business Ethics Quarterly*, 14(2), 243–262, <https://doi.org/10.5840/beq200414211>.
31. OECD - Organisation for Economic Cooperation and Development (2011). Towards Green Growth, OECD Green Growth Studies, OECD Publishing, Paris, Retrieved from <https://doi.org/10.1787/9789264111318-en> (September 20, 2025)

32. OECD, Organisation for Economic Co-operation and Development. (2013). Green innovation in tourism services (OECD Tourism Papers, 2013/01). OECD Publishing, Retrieved from <https://doi.org/10.1787/5k4bxkt1cjd2-en> (September 20, 2025)
33. OECD. (2000). Towards sustainable development: Indicators to measure progress. OECD Publishing, Retrieved from https://www.oecd.org/content/dam/oecd/en/publications/reports/2000/09/towards-sustainable-development_g1gh28_58/9789264187641-en.pdf (September 20, 2025)
34. OECD - Organisation for Economic Cooperation and Development (2020). Sustainable Ocean for All: Harnessing the Benefits of Sustainable Ocean Economies for Developing Countries, The Development Dimension, OECD Publishing, Paris, Retrieved from <https://doi.org/10.1787/bede6513-en> (September 19, 2025)
35. OECD, Organisation for Economic Co-operation and Development (2022). Tourism Trends and Policies 2022, OECD Publishing, Paris, Retrieved from <https://doi.org/10.1787/a8dd3019-en> (September 19, 2025)
36. Pathirana, A. (2025). Small islands: Living laboratories revealing global climate and sustainable development challenges. *Frontiers in Climate*, 6, 1445378. DOI: 10.3389/fclim.2024.1445378
37. Pavlinović Mršić, S. i Čale, D. (2020). Analiza ETIS sustava pokazatelja za ocjenu i praćenje održivosti turizma u gradu Splitu, Hrvatska. *Oeconomica Jadertina*, 10 (2), 41-58, <https://doi.org/10.15291/oec.3164> [in English: Pavlinović Mršić, S., & Čale, D. (2020). Analysis of the ETIS indicator system for assessing and monitoring tourism sustainability in the city of Split, Croatia. *Oeconomica Jadertina*, 10(2), 41–58.]
38. Pintér, L., Hardi, P., & Bartelmus, P. (2005). Sustainable development indicators: Proposals for a way forward. International Institute for Sustainable Development. Prepared for the United Nations Division for Sustainable Development (UN-DSD).
39. Sastri R, Li F, Setiyawan A, Monika AK (2025), Measuring the multiplier effect of regional tourism and its spatial distribution in Indonesia before and after the COVID-19. *Kybernetes*, 54(4), 2087–2110, <https://doi.org/10.1108/K-09-2023-1843>
40. Sharpley, R. (2009). *Tourism Development and the Environment: Beyond Sustainability?*, London, New York: Earthscan, <https://doi.org/10.4324/9781849770255>
41. Smart Islands Initiative. (2017). Smart Islands Declaration: To create smart, inclusive and thriving island societies for an innovative and sustainable Europe, Retrieved from https://www.smartislandsinitiative.eu/pdf/Smart_Islands_Declaration.pdf (October 1, 2025)
42. Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press.

43. Tang, H., Maqbool, A., Khan, A. J., Ul Hameed, W., Batool, H., & Ahmed, T. (2023). The moderating role of sustainable development goals in reviving the economy through green initiatives. *Frontiers in Environmental Science*, 11. <https://doi.org/10.3389/fenvs.2023.1180479>
44. Tiller, S. J., Rhindress, A. P., Oguntola, I. O., Ülkü, M. A., Williams, K. A., & Sundararajan, B. (2022). Exploring the Impact of Climate Change on Arctic Shipping through the Lenses of Quadruple Bottom Line and Sustainable Development Goals. *Sustainability*, 14(4), 2193. <https://doi.org/10.3390/su14042193>
45. UCLG. (n.d.). Culture. The fourth pillar of sustainability, Retrieved from <https://agenda21culture.net/documents/culture-the-fourth-pillar-of-sustainability>, (October 11, 2025)
46. UNEP/MAP. (2011). Protocol on Integrated Coastal Zone Management in the Mediterranean under the Barcelona Convention. United Nations Environment Programme – Mediterranean Action Plan.
47. United Nations Environment Programme - UNEP (n.d.). About green economy. UNEP. Retrieved from <https://www.unep.org/explore-topics/green-economy/about-green-economy> (October 13, 2025)
48. United Nations World Tourism Organization - UNWTO (2004). Indicators of sustainable development for tourism destinations: A guidebook. Madrid, Spain: World Tourism Organization.
49. UNWTO, United Nations and World Tourism Organization (2025), Guiding Principles for Sustainable Investment in Tourism, UN/UN Tourism, New York/ Madrid, Retrieved from <https://doi.org/10.18111/9789284425389> (October 21, 2025)
50. Vornholz, G. (1994). The sustainable development approach. *Intereconomics*, 29, 194–198, <https://doi.org/10.1007/BF02926438>
51. WCED - World Commission on Environment and Development - (1987). Our Common Future. Oxford: Oxford University Press.
52. World Bank (2025). Tourism and Competitiveness, Retrieved from <https://www.worldbank.org/en/topic/competitiveness/brief/tourism-and-competitiveness> (October 2, 2025)
53. Zaccai, E. (2012). Over two decades in pursuit of sustainable development: Influence, transformations, limits. *Environmental development*, 1, 79-90, <https://doi.org/10.1016/j.envdev.2011.11.002>.

OCCUPATIONAL HEALTH AND SAFETY, MENTAL HEALTH, JOB SATISFACTION AND PERFORMANCE OF TEMPORARY WORKERS IN FRUIT GROWING

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ABSTRACT

The paper analyses the associations between two temporary work characteristics (workplace burnout and job insecurity), job satisfaction, and mental health in fruit growing in the Republic of Serbia, as well as the role of satisfaction with employee care in these relationships. The research involved 1,359 seasonal workers engaged in pruning and harvesting tasks on fruit plantations. Using structural equation modelling the analysis explored cause-and-effect associations. The findings reveal that job burnout exerts a stronger influence on temporary workers' mental health than on job satisfaction, whereas job insecurity has a more pronounced effect on job satisfaction than on mental health. Across these relationships, satisfaction with employee care functions as a buffer, mitigating the adverse impacts of burnout and job insecurity on both mental health and job satisfaction - two critical determinants of workplace performance.

Introduction

Temporary work is a form of flexible labor engagement, that allows employers to adjust workforce size and working hours in line with their operational needs (Hünefeld et al., 2020). Although temporary workers are not widely represented on the European labour market, in agricultural sector in Serbia, they are important group. The largest number of seasonal workers in Serbia are employed in fruit growing. For that reason, for Republic of Serbia, it is important to focus on these employees and this of form of

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labor engagement. First, temporary work is widely regarded as the most precarious type of labour arrangement in Europe (Eichhorst & Tobsch, 2017). It represents a less advantageous employment status compared to permanent work, largely because temporary employees are frequently subjected to unequal and unjust treatment when contrasted with core staff (Arrowsmith, 2006). Temporary employees are frequently disadvantaged in terms of compensation and benefits, with limited opportunities to participate in career development or training. As a rule, they receive lower wages and typically occupy lower professional positions (Mitlacher, 2008). They are often excluded from advanced occupational health and safety programs and have reduced access to workplace health promotion initiatives (Becker & Engel, 2015). Furthermore, they are commonly exposed to stressful and hazardous working environments (De Cuyper et al., 2009). Collectively, these circumstances generate a distinct risk profile for temporary workers.

Above all, this refers to the risk of burnout at work, which has negative effects on worker's mental health and their job satisfaction. It is well known that satisfied workers are motivated for hard work and express a strong psychological commitment to their work and attachment to organizational goals (LaGree et al., 2023), despite insecure conditions. Other words, they exhibit a strong resilience on adverse working conditions. They voice a standpoint a positive attitude towards one's job and a willingness to contribute actively to organizational goals (Tran, 2023), which enhance operational effectiveness. In doing so, they enhance the overall efficiency of organizational processes and the achievement of organizational objectives. Therefore, it is regarded as an essential element of psychological well-being and a marker of stress. In the case of seasonal workers in fruit growing, low levels of motivation and dissatisfaction often result in reduced attentiveness during work. This lack of focus increases the likelihood of workplace accidents and absenteeism, while also diminishing workers' motivation to achieve better performance. Such outcomes are particularly concerning, as dissatisfaction is commonly linked to greater exposure to occupational risks. When you add to this the difficult working conditions in fruit growing because harvesting tasks require prolonged standing, bending, and working outdoors, work at heights often under strong sunlight; workers are exposed to the risk of heatstroke, dehydration, and injuries caused by repetitive movements, it comes to the point that, satisfied with the quality of safety and health measures at work (i.e. employee satisfaction with care is regarded as a dimension of overall job satisfaction, reflecting the extent to which employees perceive their physical and psychological well-being as adequately supported by the organization. (Krick et al., 2022)) and mental health, because of the specifics of temporary employment, in terms of burnout at work and job insecurity, are the main factors that affect the performance workers at job. Therefore, the aim of this paper is to examine the impact of mental health, as a consequence of workplace burnout and job insecurity, and job satisfaction on employee performance, considering the mediating role of satisfaction in these relationships.

Materials and methods

Theoretical foundations of the research

According to the World Health Organization, “mental health is a state of well-being in which individuals are able to realize their abilities, cope effectively with everyday stress, work productively, and make meaningful contributions to their community.” (WHO, 2007, p. 1). It is often considered a consequence of workplace burnout. This is evidenced by an extensive body of research spanning multiple fields of inquiry, such as (Papathanasiou, 2015; Paspalj et al., 2024; Schonfeld et al., 2019; Bianchi et al., 2021; Sullivan et al., 2022; Nadon et al., 2022). Whereas stress reflects a transient adaptation accompanied by somatic and psychological signs, workplace burnout constitutes a chronic disorder connected to compromised mental health under continuous job pressure and difficult working conditions. Also, numerous studies have demonstrated that workplace burnout consists of four dimensions (Schaufeli et al., 2020; Angelini et al., 2021; Đorđević & Novičević Čečević, 2025; Miljković, & Arsić, 2025; Jakšić & Burić, 2024; Stojilkovic & Malenovic Nikolic, 2024): physical exhaustion, emotional exhaustion, depersonalization, and low personal accomplishment. “Physical exhaustion is associated with the perception of being overexploited at work. Its manifestations include persistent fatigue, insomnia, and loss of appetite over an extended period, which may contribute to the onset of occupational illnesses and adverse life outcomes” (Harjanti & Todani, 2019). Emotional exhaustion refers to a condition in which individuals feel unable to make meaningful psychological contributions to organizational activities. It is recognized as the most critical dimension of workplace burnout and typically emerges from repeated exposure to occupational stress (Erkan, 2018). Individuals experiencing emotional exhaustion often report discomfort, fatigue, and depressive symptoms, and may engage in maladaptive coping strategies such as alcohol abuse (Stojilkovic & Malenovic Nikolic, 2024). Depersonalization is indifference towards workplace demands, clients, and colleagues. A lack of personal accomplishment is the feeling that the employee is not successful enough at the workplace, that he is not worthy enough of that workplace.

Research shows that workplace burnout has a negative impact on job satisfaction. Wolpin et al. (1991) and Bal & Kökalan (2021) explained the causal relationship between burnout and job satisfaction, suggesting that burnout leads to decreased job satisfaction rather than the reverse. In this relationship, occupational health and safety (OHS) is essential as it mitigates occupational stress, which in turn decreases the likelihood of burnout and related health problems. On the other hand, there is a strong correlation between workplace burnout and occupational risks: the greater the occupational risk, the higher the level of employee burnout (Chirico, 2016). Leiter and Robichaud (1997) demonstrated that the sense of control over managing occupational risks, as a result of OHS, reduces emotional and physical exhaustion, i.e., workplace burnout. Hence, OHS functions as a protective buffer mitigating workplace burnout. The stronger the perceived sense of control, the greater the satisfaction employees

report with workplace care, reflecting the protective role of OHS practices. Therefore, it can be assumed that employee satisfaction with care (as an outcome of the quality of OHS) moderates the relationship between burnout and mental health, such that higher levels of OHS reduce the negative impact of burnout, but the relationship between burnout and job satisfaction. The greater employee satisfaction with care will reduce the negative effect of job burnout on job satisfaction. Further empirical investigations demonstrate that, alongside job insecurity, mental health plays a decisive role in shaping job satisfaction (Thekiso et al., 2013; Witt et al., 2020; Otaghi, et al., 2023).

Based on this, the following hypotheses can be formulated:

H1: Job burnout has a negative impact on the mental health and job satisfaction of seasonal workers in fruit growing;

H2: Satisfaction with employee care mitigates the negative effect of job burnout on the mental health and job satisfaction of seasonal workers in fruit growing.

H3: Mental health has a positive impact on job satisfaction of seasonal workers in fruit growing.

Alongside workplace burnout, job insecurity, which represents a key characteristic of temporary employment, is consistently acknowledged in the literature as a critical factor impacting the mental health of employees. It should be understood as an overall concern about the continued existence of the job in the future (Heaney et al., 1994). Job insecurity is a chronic stressor that increases psychological withdrawal, such as decreased job satisfaction (Ferrie, 1999). It reduces psychological well-being and job satisfaction while increasing psychosomatic complaints and physical strains (Witte, 1999). In line with these views, other authors also highlight that job insecurity contributes to decreased job satisfaction and adversely affects employees' mental health (Rajani et al., 2016; Richter, A., & Näswall, 2019; Jaramillo et al., 2022).

Based on this, it can be hypothesized that:

H4: Job insecurity has a negative impact on the mental health and job satisfaction of seasonal workers in fruit growing;

According to social exchange theory (SET), individuals enter relationships with organizations to maximize benefits, based on the principle of reciprocity. One party knows what it expects from the other, and what the other expects in return. Both parties have a clear understanding of mutual expectations. Considering that OHS practices are interpreted as signals of employer goodwill (Wang et al., 2020), which typically foster positive employee reactions, it is reasonable to expect that employees will respond to OHS by expressing satisfaction. In the context of temporary employment, this implies that employee satisfaction with workplace care should buffer the negative effect of job insecurity on job satisfaction, ultimately resulting in improved workplace outcomes.

Based on this, it can be hypothesized that:

H5: Satisfaction with employee care mitigates the negative effect of job insecurity on the job satisfaction of seasonal workers in fruit growing.

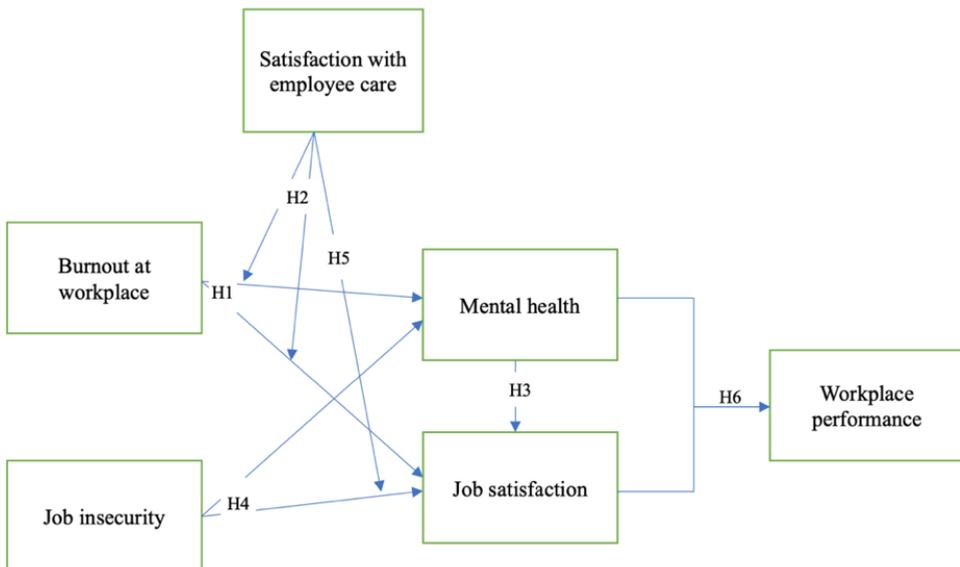
It is well established that high levels of job satisfaction foster positive attitudes toward one's work and a greater willingness to contribute actively to organizational objectives (Radivojevic et al., 2025). Employees who perceive that their organization cares for them tend to demonstrate loyalty and dedication, thereby enhancing organizational outcomes (Oh et al., 2023). Such loyalty contributes to organizational efficiency, as satisfied employees are more likely to engage in behaviours that strengthen operational effectiveness.

Based on this, it can be hypothesized that:

H6: Job satisfaction and mental health have a positive effect on workplace performance.

The preceding discussion implies the following model, which is presented in Figure 1.

Figure 1. The research model



Source: Authors

Research methodology

The research was conducted on a sample of 1,359 seasonal workers in the Republic of Serbia, employed on fruit plantations in pruning and harvesting tasks. Data were collected during 2025. The questionnaire is presented in Table A1. All items were measured on a 5-point Likert-type scale. In accordance with the WHO's definition of mental health, research on employee performance typically applies GHQ measures (Hünefeld et al., 2020), and this study follows that practice by adopting an eight-item scale. Although burnout has been shown to affect employees' mental health, empirical

studies diverge on which dimension is most impactful. Reported findings range from emotional exhaustion exerting the strongest influence (Schonfeld et al., 2019) to depersonalization being found to have no effect (Papathanasiou, 2015). Nevertheless, the operationalization of workplace burnout (BO) is consistently based on a scale that incorporates all four of its dimensions. For the purposes of this study, the scale developed by Stoiljkovic and Malenovic Nikolic (2024) was employed. Job insecurity (JI) is commonly assessed through a two-item scale (Wagenaar et al., 2012). Yet, as Jaramillo et al. (2022) emphasize, job insecurity consistently exerts a negative impact on workers' mental health, regardless of the operationalization method employed. Job satisfaction (JS) was measured with four items covering satisfaction with different job facets (de Graaf-Zijl, 2012). According to Radivojevic et al. (2025), employee performance should be expressed in terms of orientation to results. Therefore, employee performance (EP) was measured using a four-item scale. Satisfaction with employee care (SC) was assessed using the scale proposed by Radivojevic et al. (2025).

The validity of the questionnaire was tested through factor analysis using the varimax rotation method. Construct validity was assessed using exploratory factor analysis (EFA), while reliability was evaluated through composite reliability (CR). Confirmatory factor analysis (CFA) was conducted to assess the validity of the measurement instrument. The results are presented in Table A1. The factors clustered as expected, with all items showing factor loadings above 0.40 and no cross-loadings exceeding 0.30. Average variance extracted (AVE) values indicated good convergent validity, as each subscale exceeded the threshold of 0.50. Reliability was also satisfactory, with CR values for all subscales surpassing the recommended standard of 0.70. Discriminant validity was examined using the Fornell–Larcker criterion, and the results confirmed adequate discriminant validity (see Table 1). The adequacy of the sample was tested using the Kaiser-Meyer-Okin sample adequacy test (test value = 0.842). The Bartlett's sphericity test was also conducted ($\chi^2_{(378)} = 7225.1$).

Table 1. Results of the discriminant validity

	MH	BO	SC	JI	JS	EP
MH	0.826					
BO	0.342	0.774				
SC	0.339	0.174	0.835			
JI	0.276	0.231	0.129	0.972		
JS	0.438	0.076	0.567	0.172	0.847	
EP	0.128	0.097	0.418	0.089	0.511	0.849

Note: Coefficients are given in absolute values. All correlations are significant at $p < 0.05$.

Source: Authors

Discriminant validity was examined using the Fornell–Larcker criterion, and the results confirmed adequate discriminant validity (see Table 1).

Results

Descriptive statistical analysis reveals that seasonal workers exhibit lower levels of mental health, with considerable variation among individuals in this regard. The majority of respondents report lower levels of mental health. The analysis further indicates that workers are exposed to high levels of workplace burnout, with relatively low variability across this dimension. A similar pattern is observed in relation to job insecurity. In contrast, responses concerning job satisfaction and work performance display substantial dispersion. Overall, employees report being satisfied with their performance at the workplace. However, these findings point to the need to examine additional factors that may influence employees' mental health and motivation, such as personality type and related characteristics.

Table 2. Descriptive analysis

	MH	BO	SC	JI	JS	EP
Mean	1.271	3.133	1.512	3.201	2.409	3.103
St. Dev.	0.510	0.071	0.713	0.316	3.116	1.671
Excess kur.	-0.103	1.012	1.437	0.035	3.628	1.115
Skewness	-0.202	1.031	-1.061	1.091	-1.315	2.042

Source: Authors

The research model depicted in Figure 1 was estimated using JASP software. Structural equation modeling (SEM) was employed to assess the validity of the measures and to test the hypothesized relationships. Different goodness-of-fit indices were applied, with one selected from each index category. The results for the overall model are as follows: root mean square error of approximation (RMSEA) = 0.032; root mean square residual (RMSR) = 0.052; non-normed fit index (NNFI) = 0.971; and adjusted goodness-of-fit index (AGFI) = 0.911. All indices indicate good values.

Table 3. Results of hypothesis testing

Variables	Coeff.	Stand. error	Crit. Val.	P value	Results
MH - BO	-0.468	0.028	-16.714	0.000	H1 accept
JS - BO	-0.362	0.019	-19.053	0.000	
MH (BO*SC)	-0.277	0.024	-11.542	0.000	H2 accept
JS - (BO*SC)	-0.128	0.012	-10.667	0.000	
JS - MH	0.204	0.030	6.800	0.000	H3 accept
MH - JI	-0.074	0.003	-24.667	0.000	H4 accept
JS - JI	-0.081	0.002	-40.500	0.000	
JS - (SI*SC)	-0.067	0.002	-33.500	0.000	H5 accept
EP \leftarrow MH	0.164	0.011	14.909	0.000	H6 accept
EP \leftarrow JS	0.253	0.013	19.462	0.000	

Source: Authors

Discussions

The results imply that the influence of BO on MH is more significant than the influence of BO on JS. The justification for such a finding can be found in the fact that burnout directly affects employees' psychological resources and emotional stability, whereas job satisfaction is more closely related to cognitive evaluations of the work environment (Singh & Pandey, 2025). Burnout is primarily a health phenomenon, so its impact on mental health is stronger and more immediate. Job satisfaction is an evaluative construct that can be maintained even when mental health declines, as it depends on a wider range of work factors (Evans et al., 2006). Such findings suggest that employers should not regard job satisfaction as a sufficient indicator of employee well-being. Mental health represents a fundamental resource, if it is impaired, job satisfaction cannot compensate for the consequences on performance and the long-term sustainability of the workforce. In addition to the above, the finding that satisfaction with employee care emerges as a shock absorber that mitigates the impact of workplace burnout on both mental health and job satisfaction. However, the moderating effect is stronger in the relationship between burnout and job satisfaction than in the relationship between burnout and employees' mental health. The moderating effect of satisfaction with employee care (as a result of OHS) is stronger in the relation burnout → job satisfaction because both constructs are based on the evaluation of the work environment. In contrast, burnout → mental health is a behaviorally and physiologically rooted relationship, so organizational care can alleviate it only partially. Mental health is a fundamental condition that depends on a wider range of factors (genetics, personality, life circumstances). Burnout directly affects it through exhaustion and stress reactions, so there is less room for moderation. Job satisfaction is an evaluative category - it depends on the perception of the work environment, relations with colleagues, benefits and care of the employer. This is precisely where OHS interventions and the perception of "employee care" have the greatest impact. Unlike mental health, which is more deeply rooted in individual psychological resources, job satisfaction relies more on evaluation of the work environment. Employers have more room to influence it through policies, benefits and a culture of care.

Employees with preserved mental health have more energy, emotional stability and resistance to stress. This allows them to evaluate work tasks and circumstances more positively, which directly reflects on greater job satisfaction. Results also show that that job insecurity has a greater negative impact on mental health than job satisfaction. The justification for this can be found in the fact that job insecurity creates chronic stress, anxiety and a sense of unpredictability. These factors directly affect the psychological stability and emotional well-being of employees. Job insecurity activates existential stress - worrying about the future, financial stability and identity. This stress has a stronger and more immediate effect on mental health than on the evaluation of job satisfaction, because it affects basic psychological needs (security, predictability, control). On the other hand, although job insecurity may reduce satisfaction, employees may still be satisfied with some aspects of the job.

The finding that satisfaction with employee care mitigates the negative effect of job insecurity on job satisfaction confirms the core postulates of SET. When employees perceive that their employer cares about them, a sense of reciprocity and trust develops, which lies at the heart of SET. This perception can buffer the adverse consequences of job insecurity, as employees evaluate that the employer nevertheless invests in their well-being.

The finding that mental health and job satisfaction have a positive impact on the performance of employees at the workplace, while the impact of job satisfaction is stronger, can be explained by the fact that job satisfaction is directly related to motivation, engagement and organizational commitment. Mental health provides stability and resilience, but its impact on performance is indirect. Employees may have relatively poor mental health but still perform well if they are satisfied with their work (e.g. because of support from colleagues, benefits, or a sense of purpose).

Conclusions

The research demonstrates that the characteristics of temporary employment significantly influence both mental health impairments and job satisfaction. First, workplace burnout exerts a stronger impact on mental health than on job satisfaction, as it directly undermines employees' psychological resources and emotional stability. Second, job satisfaction is an evaluative construct that can remain stable even under conditions of declining mental health, since it depends on a broader range of work-related factors (Evans et al., 2006). These findings suggest that employers should not treat job satisfaction as a sufficient indicator of employees' overall well-being. Third, satisfaction with employee care acts as a buffer that reduces the effects of workplace burnout on both mental health and job satisfaction. Moreover, satisfaction with employee care also mitigates the impact of job insecurity on job satisfaction.

The findings carry practical implications, highlighting the influence of job characteristics on the job satisfaction of temporary workers. Employers are therefore advised to prioritize employee care, as this will enhance satisfaction, motivation, and work performance. Although they cannot eliminate inherent features of temporary work, such as fruit picking and pruning, by demonstrating concern for the safety and health of seasonal workers, employers can offset the negative consequences associated with temporary employment.

Future research should focus on longitudinal approaches and different sectors of temporary work to gain a deeper understanding of the effects on mental health and job satisfaction. Special emphasis can be placed on examining employer interventions and cultural contexts that shape the experiences of temporary workers.

Conflict of interests

The authors declare no conflict of interest.

References

1. Angelini, G., Buonomo, I., Benevene, P., Consiglio, P., Romano, L., & Fiorilli, C. (2021). The Burnout Assessment Tool (BAT): A contribution to Italian validation with teachers. *Sustainability*, 13(16), 9065.
2. Arrowsmith, J. (2006). Temporary agency work in an enlarged European Union. Luxembourg: Office for Official Publications of the European Communities.
3. Bal, Y., & Kökalan, Ö. (2021). The moderating effect of religiosity on the relationship between burnout and job satisfaction. *Frontiers in Psychology*, 12, 750493.
4. Bianchi, R., Verkuilen, J., Schonfeld, I. S., Hakanen, J. J., Jansson-Fröjmark, M., Manzano-García, G., ... & Meier, L. L. (2021). Is burnout a depressive condition? A 14-sample meta-analytic and bifactor analytic study. *Clinical Psychological Science*, 9(4), 579-597.
5. Chirico, F. (2016). Job stress models for predicting burnout syndrome: a review. *Annali dell'Istituto superiore di sanità*, 52(3), 443-456.
6. de Graaf-Zijl, M. (2012). Job satisfaction and contingent employment. *De Economist*, 160(2), 197-218.
7. Đorđević, M., & Novičević Čečević, B. (2025). To what extent does financial performance influence audit opinion modification in the Republic of Serbia?. *BizInfo Blace*, 16(2), 59-66. <https://doi.org/10.71159/bizinfo250028D>
8. Eichhorst, W., & Tobsch, V. (2017). *Risk of precariousness: Results from European Working Conditions Survey 2010 and 2015*. Brussels. Economy and Scientific Policy European Parliament. 2017.
9. Erkan, M. The effects of quality of work life on burnout syndrome: A study on hospitality industry. *Journal of Tourismology*, 2018, 4(1), 35-53
10. Evans, S., Huxley, P., Gately, C., Webber, M., Mears, A., Pajak, S., ... & Katona, C. (2006). Mental health, burnout and job satisfaction among mental health social workers in England and Wales. *The British Journal of Psychiatry*, 188(1), 75-80.
11. Ferrie, J. E. (1999). Health consequences of job insecurity. *WHO Regional Publications European Series*, 59-100.
12. Heaney, C. A., Israel, B. A., & House, J. S. (1994). Chronic job insecurity among automobile workers: Effects on job satisfaction and health. *Social science & medicine*, 38(10), 1431-1437.
13. Hünefeld, L., Gerstenberg, S., & Hüffmeier, J. (2020). Job satisfaction and mental health of temporary agency workers in Europe: a systematic review and research agenda. *Work & Stress*, 34(1), 82-110.
14. Isaac, M. E., Lin, T., Caillon, S., Sebastien, L., Macdonald, K., Prudham, S., ... & Sterling, E. (2024). Multidimensional measures of farmer well-being: A scoping review. *Agronomy for Sustainable Development*, 44(4), 39-445.

15. Jakšić, K., & Burić, I. (2024). Povezanost globalne i kontekstualizirane ličnosti sa sagorijevanjem na poslu kod srednjoškolskih nastavnika. *Društvena istraživanja: časopis za opća društvena pitanja*, 33(2), 201-221.
16. Jaramillo, N. R., Trillos, C. E., & Julià, M. (2022). The measure of precarious employment and its impact on the mental health of workers: A systematic review 2007–2020. *Work*, 73(2), 639-650.
17. Krick, A., Felfe, J., & Pischel, S. (2022). Health-oriented leadership as a job resource: can staff care buffer the effects of job demands on employee health and job satisfaction?. *Journal of Managerial Psychology*, 37(2), 139-152.
18. LaGree, D., Houston, B., Duffy, M., & Shin, H. (2023). The effect of respect: Respectful communication at work drives resiliency, engagement, and job satisfaction among early career employees. *International Journal of Business Communication*, 60(3), 844-864.
19. Leiter, M. P., & Robichaud, L. (1997). Relationships of occupational hazards with burnout: An assessment of measures and models. *Journal of Occupational Health Psychology*, 2(1), 35.
20. Miljković, M., & Arsić, I. (2025). Determinisanje promena organizaciono-upravljačkih procesa u sistemu upravljanja. *Finansijski Savetnik*, 30(1), 55-74. <https://fa-journal.com/index.php/fa/article/view/3>
21. Mitlacher, L. W. (2008). Job quality and temporary agency work: Challenges for human resource management in triangular employment relations in Germany. *The International Journal of Human Resource Management*, 19(3), 446-460.
22. Momose, Y., Suenaga, T., & Une, H. (2008). Job satisfaction and mental distress among Japanese farmers. *Journal of Rural Medicine*, 3(2), 29-33.
23. Nadon, L., De Beer, L. T., & Morin, A. J. (2022). Should burnout be conceptualized as a mental disorder? *Behavioral Sciences*, 12(3), 82-89.
24. Oh, H., Jeong, M., Shin, H. H., & Schweyer, A. (2023). Nonlinear effects of employee engagement and satisfaction on turnover intention. *International Journal of Contemporary Hospitality Management*, 35(7), 2410-2436.
25. Ottaghi, M., Azadi, A., Sayehmiri, K., & Nikeghbal, N. (2023). Relationship between mental health, life satisfaction, and job satisfaction of nurses. *Romanian Journal of Military Medicine*, 126(2), 185-191.
26. Papathanasiou, I. V. (2015). Work-related mental consequences: Implications of burnout on mental health status among health care providers. *Acta Informatica Medica*, 23(1), 22.
27. Paspalj, M., Paspalj, D., & Milojević, I. (2024). Održivost savremenih ekonomskih sistema. *Održivi razvoj*, 6(1), 33-45. <https://doi.org/10.5937/OdrRaz2401033P>
28. Radivojevic, N., Radomir, J., Pimić, M., Cvjetković, M., & Cvjetković, M. (2025). The impact of employee satisfaction with care on the performance of employees in the food industry in the Republic of Serbia. *Journal of East European Management Studies*, 30(2), 41067.

29. Rajani, N. B., Giannakopoulos, G., & Filippidis, F. T. (2016). Job insecurity, financial difficulties and mental health in Europe. *Occupational Medicine*, 66(8), 681-683.
30. Richter, A., & Näswall, K. (2019). Job insecurity and trust: Uncovering a mechanism linking job insecurity to well-being. *Work & Stress*, 33(1), 22-40.
31. Schaufeli, W. B., Desart, S., & De Witte, H. (2020). Burnout Assessment Tool (BAT)—development, validity, and reliability. *International Journal of Environmental Research and Public Health*, 17(24), 9495.
32. Schonfeld, I. S., Verkuilen, J., & Bianchi, R. (2019). Inquiry into the correlation between burnout and depression. *Journal of Occupational Health Psychology*, 24(6), 603.
33. Singh, C., & Pandey, N. (2025). Effect of Burnout Syndrome on Job Satisfaction and Mental Wellbeing of Employees. *International Journal of Interdisciplinary Approaches in Psychology*, 3(5), 530-541.
34. Stojilković, P., & Malenović-Nikolić, J. (2023). The impact of work environment factors on burnout at work. *1st international eurosa conference*, 186-192.
35. Sullivan, V., Hughes, V., & Wilson, D. R. (2022). Nursing burnout and its impact on health. *Nursing Clinics*, 57(1), 153-169.
36. Thekiso, S. M., Botha, K. F., Wissing, M. P., & Kruger, A. (2013). Psychological well-being, physical health, and the quality of life of a group of farm workers in South Africa: The FLAGH study. In *Well-being research in South Africa* (pp. 293-313). Dordrecht: Springer Netherlands.
37. Tran, Q. H. N. (2023). Exploring relationships among overload stress, work-family conflict, job satisfaction, person–organisation fit and organisational commitment in public organizations. *Public Organization Review*, 23(2), 759-775.
38. Wagenaar, A. F., Taris, T. W., Houtman, I. L. D., van den Bossche, S., Smulders, P., & Kompier, M. A. J. (2012). Labour contracts in the European Union, 2000-2005: Differences among demographic groups and implications for the quality of working life and work satisfaction. *European Journal of Work and Organizational Psychology*, 21, 169–194.
39. Witt, C. D., Reed, D. B., Rayens, M. K., & Hunsucker, S. (2020). Predictors of job satisfaction in female farmers aged 50 and over: implications for occupational health nurses. *Workplace Health & Safety*, 68(11), 526-532.
40. Witte, H. D. (1999). Job insecurity and psychological well-being: Review of the literature and exploration of some unresolved issues. *European Journal of Work and Organizational Psychology*, 8(2), 155-177.
41. Wolpin, J., Burke, R. J., & Greenglass, E. R. (1991). Is job satisfaction an antecedent or a consequence of psychological burnout? *Human Relations*, 44(2), 193-209.
42. WHO. (2007). Mental health: strengthening mental health promotion. Available: <https://mindyourmindproject.org/wp-content/uploads/2014/11/WHO-Statement-on-Mental-Health-Promotion.pdf>

Appendix

Table A1. The results of EFA and CFA

	Items	ECF Factor loads	CFA		CR
			Factor loads	AVE	
MH	Have you been feeling perfectly well and in good health?	0.470	0.763	0.682	0.928
	Somatic symptoms	0.413	0.891		
	Anxiety/insomnia	0.620	0.902		
	Social dysfunction	0.424	0.733		
	Severe depression	0.463	0.805		
	Have you been managing to keep yourself busy and occupied?	0.482	0.847		
BO	I have continued to feel tired in completing work.	0.416	0.763	0.600	0.923
	I continue to feel headaches when facing work assignments.	0.406	0.811		
	I have continued to feel anxious.	0.462	0.731		
	I lost the enthusiasm to do daily activities.	0.419	0.725		
	I found it difficult to concentrate.	0.532	0.703		
	I did not care about colleagues who were facing work problems.	0.512	0.774		
	I often ignore conversations when colleagues start the conversation.	0.483	0.851		
	I feel unable to complete work tasks	0.422	0.825		
SC	Management provides strong support to employees in OHS	0.408	0.842	0.698	0.902
	The amount of compensation about suffered pain and physical damage	0.513	0.811		
	The protective equipment provided by the employer is suitable for the tasks and hazards present in your job	0.489	0.784		
	Risk judgment and management reaction	0.449	0.901		
JI	How concerned are you about the following issues	0.765	0.975	0.945	0.972
	Your job security	0.921	0.969		
JS	Satisfaction - job content	0.453	0.859	0.717	0.910
	Satisfaction - working conditions	0.491	0.784		
	Satisfaction - working hours	0.501	0.905		
	Satisfaction - wage	0.459	0.835		
EP	Achieving results	0.411	0.911	0.720	0.911
	Employee orientation;	0.529	0.887		
	Achieving personal work goals and tasks	0.603	0.821		
	Adherence to principles and values	0.442	0.768		

DIGITAL MARKETING STRATEGY FOR ENHANCING THE COMPETITIVENESS OF RURAL AGRITOURISM FARMS

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ABSTRACT

The digitalization of the tourism market requires agritourism farms to develop contemporary marketing strategies to enhance competitiveness and ensure sustainable performance. This study examines the relationship between digital marketing strategy and competitiveness based on a sample of 123 agritourism farms in Serbia. Correlation analysis indicates moderate to strong positive associations between digital strategy and all competitiveness dimensions. Multiple regression results show that social media activity, online reputation management, direct digital communication with guests, and the integration of digital strategy have a statistically significant and positive impact on overall competitiveness, whereas basic web presence and platform presence do not demonstrate an independent effect. Cluster analysis identifies three distinct groups of farms, with those characterized by a highly integrated digital strategy achieving higher market visibility, capacity utilization, revenue, and guest loyalty. The findings confirm that competitive advantage primarily stems from a strategic and integrated digital approach.

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Introduction

Agritourism is increasingly recognized in contemporary economies as an important segment of rural tourism with significant potential for the sustainable development of rural areas, particularly in countries undergoing economic transition. Although international literature increasingly emphasizes the role of digital marketing in strengthening the market position and competitiveness of tourism entities, agritourism farms face specific challenges due to limited resources, business seasonality, and the need to build trust in the market. In this context, digital marketing acquires particular importance as a mechanism for increasing visibility, improving communication with guests, and differentiating the tourism offering, thereby creating conditions for enhancing the competitiveness of agritourism entities.

Despite a growing body of international research confirming a positive relationship between digital marketing and competitiveness in tourism, empirical evidence related to agritourism farms in the Republic of Serbia and the wider region remains limited. A notable research gap exists in identifying the key elements of digital marketing strategy that most strongly contribute to competitiveness, as well as in understanding differing patterns of digital development among agritourism farms. Based on these considerations, this study aims to examine the impact of digital marketing strategy on the competitiveness of agritourism farms and to contribute to addressing the existing research gap through empirical analysis conducted within the domestic context.

Literature Review

In contemporary academic literature, agritourism is defined as a specific form of rural tourism that integrates agricultural production with tourism, hospitality, and experiential services, relying on local resources, tradition, and the authenticity of rural areas (Phillip et al., 2010; Lane & Kastenholtz, 2015; Popescu et al., 2025). Agritourism is increasingly recognized as a form of rural tourism that plays a key role in the sustainable development of rural areas, as it contributes to the diversification of local income sources, strengthens economic performance, and enhances the resilience of rural communities to socio-economic challenges (Davidović et al., 2025; Turtureanu et al., 2025). In countries in transition, including the Republic of Serbia, agritourism is increasingly viewed as an instrument for the revitalization of rural communities under conditions of depopulation, population ageing, and limited employment opportunities (Dašić et al., 2020).

The contemporary tourism market is characterized by a high degree of digitalization, whereby potential guests intensively use digital information sources, social media, online platforms, and user-generated reviews prior to making travel decisions. In such an environment, the competitiveness of agritourism farms increasingly depends on their ability to position themselves effectively in the digital space and to build visibility, trust, and long-term market relationships through digital channels (Sima, & Gheorghe, 2019; Rodrigues et al., 2023; Turtureanu et al., 2025).

In the literature, the competitiveness of agritourism farms is conceptualized as a multidimensional construct encompassing market visibility and reach, operational performance indicators such as capacity utilization and business profitability, as well as relational dimensions that include guest loyalty and service differentiation. Research indicates that small rural enterprises are particularly vulnerable to fluctuations in demand and reputation due to their limited financial, human, and marketing resources (Hefny, 2023; Dumitru & Cosma, 2023; Xia et al., 2024). In this context, improving market access and professionalizing marketing activities are identified as key prerequisites for the long-term competitiveness of rural and agritourism entities (Dašić et al., 2020; Zhang et al., 2025).

Within contemporary theoretical approaches, digital marketing is not viewed merely as a promotional activity, but rather as a strategic process that includes the management of digital channels, distribution systems, online reputation, guest communication, and the integration of various digital activities into a coherent business logic (Uong & Ngoc, 2025; Zaman et al., 2025; Christou et al., 2025). Studies in tourism and agritourism emphasize that the competitive effects of digital marketing depend on the quality and coordination of digital activities rather than on their mere presence (Afren, 2024; Kanellos et al., 2024; Vrdoljak Raguž et al., 2025).

The contemporary literature further suggests that digital marketing in tourism cannot be reduced to promotional actions, but represents a strategic process of managing multiple digital channels, consumer interaction, and the reputation of destinations and tourism entities. This approach involves the integration of social media, mobile technologies, and contextual information into a unified marketing logic (Buhalis & Foerste, 2013; Sigala, 2018), whereby digital transformation becomes a key determinant of competitiveness in modern tourism (UNWTO, 2021; OECD, 2020; Kamalaveni et al., 2021). In rural and agritourism contexts, where small-scale operators with limited resources dominate, digital channels play a particularly important role in increasing visibility, building trust, and expanding market reach (Lane & Kastenholtz, 2015; Pesonen & Tuohino, 2017).

Digital marketing, through high-quality website presence, active use of social media, and effective management of online reviews, has a statistically significant impact on trust building, user satisfaction, and customer loyalty in tourism services (Ostojić et al., 2025). In this way, digital strategies influence not only communication-related aspects of business operations but also generate broader and more sustainable effects on the competitive performance of tourism entities. Studies indicate that social media activities significantly affect tourists' attitudes, visit intentions, and repeat visitation, which is particularly important for rural destinations and agritourism farms with limited promotional budgets (Chin & Wong, 2022; Cheng & Jiang, 2025).

Online reputation management is simultaneously identified as a critical dimension of competitiveness, as reviews, ratings, and interactions with users reduce information asymmetries and perceived purchase risk, thereby directly influencing trust and guest loyalty (Rodrigues et al., 2023; Afren, 2024). Presence on online booking platforms is

associated with increased market accessibility and easier conversion of demand into actual reservations, although the literature suggests that the effects of such platforms may be moderate and context-dependent, influenced by business models, commission structures, and the seasonality of tourism activity (Mihailović & Popović, 2021; Kanellos et al., 2024; Milačić, 2024; Mendieta-Aragón, Rodríguez-Fernández & Navío-Marco, 2025). Direct digital communication with guests, through timely and personalized responses, is theoretically linked to relationship marketing and customer relationship management concepts, with empirical evidence confirming its positive impact on loyalty and long-term market relationships (Cheng & Jiang, 2025; Afren, 2024).

A particularly relevant theoretical layer in the context of Serbia and the broader region relates to the digital competencies and digital literacy of agritourism farm operators. Research indicates that the level of digital knowledge and readiness to adopt digital technologies represent key determinants of the successful implementation of digital marketing in rural tourism, directly influencing the quality of digital marketing strategies and overall business competitiveness (Paraušić et al., 2025).

Based on these theoretical insights, it can be expected that a higher level of digital marketing strategy development contributes to strengthening the competitiveness of agritourism farms through increased market visibility, trust, operational efficiency, and service differentiation. This conceptual framework is consistent with contemporary research that views agritourism as a sustainable business model with significant development potential, alongside a growing need for strategic and integrated digital positioning within the modern market environment (Nguyen et al., 2025; Horvat et al., 2025; Turtureanu et al., 2025). Hossain, Abdul Hamid, and Hanafiah (2024) emphasize that tourist destinations with higher competitive performance achieve superior overall results in moderately developed countries, implying that competitiveness in tourism represents a multidimensional construct encompassing economic, operational, and market dimensions.

Materials and methods

Rural agritourism farms represent an important instrument for income diversification and rural development. However, in practice, they often face limited market visibility and insufficient competitiveness. In the context of the increasingly digitalized tourism market, digital marketing strategy has become a key factor for the effective market positioning of agritourism offerings. Nevertheless, in Serbia and the wider region there remains a lack of empirical studies that systematically examine the manner and intensity of the impact of digital marketing strategy on the competitiveness of rural agritourism farms, assessed through their market and economic performance.

The subject of this study is the impact of digital marketing strategy on the competitiveness of rural agritourism farms, while the overall research objective is to examine the role and importance of digital marketing strategy in enhancing their competitiveness. In line with this objective, the research focuses on determining the level of implementation

of key elements of the digital marketing strategy and analyzing their relationship with competitiveness indicators. In addition, the study aims to identify elements with a statistically significant impact on competitiveness and to segment agritourism farms according to their level of digital development and business performance.

Based on available statistical data, the population of rural agritourism farms in the Republic of Serbia is operationalized through registered rural tourism households that provide tourism services in rural areas. According to data from the central tourism information system of the Republic of Serbia (eTurista), approximately 700 rural tourism households are registered nationwide. This approach is methodologically justified and consistent with previous research that considers rural tourism and rural tourism households as a relevant segment of the rural economy and agricultural diversification in Serbia (Dašić et al., 2020).

The research was conducted between April and September 2025. The sample consists of 123 rural agritourism farms in the Republic of Serbia. To ensure regional representativeness, stratification by regions was applied: Vojvodina Autonomous Province (39 farms), Šumadija and Western Serbia (47 farms), and Southern and Eastern Serbia (37 farms). The surveyed entities are family-owned agritourism farms that, in addition to primary agricultural production, generate additional income through tourism services. These services include rural accommodation, traditional gastronomy, and the organization of authentic rural experiences. Their activities are positioned at the intersection of agriculture and tourism, with agritourism serving as an important instrument for business diversification and the enhancement of economic sustainability in rural areas. The respondents were owners, co-owners, or managers who are directly involved in business and marketing decision-making processes. The largest share of respondents belongs to the 36-50 age group (52%), while 23% are younger than 35 and 25% are older than 50. In terms of education, 61% of respondents have completed higher or university education, while 39% have secondary education. From the perspective of professional experience, 68% of respondents have more than five years of experience in agritourism, indicating that the findings are based on assessments provided by decision-makers with substantial practical experience.

The variables of digital marketing strategy in this study encompass key elements of the digital presence of agritourism farms that influence their visibility, communication with the market, and the effectiveness of marketing activities. The quality of digital presence is defined as the level of professionalism and functionality of the website or the overall digital presentation of the farm, as previous studies confirm that digital channels represent the foundation of visibility and image formation of rural tourism offerings (Rodrigues et al., 2023; Afren, 2024). Social media activity is understood as the planned and continuous use of social platforms for promotion, information dissemination, and communication with guests, with empirical findings indicating its direct impact on consumer behavior and the sales of rural tourism products (Cheng & Jiang, 2025; Afren, 2024). Presence on online booking platforms is included as a variable due to the importance of digital intermediaries in facilitating market access and increasing the availability of rural

tourism offerings, particularly in conditions of limited traditional distribution channels (Mihailović & Popović, 2021). Online reputation management is defined through the monitoring, analysis, and response to guest reviews and ratings, as research confirms a strong relationship between online image, trust, and intention to visit rural destinations (Rodrigues et al., 2023). Direct digital communication with guests is considered an element of personalization and customer relationship management, while the level of digital literacy and skills of farm operators represents a key prerequisite for the effective implementation of these activities in rural tourism (Paraušić et al., 2025). Finally, the integration of digital activities refers to the degree of alignment and interconnection among digital channels within a unified marketing strategy, which is recognized as a prerequisite for effective digital presence and long-term business effects in tourism (Afren, 2024; Rosić & Getman 2025; Mihailović & Popović, 2021). The digital marketing strategy variables were measured using a multi-item scale adapted from previously validated instruments in the tourism and rural marketing literature. The scale dimensions and item formulation were contextually adjusted to reflect the specific characteristics of small, family-owned agritourism farms in Serbia. All items were measured using a five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”).

The competitiveness variables of agritourism farms comprise several interrelated dimensions that together reflect market, operational, and economic performance. Market recognition is defined as the degree to which an agritourism farm is known and recognizable to potential guests, which the destination competitiveness literature identifies as a basis for differentiation and successful market positioning (Hefny, 2023; Xia et al., 2024). Market reach refers to the ability of the farm to attract guests from a wider geographical area, with empirical research indicating that this aspect of competitiveness is strongly associated with market accessibility and the development of modern distribution channels (Dumitru & Cosma, 2023; Zhang et al., 2025). Accommodation capacity utilization is considered an operational indicator of competitiveness, as it reflects the effectiveness of converting market visibility and interest into realized tourism demand (Hossain et al., 2024). Business profitability is defined as the ability of an agritourism farm to generate positive financial outcomes from agritourism activities relative to invested resources and cost structures, with the relevant literature recognizing profitability as a key economic indicator of competitiveness and long-term sustainability in rural tourism (Hossain et al., 2024; Zhang et al., 2025). Guest loyalty includes repeat visits, recommendations, and positive word-of-mouth and is identified in destination competitiveness studies as one of the most important indicators of long-term sustainability and service quality (Xia et al., 2024). Offer differentiation refers to the degree of uniqueness of tourism products and experiences compared to competitors, with authenticity, local identity, and specific local resources emphasized as significant sources of competitive advantage in rural tourism and agritourism (Dumitru & Cosma, 2023; Nguyen et al., 2025). The competitiveness of agritourism farms was measured using a multi-item scale adapted from established studies on destination competitiveness and rural tourism performance. The scale dimensions and item wording were adjusted to reflect the specific characteristics of agritourism

farms, capturing market, operational, and economic performance aspects. All items were measured on a five-point Likert scale, and the reliability analysis confirmed satisfactory internal consistency of the adapted scale.

In this study, two main hypotheses are formulated, derived from the theoretical framework of digital marketing and the competitiveness of agritourism farms, as well as from the objectives of the empirical analysis.

The first main hypothesis (H1) assumes that elements of digital marketing strategy have a statistically significant impact on the competitiveness of agritourism farms. This hypothesis is operationalized through the following sub-hypotheses:

H1.1 Quality of digital (web) presence has a statistically significant impact on the competitiveness of agritourism farms.

H1.2 Social media activity (DM2) has a statistically significant impact on the competitiveness of agritourism farms.

H1.3 Presence on online booking platforms (DM3) has a statistically significant impact on the competitiveness of agritourism farms.

H1.4 Online reputation management (DM4) has a statistically significant impact on the competitiveness of agritourism farms.

H1.5 Direct digital communication with guests (DM5) has a statistically significant impact on the competitiveness of agritourism farms.

H1.6 Integration of digital marketing strategy (DM6) has a statistically significant impact on the competitiveness of agritourism farms.

The second main hypothesis (H2) assumes that agritourism farms can be classified into distinct and clearly differentiated clusters based on the level of implementation of digital marketing strategy elements. This hypothesis is further elaborated through the following sub-hypotheses:

H2.1 There are statistically significant differences among the identified clusters of agritourism farms in the level of implementation of digital marketing strategy elements.

H2.2 There are statistically significant differences among the identified clusters of agritourism farms in the level of competitiveness.

The collected data were processed and analyzed using the statistical software package IBM SPSS Statistics 26. Within the empirical analysis, descriptive statistics were applied to examine the basic characteristics of the sample and variables, correlation analysis was used to assess relationships between digital marketing strategy elements and competitiveness variables, multiple regression analysis was employed to determine the impact of digital marketing activities on the competitiveness of agritourism farms, and cluster analysis was conducted to identify homogeneous groups of farms based on the level of implementation of digital marketing strategy elements.

Results

The results of the descriptive statistical analysis and the assessment of the reliability of the measurement scales are presented in Table 1. The analysis provides an overview of the level of implementation of digital marketing strategy elements and the competitiveness of agritourism farms, as well as an examination of the internal consistency of the applied measurement instruments based on a sample of 123 respondents. All variables were measured using a five-point Likert scale ranging from 1 to 5.

Table 1. Descriptive statistics of digital marketing strategy variables (n=123)

Variable	Min	Max	Mean	Standard Deviation	Cronbach's Alpha
DM1 - Quality of digital (web) presence	1	5	2.90	1.094	0.80
DM2 - Social media activity	1	5	3.30	0.984	0.78
DM3 - Presence on online booking platforms	1	5	3.10	1.176	0.81
DM4 - Online reputation management	1	5	3.02	0.993	0.79
DM5 - Direct digital communication with guests	1	5	3.41	0.912	0.77
DM6 - Integration of digital activities	1	5	2.79	1.094	0.83

Source: Author's research

Table 1 presents the descriptive statistics and reliability of the digital marketing strategy scale. The mean values of the variables range from 2.79 to 3.41, indicating a moderate level of implementation of digital marketing activities among agritourism farms. The highest mean values are observed for direct digital communication with guests ($M = 3.41$; $SD=0.912$) and social media activity ($M=3.30$; $SD=0.984$), whereas the lowest mean value is recorded for the integration of digital activities ($M=2.79$; $SD=1.018$). This finding suggests an insufficient level of strategic alignment and coordination among different digital channels. The Cronbach's alpha coefficients for the individual dimensions range from 0.77 to 0.83, while the overall scale reliability is $\alpha=0.82$, confirming good internal consistency and the suitability of the scale for further statistical analysis.

Table 2. Descriptive statistics of farm competitiveness variables (n=123)

Variable	Min	Max	Mean	Standard Deviation	Cronbach's Alpha
K1 - Market awareness	1	5	3.02	0.921	0.83
K2 - Market coverage	1	5	2.88	1.004	0.84
K3 - Accommodation capacity utilization	1	5	3.12	0.843	0.82
K4 - Business profitability	1	5	2.81	0.936	0.85
K5 - Guest loyalty	1	5	3.23	0.824	0.81
K6 - Offering differentiation	1	5	3.38	0.712	0.79

Source: Author's research

The mean values of the variables range from 2.81 to 3.38, indicating a moderate level of competitiveness among the observed farms. The highest mean scores are recorded for offering differentiation ($M=3.38$; $SD=0.712$) and guest loyalty ($M=3.23$; $SD=0.824$), whereas market coverage ($M=2.88$; $SD=1.004$) and business profitability ($M=2.81$; $SD=0.936$) exhibit the lowest mean values. The overall Cronbach's alpha coefficient of the scale equals $\alpha=0.85$, indicating high reliability, while the alpha values obtained in the case of deleting individual variables (0.79-0.85) confirm that none of the indicators undermine the internal consistency of the scale. These results confirm the adequacy and stability of the variables employed for use in subsequent statistical analyses.

Table 3 presents the results of Pearson's correlation analysis between the elements of digital marketing strategy and individual dimensions of the competitiveness of agritourism farms, allowing for an assessment of the direction and strength of the relationships among the analyzed variables.

Table 3. Pearson correlation matrix between digital marketing strategy elements and competitiveness dimensions of agritourism farms

Variable	K1	K2	K3	K4	K5	K6
DM1	0.340**	0.410**	0.290**	0.260**	0.220*	0.280**
DM2	0.480**	0.550**	0.370**	0.330**	0.310**	0.390**
DM3	0.390**	0.460**	0.440**	0.420**	0.280**	0.300**
DM4	0.520**	0.490**	0.410**	0.380**	0.470**	0.360**
DM5	0.360**	0.400**	0.450**	0.340**	0.510**	0.330**
DM6	0.430**	0.470**	0.390**	0.410**	0.350**	0.460**

** . The correlation is significant at the 0,01 level (2-tailed).

Source: Author's research

The results of the correlation analysis indicate statistically significant positive relationships of moderate to relatively strong intensity between the elements of digital marketing strategy and the indicators of competitiveness of agritourism farms. The strongest relationship was observed between social media activity and market coverage ($r=0.550$; $p<0.01$), confirming that an active presence on social media platforms represents a key mechanism for expanding market reach and accessing new geographical and market segments. Furthermore, online reputation management demonstrates a strong association with market awareness ($r=0.520$; $p<0.01$) and guest loyalty ($r=0.470$; $p<0.01$), highlighting the importance of reviews, ratings, and continuous interaction with users in building trust and maintaining long term relationships with guests.

Relatively strong correlations were also identified between direct digital communication with guests and guest loyalty ($r=0.510$; $p<0.01$), as well as between presence on online booking platforms and accommodation capacity utilization ($r=0.440$; $p<0.01$). These findings confirm the role of digital channels in facilitating the reservation process and contributing to more stable tourism demand. In addition, the integration of the digital marketing strategy shows statistically significant associations with multiple dimensions of competitiveness, particularly market coverage ($r=0.470$; $p<0.01$) and

offering differentiation ($r=0.460$; $p<0.01$), indicating that coordinated and strategically aligned use of digital channels contributes to strengthening the market position of agritourism farms.

On the other hand, weaker but still statistically significant correlations were observed between the quality of basic web presence and certain competitiveness indicators, especially guest loyalty ($r=0.220$; $p<0.05$) and business profitability ($r=0.260$; $p<0.01$). These results suggest that the mere existence of a website has a limited direct impact on competitiveness if it is not accompanied by active content management, systematic communication, and consistent reputation management. Overall, the observed pattern of correlations supports contemporary theoretical perspectives in digital marketing, according to which competitive effects in tourism are achieved primarily through the integrated and interactive application of digital tools, whereas isolated use of individual digital channels yields limited outcomes, particularly in the context of rural and agritourism farms.

Given that the correlation analysis revealed statistically significant relationships between the elements of digital marketing strategy and the competitiveness indicators, a multiple regression analysis was subsequently conducted in order to determine the individual contribution of each digital marketing strategy element to the overall competitiveness of rural agritourism farms. Results of the regression analysis are presented in Table 4.

Table 4. Results of the multiple regression analysis: Impact of digital marketing strategy elements on the competitiveness of agritourism farms ($n=123$)

Independent variable	Standardized β	t	p	Partial R^2 (sr^2)	Explained variance (%)
DM2	0.310	3.840	<0.001	0.113	11.3
DM4	0.280	3.420	0.001	0.092	9.2
DM5	0.260	3.180	0.002	0.080	8.0
DM6	0.220	2.710	0.008	0.060	6.0

Model summary: $R^2=0.49$, Adjusted $R^2=0.46$, $F=27.3$, $p<0.001$

Note: The dependent variable is a composite competitiveness index. Only statistically significant predictors ($p<0.05$) are presented. Partial R^2 (sr^2) indicates the unique contribution of each predictor to the explained variance.

Source: Author's research

The results of the multiple regression analysis indicate that the overall model is statistically significant ($F=27.3$; $p<0.001$), with the elements of the digital marketing strategy explaining 49% of the total variance in the competitiveness of agritourism farms ($R^2=0.49$). This level of explained variance is considered high in tourism and digital marketing research, thereby confirming the general research assumption regarding the substantial role of digital marketing strategies in enhancing the competitiveness of agritourism farms. After adjusting for the number of predictors, the adjusted coefficient of determination (Adjusted $R^2=0.46$) further confirms the stability and robustness of the model.

Out of the six analyzed elements of the digital marketing strategy, four variables exhibited a statistically significant and positive independent effect on the competitiveness of agritourism farms, thereby confirming the corresponding sub-hypotheses within the main hypothesis H1. The strongest individual predictor is social media activity (DM2), with a standardized coefficient of $\beta=0.31$ ($p<0.001$), which independently explains 11.3% of the variance in competitiveness. Accordingly, hypothesis H1.2, which assumed that social media activity has a statistically significant impact on the competitiveness of agritourism farms, is empirically confirmed.

Online reputation management (DM4) also demonstrates a strong and statistically significant effect ($\beta=0.28$; $p=0.001$), with a unique contribution of 9.2% to the explained variance, thus confirming hypothesis H1.4. This finding highlights the crucial role of reviews, ratings, and digital interaction with users in building trust and customer loyalty, which directly affects overall competitiveness.

Direct digital communication with guests (DM5) shows a statistically significant and stable effect ($\beta=0.26$; $p=0.002$), contributing an additional 8.0% to the explained variance, thereby confirming hypothesis H1.5. These results indicate that personalized, timely, and continuous digital communication represents an important mechanism for guest retention and the strengthening of long-term market relationships.

The integration of the digital marketing strategy (DM6) exhibits a somewhat weaker, yet still statistically significant effect ($\beta=0.22$; $p=0.008$), with a unique contribution of 6.0% to the explained variance, confirming hypothesis H1.6. This finding empirically supports the assumption that a coordinated and strategically aligned use of digital channels further enhances the overall market and business performance of agritourism farms.

In contrast, the quality of basic digital (website) presence (DM1) and presence on online booking platforms (DM3) did not demonstrate a statistically significant independent effect on competitiveness within the regression model ($p>0.05$). Consequently, hypotheses H1.1 and H1.3 were not supported. These results suggest that passive forms of digital presence, if not accompanied by active content management, reputation management, and interactive communication, have a limited impact on competitiveness.

Based on the obtained results, it can be concluded that the main hypothesis H1 is partially supported, with sub-hypotheses H1.2, H1.4, H1.5, and H1.6 confirmed, while sub-hypotheses H1.1 and H1.3 are not supported. Overall, the findings clearly indicate that the competitive effects of digital marketing in agritourism primarily arise from active, interactive, and strategically integrated digital activities, whereas isolated and passive use of individual digital tools provides a limited contribution to business performance improvement.

Cluster Analysis of Digital Marketing Strategy and Competitiveness of Agritourism Farms

Cluster analysis was applied with the aim of identifying homogeneous groups of agritourism farms based on the level of implementation of digital marketing strategy elements. Six dimensions of the digital marketing strategy were used as input variables: quality of digital (web) presence (DM1), activity on social media (DM2), presence on online booking platforms (DM3), online reputation management (DM4), direct digital communication with guests (DM5), and the integration of the digital marketing strategy (DM6).

In the first phase, hierarchical cluster analysis was conducted using Ward's method and squared Euclidean distance in order to determine the optimal number of clusters. The analysis of the dendrogram and the agglomeration schedule indicated a three-cluster solution. Based on this result, a K-means cluster analysis with a predefined number of three clusters was applied in the second phase. Convergence of the solution was achieved after four iterations, indicating the stability and reliability of the clustering solution. These results confirm that, based on the elements of the digital marketing strategy, clearly differentiated types of agritourism farms can be identified.

The final cluster centers according to the elements of the digital marketing strategy are presented in Table 5.

Table 5. Final cluster centers based on digital marketing strategy elements

Digital marketing strategy elements	Cluster 1 (n = 41)	Cluster 2 (n = 46)	Cluster 3 (n = 36)
DM1	2.18	4.21	3.12
DM2	2.34	4.67	3.45
DM3	2.51	4.54	3.66
DM4	2.29	4.72	3.58
DM5	2.41	4.81	3.69
DM6	2.02	4.60	3.2

Source: Author's research

The results presented in Table 5 indicate clearly differentiated patterns in the application of digital marketing strategies among agritourism farms. The first cluster is characterized by consistently low values across all analyzed dimensions, suggesting farms with weak, fragmented, and predominantly passive digital presence. The second cluster records the highest mean values across all dimensions, particularly in social media activity ($M=4.67$), online reputation management ($M=4.72$), and direct digital communication with guests ($M=4.81$). This cluster represents the most digitally developed and strategically oriented agritourism farms. The third cluster exhibits moderate values and includes farms that are currently in a phase of gradual digital transformation.

A one-way analysis of variance (ANOVA) was conducted to examine differences in competitiveness dimensions among the identified clusters, and the results are presented in Table 6.

Table 6. One-way ANOVA results - differences in competitiveness across clusters

Competitiveness variable	F value	Sig.
K1	214.36	< 0.001
K2	198.42	< 0.001
K3	176.58	< 0.001
K4	163.21	< 0.001
K5	221.74	< 0.001
K6	189.63	< 0.001

Source: Author's research

The average values of the composite competitiveness index across the identified clusters are presented in Table 7, providing additional comparative insight into the overall competitive performance of agritourism farms in relation to the level of development of their digital marketing strategies.

Table 7. Average values of the competitiveness index by cluster

Competitiveness	Cluster 1	Cluster 2	Cluster 3
Competitiveness index	2.41	4.62	3.57

Source: Author's research

The results reveal a clearly defined hierarchy among the clusters. Cluster 2, which comprises agritourism farms with the most advanced and integrated digital marketing strategies, achieves by far the highest average competitiveness index value ($M=4.62$), indicating superior market, operational, and relational performance. In contrast, Cluster 1, characterized by a low level of digital marketing adoption, records the lowest competitiveness index value ($M=2.41$), reflecting limited market visibility and weaker overall business performance. Cluster 3 occupies an intermediate position ($M=3.57$), which is consistent with its moderate level of digital development and its transitional stage of gradual digital transformation. These findings further corroborate the results of the ANOVA and cluster analyses, clearly demonstrating that a higher degree of strategic and integrated application of digital marketing strategies is associated with significantly higher levels of overall competitiveness among agritourism farms.

The results of the hierarchical and K-means cluster analyses enabled the identification of three clearly differentiated clusters of agritourism farms based on the level of development and integration of their digital marketing strategies, thereby confirming the main research hypothesis H2. An examination of the final cluster centroids revealed pronounced and systematic differences among the clusters across all observed elements of the digital marketing strategy, including social media activity, online reputation management, direct digital communication with guests, and the degree of integration of digital activities, thus fully confirming hypothesis H2.1. The results of the one-way ANOVA indicated the existence of statistically significant differences among the identified clusters across all analyzed dimensions of competitiveness ($p<0.001$), including market awareness, market coverage, accommodation capacity utilization, business profitability, guest loyalty, and offering differentiation. These findings provide full empirical support for hypothesis H2.2, with a high level of statistical reliability.

Based on the conducted cluster analysis, it can be concluded that digital marketing strategy represents a key factor of differentiation among agritourism farms. Farms characterized by a highly developed and strategically integrated digital marketing strategy achieve significantly higher levels of competitiveness across all analyzed dimensions, whereas farms with a low level of digital adoption lag behind in market, operational, and relational performance. Farms positioned in an intermediate phase of digital transformation exhibit moderate competitive outcomes, further confirming the existence of a hierarchical and gradual relationship between the level of digital development and overall competitiveness.

The obtained findings empirically confirm that competitive advantages in contemporary agritourism do not stem from fragmented or isolated use of digital tools, but rather from their systematic, coordinated, and strategically oriented application. This underscores the central role of digital marketing as a key mechanism for enhancing competitiveness and ensuring the long-term sustainability of agritourism farms within the contemporary market environment.

Discussions

The results of the present study confirm theoretical assumptions regarding the growing role of digital marketing as a strategic determinant of competitiveness among agritourism farms operating in a highly digitalized tourism environment. In line with contemporary literature, digital marketing is not understood as a set of isolated promotional activities, but rather as an integrated strategic process encompassing the management of digital channels, online reputation, guest communication, and the coordinated use of multiple digital tools aimed at achieving market and business performance (Buhalis & Foerste, 2013; Sigala, 2018; UNWTO, 2021). The empirical findings obtained in this study further demonstrate that such an integrated approach is particularly relevant in the context of agritourism, which is predominantly characterized by small-scale operators with limited financial, human, and marketing resources.

The analysis of individual elements of the digital marketing strategy indicates that active and interactive digital channels exert a substantially stronger impact on competitiveness than passive forms of digital presence. In particular, social media activity, online reputation management, direct digital communication with guests, and the degree of integration of digital activities emerge as the most influential determinants of competitive performance, thereby confirming the relevant research hypotheses. These findings are consistent with prior studies emphasizing that social media engagement and electronic word of mouth (eWOM) play a crucial role in shaping trust, visit intention, and guest loyalty, especially within rural and agritourism contexts (Chin & Wong, 2022; Cheng & Jiang, 2025; Rodrigues et al., 2023). At the same time, the relatively weaker independent effects of basic website presence and participation on online booking platforms corroborate earlier evidence suggesting that digital tools, when applied without strategic integration, yield limited competitive advantages (Kanellos et al., 2024; Mendieta-Aragón et al., 2025).

The results of the cluster analysis further reinforce the theoretical framework by revealing the existence of clearly differentiated types of agritourism farms based on the level of development and integration of their digital marketing strategies. Farms characterized by highly developed and strategically integrated digital marketing practices achieve significantly higher levels of competitiveness across all analyzed dimensions, including market awareness, guest loyalty, and business profitability. These findings align with contemporary research highlighting that competitiveness in tourism represents a multidimensional construct, and that destinations and tourism enterprises exhibiting a higher degree of strategic coherence tend to achieve superior market and economic outcomes (Hossain et al., 2024; Xia et al., 2024).

Finally, the findings also support theoretical perspectives emphasizing the importance of digital competencies in rural tourism, as the effectiveness of digital marketing largely depends on the ability of farm operators to strategically plan, implement, and integrate digital activities. This confirms that digital marketing does not operate in isolation, but rather as an integral component of broader processes of digital transformation and professionalization of agritourism offerings, particularly in transition economies such as Serbia (Paraušić et al., 2025). Overall, the results contribute to the existing body of knowledge by providing robust empirical evidence that digital marketing strategy represents a key mechanism for enhancing both the competitiveness and long-term sustainability of agritourism farms under contemporary market conditions.

Conclusions

This study confirms the central role of digital marketing strategy in enhancing the competitiveness of agritourism farms within the contemporary and highly digitalized tourism environment. The empirical findings clearly demonstrate that the competitive effects of digital marketing do not arise from mere digital presence, but from the strategic, integrated and interactive application of digital channels. Elements involving active communication and relationship management with guests, such as social media activity, online reputation management, direct digital communication and the integration of digital activities, emerged as the most influential determinants of competitiveness. In contrast, passive forms of digital presence showed a limited independent contribution. These results provide strong empirical support for theoretical perspectives that conceptualize digital marketing as a strategic resource and a key mechanism for strengthening the market position of agritourism enterprises.

Nevertheless, the study is subject to several limitations. First, the data were collected from a relatively limited sample of agritourism farms and within a cross sectional research design, which restricts the generalizability of the findings and prevents an assessment of long term effects of digital strategies. Second, the research relied on self reported evaluations provided by respondents, which may involve a certain degree of perceptual bias. In addition, the analysis focused on a selected set of digital marketing strategy elements, while other aspects of digital transformation, such as the use of advanced analytics, automation or artificial intelligence in tourism, were not included in the scope of this study.

Despite these limitations, the findings offer significant theoretical and practical implications. From a theoretical perspective, the study contributes to the existing literature by reinforcing the multidimensional nature of competitiveness and by emphasizing the importance of strategic integration of digital activities in the context of agritourism. From a practical standpoint, the results provide valuable guidance for agritourism farm operators, public policymakers and rural development support institutions, highlighting the need for investments in digital competencies and the development of integrated digital marketing strategies. Future research should focus on longitudinal analyses, comparative studies across different regions and types of rural tourism, as well as on examining advanced digital tools and their role in enhancing the sustainability and competitiveness of agritourism farms.

Conflict of interests

The authors declare no conflict of interest.

References

1. Afren, S. (2024). The role of digital marketing promoting tourism business. A study of use of the social media in prompting travel. *World Journal of Advanced Research and Reviews*, 21(01), 272-287. <https://doi.org/10.30574/wjarr.2024.21.1.2668>
2. Buhalis, D., Foerste, MK. (2013). SoCoMo Marketing for Travel and Tourism. In: Xiang, Z., Tussyadiah, I. (eds) Information and Communication Technologies in Tourism 2014. Springer, Cham. https://doi.org/10.1007/978-3-319-03973-2_13
3. Cheng, S., & Jiang, Y. (2025). Effects of Social Media Marketing on Rural Tourism Product Sales: Evidence from Controlled Experiments. *Frontiers in Sustainable Food Systems*, 9, 1714233. <https://doi.org/10.3389/fsufs.2025.1714233>
4. Chin, C. H., & Wong, P. M. W. (2022). Exploring the impact of social media marketing on tourism destination marketing and revisit intention: The extension of stimulus-organism-response (SOR) model. *Studies of Applied Economics*, 40(2). <https://doi.org/10.25115/eea.v40i2.6848>
5. Christou, E., Giannopoulos, A., & Simeli, I. (2025). The Evolution of Digital Tourism Marketing: From Hashtags to AI-Immersive Journeys in the Metaverse Era. *Sustainability*, 17(13), 6016.
6. Dašić, D., Živković, D., & Vujić, T. (2020). Rural tourism in development function of rural areas in Serbia. *Economics of Agriculture*, 67(3), 719-733. <https://doi.org/10.5937/ekoPolj2003719D>
7. Davidović, J., Pantović, D., & Mićović, A. (2025). Agritourism as a catalyst for sustainable rural development: A literature review. *The European Journal of Applied Economics*, 22(2), 99-117. <https://doi.org/10.5937/ejae22-57241>
8. Dumitru, I. M., & Cosma, S. A. (2023). A measurement of rural tourism destinations' competitiveness. *Studia Universitatis Babeş-Bolyai Negotia*, 68(1), 81-97.

9. Hefny, L. (2023). An overview of literature on destination competitiveness: A theoretical analysis of the travel and tourism competitiveness index. *Pharos International Journal of Tourism and Hospitality*, 2(2), 45-60.
10. Horvat, D., Pjanić, M., Ivanišević, R., & Gluščević, L. . (2025). The impact of robotic process automation in financial institutions. *BizInfo Blace*, 16(2), 67-74. <https://doi.org/10.71159/bizinfo250016H>
11. Hossain, M. K., Abdul Hamid, A. B., & Hanafiah, M. H. (2024). Tourism destination competitiveness and tourism performance in middle income countries/ Md. Kaium Hossain, Abu Bakar Abdul Hamid and Mohd Hafiz Hanafiah. *Journal of Tourism, Hospitality and Culinary Arts*, 16(1), 781-801. <https://ir.uitm.edu.my/id/eprint/97888>
12. Kamalaveni, M. S., Suriya, A., Sakthivel, P. S., & Vignesh, S. (2021). Digital transformation in tourism. *International Journal of Advance and Innovative Research*, 8(4), 33-39.
13. Kanellos, N., Karountzos, P., Giannakopoulos, N. T., Terzi, M. C., & Sakas, D. P. (2024). Digital Marketing Strategies and Profitability in the Agri-Food Industry: Resource Efficiency and Value Chains. *Sustainability (2071-1050)*, 16(14). <https://doi.org/10.3390/su16145889>
14. Lane, B., & Kastenholz, E. (2015). Rural tourism: the evolution of practice and research approaches-towards a new generation concept?. *Journal of Sustainable tourism*, 23(8-9), 1133-1156. <https://doi.org/10.1080/09669582.2015.1083997>
15. Mendieta-Aragón, A., Rodríguez-Fernández, L., & Navío-Marco, J. (2025). Tourism usage of digital collaborative economy platforms in Europe: Situation, behaviours, and implications for the digital policies. *Telecommunications Policy*, 49(1), 102874. <https://doi.org/10.1016/j.telpol.2024.102874>
16. Mihailović, B., & Popović, V. (2021). *Digital marketing of agri-food products in support of rural tourism during the COVID pandemic*. In: *Tourism challenges amid COVID-19 (TISC 2021)*. University of Kragujevac, Faculty of hotel management and tourism, Vrnjacka Banja, pp. 111-126. ISBN 978-86-89949-53-7 <http://repository.iep.bg.ac.rs/id/eprint/568>
17. Milačić, D. (2024). Strategijski menadžment kao instrument razvoja održivog turizma u Srbiji. *Održivi razvoj*, 6(2), 7-22. <https://doi.org/10.5937/OdrRaz2402007M>
18. Nguyen, A. T., Vu, T. T. T., Nguyen, T. P. N., Phuong, N. T., Le, N. A., Do Thi, T., & Le Huyen, T. (2025). Sustainable Agritourism Monitoring: An Expert Delphi Study on Provincial-Level Indicators in Vietnam. *Environmental and Sustainability Indicators*, 100966. <https://doi.org/10.1016/j.indic.2025.100966>
19. Organisation for Economic Co-operation and Development (OECD). (2020). *Tourism policy responses to digitalisation*. OECD Publishing. <https://doi.org/10.1787/646db84c-en>

20. Ostojić, B., Bajramović, D., & Cvjetković, M. (2025). The impact of digital marketing on customer satisfaction in dental tourism in Serbia. *Hotel and Tourism Management*, 13(1). <https://doi.org/10.5937/menhottur2500008O>
21. Paraušić, V., Pantović, D., Mihailović, B., & Radosavljević, K. (2025). *Digital literacy of farmers in the context of rural tourism services provision in Serbia*. *Hotel and Tourism Management*, 13(1), 99-117. <https://doi.org/10.5937/menhottur2500002P>
22. Pesonen, J. A., & Tuohino, A. (2017). Activity-based market segmentation of rural well-being tourists: Comparing online information search. *Journal of Vacation Marketing*, 23(2), 145-158. <https://doi.org/10.1177/1356766715610163>
23. Phillip, S., Hunter, C., & Blackstock, K. (2010). A typology for defining agritourism. *Tourism management*, 31(6), 754-758. <https://doi.org/10.1016/j.tourman.2009.08.001>
24. Popescu, G. H., Fortea, C., Nica, E., Antohi, V. M., Andrei, J. V., & Szpilko, D. (2025). Investments in the green transition and their impact on economic growth and competitiveness in the European Union. *Oeconomia Copernicana*, 16(4), 1665-1725.
25. Rodrigues, S., Correia, R., Gonçalves, R., Branco, F., & Martins, J. (2023). Digital marketing's impact on rural destinations' image, intention to visit, and destination sustainability. *Sustainability*, 15(3), 2683.
26. Rosić, M., & Getman, V.R. (2025). Menadžerski aspekti timova i grupa. *Finansijski Savetnik*, 30(1), 95-105. <https://fa-journal.com/index.php/fa/article/view/5>
27. Sigala, M. (2018). Implementing social customer relationship management: A process framework and implications in tourism and hospitality. *International Journal of Contemporary Hospitality Management*, 30(7), 2698-2726. <https://doi.org/10.1108/IJCHM-10-2015-0536>
28. Sima, V., & Gheorghe, I. G. (2019). Green Customer Satisfaction. In *Green Business: Concepts, Methodologies, Tools, and Applications* (pp. 153-180). IGI Global Scientific Publishing.
29. Turtureanu, A. G., Crețu, C. M., Pripoaie, R., Marinescu, E. Ș., Sîrbu, C. G., & Talaghir, L. G. (2025). Sustainable Development Through Agritourism and Rural Tourism: Research Trends and Future Perspectives in the Pandemic and Post-Pandemic Period. *Sustainability*, 17(9), 3998. <https://doi.org/10.3390/su17093998>
30. Uong, T., & Ngoc, L. (2025). The Ability to Maintain the Attractiveness of Destinations: Exploring the Role of Digital Marketing. *Advances in Consumer Research*, 2(4).
31. Vrdoljak Raguž, I., Hordov, M., & Rajko, M. (2025). Digital transformation as a function of rural tourism strategic development in the Republic of Croatia. *Ekonomski vjesnik: Review of Contemporary Entrepreneurship, Business, and Economic Issues*, 38(1), 153-168. <https://doi.org/10.51680/ev.38.1.11>

32. World Tourism Organization (UNWTO). (2021). *Digital transformation in tourism*. UNWTO. <https://doi.org/10.18111/9789284422456>
33. Xia, H., Muskat, B., Karl, M., Li, G., & Law, R. (2024). Destination competitiveness research over the past three decades: a computational literature review using topic modelling. *Journal of Travel & Tourism Marketing*, 41(5), 726-742. <https://doi.org/10.1080/10548408.2024.2332278>
34. Zaman, S. U., Tabassum, H., & Alam, S. H. (2025). A Multi-Channel Digital Marketing Approach to Enhance Brand Awareness and Purchase Intentions in Emerging Firms. *Research Journal of Psychology*, 3(1), 756-775. <https://doi.org/10.59075/rjs.v3i1.117>
35. Zhang, C., Xu, K., Zhang, X., Han, D., & He, Y. (2025). An evaluation of the rural tourism industry's competitiveness in the Yangtze River economic belt based on the "Diamond Model" - exemplified by Wenjiang District, Huangpi District, and Jiangning District. *Regional Science and Environmental Economics*, 2(1), 5. <https://doi.org/10.3390/rsee2010005>

GREEN MARKETING AND SUSTAINABLE TOURISM RURAL DEVELOPMENT ON THE EXAMPLE OF MOUNT GOLIJAJ PERCEPTIONS AND ATITUDES OF GENERATION Z

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ABSTRACT

This paper explores the role of green marketing in promoting sustainable rural tourism on Mount Golija, with a particular focus on the perceptions and attitudes of Generation Z. The research was conducted through an online survey on a sample of 256 respondents aged 18 to 32, aiming to examine their level of environmental awareness, values, and behavioral intentions within the context of sustainable rural tourism in protected natural areas. The analysis revealed that environmental awareness and the perception of destination responsibility have a significant positive impact on the intention to visit Golija. At the same time, a noticeable gap was identified between the respondents' declared ecological values and their actual behavior, highlighting the need for a more consistent and transparent approach to communicating sustainable practices in rural tourism destinations. The results suggest that the long-term success of sustainable rural tourism development depends on authentic communication and the active involvement of Generation Z in initiatives that connect local communities, environmental protection, and tourism development.

Introduction

Contemporary tourism trends increasingly emphasize the importance of sustainability and social responsibility in destination development, particularly in rural tourism contexts. In this regard, green marketing has become a key instrument through which

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tourism organizations communicate environmental values, promote sustainable practices, and encourage conscious tourist behavior. Mount Golija, as a UNESCO Biosphere Reserve, represents a unique example of a rural natural area that combines rich biodiversity with the potential for sustainable rural tourism development. However, the success of such a development model depends on the integration of ecological principles with modern marketing and project management approaches.

A special role in this process belongs to Generation Z, a demographic group shaping new patterns of tourist behavior. Their expectations from destinations include authenticity, digital connectivity, and environmental responsibility. Therefore, the research conducted in this study aims to examine the perceptions, attitudes, and willingness of Generation Z members to support and participate in sustainable rural tourism on Mount Golija, as well as to identify the key factors influencing their intention to visit and support environmentally responsible practices.

Literature Review

Sustainable tourism is often viewed as a strategic framework aimed at harmonizing three key pillars, economy, ecology, and society, through careful planning, community participation, and continuous monitoring. The development of rural tourism in Serbia has proven to be a sustainable alternative that encourages local economic growth, supports the revitalization of natural and cultural areas, and reflects the growing interest of tourists in authentic, nature based experiences (Andrei et al., 2015; Radanov & Lešević, 2020; Paraušić et al., 2025; Zdravković & Peković, 2020). While the theoretical foundation of sustainable tourism is well established, its practical implementation continues to face numerous challenges, particularly in rural and ecologically sensitive areas. Recent academic contributions have highlighted ongoing issues related to the selection of sustainability indicators, appropriate measurement tools, and the institutionalization of sustainable practices within tourism systems. The literature indicates that the development of sustainability indicators in tourism remains a priority, although their broader application frequently encounters institutional, methodological, and political barriers (Sima & Gheorghe, 2015; Miller & Torres-Delgado, 2023). According to Crabolu et al. (2024), indicators serve not only as quantitative measures but also as conceptual, instrumental, and structural tools, particularly when they are institutionalized and integrated into destination management processes such as stakeholder dialogue, policy adaptation, and governance restructuring.

The challenge of applying sustainability theory in practice lies in the tendency of destinations to adopt indicators as a pro forma exercise, without their genuine integration into management mechanisms, which often leads to symbolic implementation. In the case of rural destinations such as Golija, the application of sustainability indicators must be carefully adapted to the local context, maintaining a balance between analytical precision and operational feasibility. Punzo et al. (2022) argue that the construction of synthetic indicators integrating social, economic, and environmental dimensions enables a more accurate identification of destination strengths and weaknesses, as well

as the formulation of priority development interventions. A study conducted in the Aragon region developed a set of synthetic indicators for sustainable tourism based on a three dimensional model of environmental, social, and economic components, where individual indicators were identified, defined, and evaluated according to their frequency and relevance in previous studies (Yuedi et al., 2023).

Generation Z, as the first generation to grow up in the digital and information era, demonstrates travel behavior patterns that differ markedly from those of previous cohorts. Their identities are shaped by global social networks, digital connectivity, and heightened environmental awareness, all of which directly influence their tourism preferences. Research indicates that Generation Z places strong emphasis on authenticity, local engagement, and sustainability when choosing travel experiences, particularly in nature based and rural tourism contexts. They tend to favor destinations that promote ecological responsibility through eco friendly accommodation, organic products, and opportunities for community involvement. Empirical evidence from a study involving 615 young tourists confirms that this generation demonstrates significantly higher eco centric values and a stronger commitment to sustainable practices compared to older generations (Seyfi et al., 2025). However, a clear gap persists between declared environmental concern and actual behavior, as cost and comfort continue to play a decisive role in travel decision making (Kubíková & Rudý, 2024). This paradox highlights that strong environmental awareness does not automatically translate into behavioral change, creating space for targeted green marketing strategies that reconcile ecological values with practical considerations.

Further studies emphasize that Generation Z's digital connectivity serves as a key driver of sustainable consumption and tourism behavior. Their destination choices are largely influenced by online content, influencer recommendations, and perceptions of a destination's green image (Nowacki et al., 2023). Ma, Li, and Han (2024) found that subjective norms, perceived ecological value, and environmental awareness have a significant positive impact on Generation Z's attitudes toward low carbon transport and accommodation choices, which in turn shape their behavioral intentions in tourism. Contemporary research confirms that factors such as ecological awareness, social responsibility, and self perception strongly influence their willingness to choose sustainable destinations (Ha & Hang, 2024). Conversely, studies conducted in Mediterranean and coastal destinations indicate that although young tourists are well informed about sustainability, they often behave inconsistently with their stated values, choosing eco friendly options primarily when they are accessible and affordable (Pulido-Fernández, 2024). These findings suggest that although Generation Z has significant potential to transform tourism demand, realizing this potential requires integrated policies combining sustainable marketing, education, and institutional support. González-Pozo (2025) shows that environmental criteria are becoming increasingly important in accommodation choices made by Generation Z through online travel agencies, confirming that sustainability plays an integral role in purchasing decisions. The implementation of sustainable practices and green technologies has also been

shown to increase satisfaction among younger tourists, particularly those who value innovation, environmental awareness, and digitalized services (Khmaaj et al., 2025).

With increasing global pressure to reduce environmental footprints, Generation Z increasingly perceives tourism as a means of expressing personal values, particularly through the selection of sustainable destinations and brands with clearly articulated ecological identities. Research indicates that members of this generation often associate their consumer identity with moral beliefs related to environmental protection and social responsibility (de Araújo et al., 2025). Findings by Chang et al. (2024) confirm that emotional identification with nature and a sense of collective responsibility are among the strongest predictors of sustainable behavior in tourism. Similarly, Demiris et al. (2025) demonstrate that climate change awareness directly influences Generation Z's willingness to choose low carbon transport and eco certified accommodation. Comparable results reported by Ribeiro et al. (2025) show that ecological concern and perceived benefits of sustainable practices play a decisive role in the selection of tourism offers. Marques et al. (2025) emphasize that Generation Z's travel motivations are shaped by social media influence, identity formation, and environmental values, making them particularly sensitive to transparency and ethical communication. Xia et al. (2025) further underline that young tourists seek not only nature based experiences but also cultural meaning and authenticity aligned with values of heritage preservation and responsible travel.

Green marketing in tourism is no longer merely a promotional trend but has evolved into a strategic instrument for destination positioning in an increasingly competitive global environment. Its core purpose lies in integrating ecological principles throughout the tourism product lifecycle, including planning, resource management, communication, and visitor experience design. Green marketing represents a particularly important tool in the development of sustainable rural tourism, as it enhances environmental awareness among tourists and strengthens the competitiveness of protected natural destinations such as national parks (Ostojić et al., 2025). The improvement of business and organizational process quality is recognized as a key prerequisite for innovation and long term competitiveness of small and medium sized enterprises, which is especially relevant in rural tourism contexts characterized by limited resources and high dependence on environmental quality (Cvjetković et al., 2022). Contemporary approaches highlight that successful destinations combine transparency, digital communication tools, and locally grounded narratives to build credibility and authenticity (Sanjaya et al., 2024; Hu et al., 2023). Digital platforms enable destinations to communicate measurable sustainability outcomes through interactive applications, emission reduction metrics, and ecological certification systems (Vicente et al., 2024). Such transparency strengthens trust, which represents a fundamental component of an authentic green destination image (Fandos-Herrera et al., 2025). At the same time, research warns that inconsistencies between promotional claims and actual practices can lead to greenwashing, thereby damaging destination reputation and reducing tourist loyalty (Chang et al., 2025; Schwarz, 2024). As a result, green marketing in tourism is

increasingly conceptualized as a system of trust and transparency management rather than mere promotion (Wu et al., 2024).

Within this framework, Generation Z represents a crucial target group for sustainable tourism strategies, particularly in rural and protected destinations. As the first generation raised entirely in a digital environment, they expect destinations to provide clear, verifiable, and digitally accessible information about ecological practices (Pulido-Fernández, 2024; Minazzi et al., 2025). Their travel decisions are strongly influenced by environmental messaging across social media, authentic testimonials from local communities, and influencer partnerships with sustainability oriented brands (Kubíková & Rudý, 2024). Studies show that Generation Z responds more positively to marketing campaigns that combine emotional and educational elements, perceiving them as credible and engaging (Nowacki et al., 2023; Sanjaya et al., 2024). Their willingness to pay a premium for eco friendly tourism products increases when destinations provide tangible evidence such as certifications, local partnerships, and publicly available sustainability reports (Vicente et al., 2024; Chang et al., 2025). These findings indicate that Generation Z evaluates destinations not only based on experience quality but also on integrated value systems in which sustainability represents a central component.

Mount Golija, located in southwestern Serbia, represents one of the country's most ecologically valuable rural areas. As part of the UNESCO Golija Studenica Biosphere Reserve, the destination holds protected status due to its exceptional biodiversity, endemic species, and well preserved ecosystems (Milićević et al., 2021). The high ecological value of Golija requires responsible tourism development models in which environmental conservation and prevention of degradation remain primary objectives while supporting rural economic development. Previous studies emphasize that sustainable management of mountain and rural destinations depends on achieving a balance between ecological protection and local development goals (Bošković et al., 2020). In this context, Golija is increasingly recognized as a destination with strong potential to integrate ecotourism principles, organic production, and participatory planning. However, insufficient institutional coordination among park authorities, tourism organizations, and local communities remains a significant challenge and is identified as a key precondition for effective strategy implementation in spatial and tourism planning research in Serbia (Tomić & Stojsavljević, 2013).

Effective sustainable rural tourism management on Golija requires the introduction of indicator based monitoring systems and ecological innovations that enable the measurement, monitoring, and continuous improvement of destination performance. European frameworks such as the European Tourism Indicators System and their local adaptations are increasingly applied to track tourism impacts and support strategic decision making (Gasparini & Mariotti, 2023). Studies conducted in Serbia's mountain regions highlight the importance of monitoring parameters related to waste generation, energy efficiency, and seasonality in shaping future development guidelines (Bošković et al., 2020; Milićević et al., 2021). The adoption of ecological and digital innovations, including solar energy systems, energy consumption sensors, and smart

resource management applications, can significantly improve sustainability outcomes in rural destinations such as Golija. Nevertheless, the effectiveness of such innovations ultimately depends on institutional capacity, stakeholder coordination, and continuous policy adaptation, confirming that sustainable rural tourism development represents both a technical and an organizational challenge (Rocio et al., 2023; Zhang & Deng, 2024; Aransyah et al., 2025).

Materials and methods

The research was conducted with the aim of identifying the ecological and social needs of Generation Z in the context of sustainable rural tourism development on Mount Golija, as well as examining the role of project management and green marketing in shaping attitudes, behaviors, and intentions to visit this rural destination. Particular emphasis was placed on understanding the level of environmental awareness among young tourists, their attitudes toward sustainable practices, and their willingness to support tourism offers aligned with the principles of sustainable rural development. The study sought to explore how Generation Z, as an emerging driver of future consumer trends, can contribute to the transformation of the tourism market toward sustainability, particularly in rural and protected areas.

Based on the research objectives and prior findings, five research hypotheses were formulated to examine the influence of the perception of sustainable rural tourism and green marketing on Generation Z's intention to visit Mount Golija.

H1: There is a statistically significant positive relationship between the perception of ecological practices on Golija and Generation Z's intention to visit the rural destination. This hypothesis assumes that respondents who recognize sustainable initiatives and ecological technologies within the rural tourism offer demonstrate greater motivation to visit the destination.

H2: There is a significant positive correlation between the implementation of green marketing, including digital promotion and communication via social media, and the intention to visit Golija as a rural tourism destination. This hypothesis is based on the theoretical model suggesting that digital marketing and the visibility of sustainable content enhance the destination's image among younger populations.

H3: Generation Z's willingness to pay a higher price for environmentally responsible accommodation in rural tourism settings has a positive effect on their perception of sustainable tourism and their intention to visit. This hypothesis tests the economic dimension of ecological awareness and the readiness of young tourists to support sustainable practices through their own behavior.

H4: Awareness and educational content about sustainable rural tourism significantly contribute to the positive perception of Golija as a sustainable destination. This hypothesis assumes that transparent information and accessible educational materials increase respondents' understanding of and support for sustainable initiatives.

H5: The perception of Golija as a rural destination with high ecological potential represents the most important predictor of Generation Z's intention to visit. This hypothesis arises from the idea that the destination's image, based on its natural resources and sustainable practices, has a decisive influence on the decision to visit.

The questionnaire was designed to include two main sections, demographic characteristics and attitudes toward sustainable rural tourism and green marketing. The first section covered basic information such as gender, age, place of origin, and travel frequency, while the second section focused on questions measuring perceptions of sustainability, ecological practices, and digital promotion of the rural destination. The main research variables were defined through three constructs, sustainable tourism, green marketing, and travel intention. The sustainable tourism construct included ecological initiatives, educational content, destination potential, and the use of green technologies in rural tourism. The green marketing construct comprised promotion and digital visibility as well as willingness to financially support sustainable practices. Travel intention referred to the willingness to visit a destination that follows sustainability principles. A five point Likert scale ranging from 1, strongly disagree, to 5, strongly agree, was used to measure attitudes, allowing for precise quantification of subjective perceptions and comparisons across research dimensions.

The data collected from the survey were analyzed using IBM SPSS Statistics 26. The statistical processing included several analytical levels. In the first stage, descriptive statistics were applied to display general tendencies and response distributions, calculating means, standard deviations, and percentage shares. In the second stage, Pearson's correlation coefficient was used to examine relationships between key variables, sustainable tourism, green marketing, and travel intention. The third stage involved regression analysis to determine the extent of the impact of independent variables, ecological practices, green marketing activities, and availability of information, on the dependent variable, intention to visit Golija as a rural tourism destination. All analyses were conducted at a significance level of $p < .05$ and $p < .01$, ensuring a high level of result reliability.

Results

The research was conducted between April and June 2025 through an online survey created using the Google Forms platform. The questionnaire was distributed via social media, primarily Instagram and LinkedIn, as well as by email to university students across Serbia. This approach enabled the inclusion of a diverse sample of respondents differing in education, place of residence, and travel experience. The total number of valid responses was 256, which represents an adequate sample size for quantitative analysis and allows for reliable conclusions. Generation Z, aged between 18 and 32 years, a population selected due to its pronounced environmental awareness and digital connectivity, particularly relevant for rural tourism destinations.

The sample structure shows that 59% of respondents were female (N=151), while 41% were male (N=105). The largest age group consisted of respondents aged 23 to 27 years (61.5%), followed by those aged 28 to 32 (19.7%), and finally, respondents aged 18 to 22 (18.9%). Regarding origin, 77% of participants were from Serbia, while 23% were international respondents, mainly from neighboring countries. This sample structure provided insight into the perception of sustainable rural tourism and ecological practices among both domestic and international members of Generation Z, offering a broader understanding of the trends and development potential of the Golija destination. To verify the reliability of the instrument, Cronbach's alpha coefficient was calculated, yielding $\alpha = 0.86$, indicating high internal consistency of the items and confirming the adequacy of the questionnaire for research purposes. This methodological design enabled a comprehensive analysis of the factors influencing Generation Z's perception of sustainable tourism, as well as the identification of key elements that can contribute to the successful development and positioning of Golija as an environmentally responsible rural tourist destination.

The study analyzed the main variables related to the perception of sustainable tourism and green marketing on Golija. Each statement was measured using a five-point Likert scale (1 - strongly disagree; 5 - strongly agree). The goal of this analysis was to determine which areas respondents rated most positively and which require further improvement.

Table 1. Descriptive Indicators for Main Variables (N = 256)

Variable	Mark	M	SD	Min	Max
The tourist offer contributes to the preservation of the natural environment	ST1	3.724	0.913	1	5
Information on sustainable practices is available and transparent	ST2	2.832	0.972	1	5
Golija is promoted on social media	GM1	2.611	1.025	1	5
Accommodation facilities use ecological technologies	ST3	3.007	0.876	1	5
I am willing to pay more for eco-accommodation	GM2	3.873	0.934	1	5
There are enough educational contents about ecology	ST4	3.019	0.948	1	5
Golija has potential as a sustainable rural destination	ST5	4.093	0.818	1	5
Intention to visit Golija (dependent variable)	DV	4.038	0.789	1	5

Source: Own research

The analysis shows that respondents rated the statements *Golija has the potential to become an example of a sustainable destination* (M=4.093) and *Intention to visit Golija* (M=4.038) the highest. These results indicate that Generation Z largely recognizes the natural potential of Golija and demonstrates a positive predisposition toward visiting a destination that upholds sustainability principles.

The lowest-rated statements refer to *Promotion of Golija on social media* (M=2.611) and *Availability of information on sustainable practices* (M=2.832). This implies that respondents perceive the communication and visibility of sustainability initiatives as

insufficiently developed, which may negatively affect the destination's perception and image among young people.

Moderate values for the variables *Accommodation uses ecological technologies* (M=3.007) and *Educational content on ecology* (M=3.019) suggest that respondents are neutral, indicating that certain sustainability efforts are present but their visibility and implementation remain unsatisfactory.

The conclusion derived from the descriptive analysis is that while the perception of Golija's ecological potential and the respondents' willingness to support environmental initiatives are evident, it is necessary to strengthen green marketing and information channels to adequately leverage this potential.

A correlation analysis was conducted to examine the relationships between the perception of sustainable tourism, green marketing, and the intention to visit Golija. Pearson's correlation coefficient (r) was used for the analysis, where values between 0.10 - 0.29 indicated a weak correlation, 0.30 - 0.49 a moderate correlation, and ≥ 0.50 a strong correlation. Statistical significance was tested at the $p < 0.01$ level.

Table 2. Correlation Matrix Between Variables (N = 256)

Variable	ST1	ST2	GM1	ST3	GM2	ST4	ST5	DV
ST1	1	.476**	.334**	.414**	.372**	.435**	.562**	.582**
ST2		1	.513**	.452**	.402**	.472**	.529**	.492**
GM1			1	.384**	.592**	.357**	.418**	.458**
ST3				1	.391**	.441**	.481**	.524**
GM2					1	.402**	.539**	.572**
ST4						1	.514**	.551**
ST5							1	.618**
DV								1

** . Correlation is significant at the 0.01 level (2-tailed).

Source: Own research

The results indicate a high degree of correlation between almost all variables, confirming the theoretical framework that sustainable practices and green marketing jointly contribute to shaping Generation Z's positive attitudes toward the rural destination.

The highest correlation was recorded between the variables *Golija has potential as a sustainable destination* (ST5) and *Intention to visit Golija* (DV), $r = .618$, $p < 0.01$. This strong positive relationship shows that the perception of a destination as sustainable directly influences the decision to visit. Another significant correlation was observed between *Willingness to pay more for eco-accommodation* (GM2) and *Intention to visit* (DV), $r = .572$, $p < 0.01$, confirming that younger populations value environmental responsibility and are willing to invest additional resources in sustainable services.

The variable *Promotion on social media* (GM1) shows a moderate but statistically significant correlation with the intention to visit ($r = .458$, $p < 0.01$), highlighting the importance of digital marketing as a communication channel for Generation Z. The

lowest correlation was found between *Information on sustainable practices* (ST2) and *Intention to visit* ($r=.492$), which still represents a moderate relationship and suggests that better access to information can enhance tourist motivation.

Based on these findings, it can be concluded that the variables are interrelated in accordance with theoretical expectations, where the perception of sustainable potential and economic readiness to support ecological initiatives are the most important factors influencing the decision to visit the destination.

To determine the extent of the influence of independent variables (sustainable tourism and green marketing) on the dependent variable (intention to visit Golija), a multiple linear regression analysis was conducted. The model was tested using the Enter method, and significance levels were verified at $p<0.05$ and $p<0.01$.

Table 3. Results of Multiple Linear Regression
(DV - Intention to visit the rural tourism destination)

Predictor	β	t	p
The tourist offer contributes to preserving nature (ST1)	0.173	2.913	0.004
Information on sustainable practices (ST2)	0.108	2.082	0.039
Promotion on social media (GM1)	0.191	3.249	0.001
Accommodation uses ecological technologies (ST3)	0.089	1.754	0.081
Willingness to pay more for eco-accommodation (GM2)	0.247	4.182	0.000
Educational content on ecology (ST4)	0.142	2.442	0.015
Golija has potential as a sustainable destination (ST5)	0.284	5.030	0.000
Model summary: R = 0.818 R ² = 0.669 Adjusted R ² = 0.652 F(7, 248) = 70.308, p < 0.001			

Source: Own research

The model explains 66.9% of the variance in the intention to visit Golija, indicating a high level of predictive power and confirming that the combination of ecological practices and green marketing significantly influences the formation of Generation Z's attitudes.

The strongest individual effect was observed for the variable *Golija has potential as a sustainable destination* ($\beta = 0.284$, $p = 0.000$), indicating that the perception of the destination as environmentally responsible plays a decisive role in shaping the intention to visit. The second strongest predictor was *Willingness to pay more for eco-accommodation* ($\beta = 0.247$, $p = 0.000$), confirming that economic support for sustainable practices is an important indicator of Generation Z's real engagement. A significant contribution was also observed for *Promotion on social media* ($\beta = 0.191$, $p = 0.001$), implying that effective digital communication can increase young tourists' interest.

Variables with smaller but still statistically significant effects include *Educational content on ecology* ($\beta = 0.142$, $p = 0.015$) and *Information on sustainable practices* ($\beta = 0.108$, $p = 0.039$), emphasizing the importance of accessible information and education in travel decision-making. The variable *Ecological technologies in accommodation* (ST3) shows a weaker, marginally significant effect ($\beta = 0.089$, $p = 0.081$), suggesting that respondents may lack sufficient knowledge about existing eco-friendly solutions in accommodation offerings.

Overall, the regression model confirms that the perception of sustainable potential, willingness to support eco-friendly offers, and digital visibility are key factors in predicting Generation Z's intention to visit. These findings support the main hypothesis that project management and green marketing, when integrated into destination development, significantly enhance competitiveness and recognition among younger populations.

Discussions

The primary aim of this research was to identify the ecological and social needs of Generation Z in the context of sustainable rural tourism development on Mount Golija and to examine how project management and green marketing can contribute to enhancing the destination's tourism offer. Through the application of descriptive, correlation, and regression analyses, the results provide an empirical basis for testing the proposed hypotheses and understanding the behavior of Generation Z in relation to sustainable tourism practices.

The correlation analysis revealed a strong positive relationship between the variables *The tourist offer contributes to the preservation of the natural environment* and *Intention to visit Golija* ($r = .582$, $p < 0.01$). This finding indicates that the greater the respondents' awareness of ecological practices and environmental protection, the stronger their willingness to visit the rural destination. Regression analysis further confirmed a statistically significant positive effect ($\beta = 0.173$, $p = 0.004$), validating its predictive value. Based on these findings, hypothesis H1 is confirmed, establishing a significant positive relationship between the perception of ecological practices on Golija and Generation Z's intention to visit this destination. This result aligns with Font and McCabe (2017), who emphasize that the perception of ecological initiatives plays a central role in shaping the preferences of environmentally conscious tourists.

The results also show a moderate but statistically significant correlation between *Golija is promoted on social media* and *Intention to visit* ($r = .458$, $p < 0.01$). The regression model confirms the effect of digital promotion ($\beta = 0.191$, $p = 0.001$), suggesting that increasing online visibility can significantly enhance the destination's positioning among Generation Z. Consequently, hypothesis H2 is confirmed, supporting the existence of a positive relationship between green marketing (digital promotion and social media communication) and the intention to visit Golija as a rural tourism destination. This finding supports the perspective of Permanent et al. (2021), who highlight the role of digital communication and technological tools in contemporary marketing, particularly among Generation Z, who obtain most of their travel information through social networks.

The variable *Willingness to pay more for eco-accommodation* demonstrated a strong correlation with *Intention to visit* ($r = .572$, $p < 0.01$). In the regression model, this variable showed high statistical significance ($\beta = 0.247$, $p = 0.000$), indicating that financial willingness is a key factor distinguishing environmentally aware tourists from others. Based on these results, hypothesis H3 is confirmed, indicating that Generation Z's readiness to pay a higher price for environmentally responsible accommodation

positively affects their perception of sustainable tourism and intention to visit. This finding underlines the growing importance of ethical consumption and confirms that Generation Z recognizes the value of sustainability and is willing to support it financially, which is consistent with contemporary research showing that young tourists increasingly choose green products and socially responsible brands.

A moderate but significant correlation was also found between *Educational content on ecology* and *Perception of Golija's potential as a sustainable rural destination* ($r = .514, p < 0.01$). Regression analysis showed that educational content has a positive and statistically significant effect on the intention to visit ($\beta = 0.142, p = 0.015$). This suggests that the availability of educational and informational content increases respondents' awareness and trust in sustainable initiatives. Therefore, hypothesis H4 is confirmed, showing that awareness and educational content on sustainable tourism significantly contribute to the positive perception of Golija as a sustainable destination. These empirical findings are consistent with the approach advocated by UNESCO (2022), which emphasizes education as a key factor in raising environmental awareness and strengthening youth participation in environmental protection.

The strongest relationship in the correlation matrix was observed between *Golija has potential as a sustainable destination* and *Intention to visit* ($r = .618, p < 0.01$). Regression analysis confirmed that this variable had the highest standardized coefficient ($\beta = 0.284, p = 0.000$), demonstrating that the perception of ecological potential is the main motivational factor for visiting the destination. Based on this evidence, hypothesis H5 is confirmed, indicating that the perception of Golija as a destination with high ecological potential is the most important predictor of Generation Z's intention to visit. This result supports the central thesis of the study: the successful development of sustainable tourism depends on effective project management of resources and destination branding based on sustainability values, positioning Golija as a representative example of a sustainable mountain destination.

Overall, the results confirm all proposed hypotheses, showing that the perception of sustainability, environmental awareness, and digital communication significantly shape Generation Z's behavior in the rural tourism context. Generation Z demonstrates a high degree of environmental responsibility and willingness to support sustainable initiatives both financially and behaviorally, confirming that ecological factors are becoming a central determinant of travel decisions in contemporary tourism.

The findings clearly indicate that the perception of Golija's ecological potential ($r = .618, \beta = 0.284, p < 0.01$) is the strongest predictor of travel intention, confirming that destinations effectively communicating their natural assets and green initiatives can attract younger, environmentally conscious tourists. Sustainable practices such as the use of renewable energy and recycling in accommodation facilities were positively evaluated and showed a statistically significant impact on respondents' decisions ($r = .582, p < 0.01$). This suggests that tourists increasingly seek tangible evidence of sustainability - not only through visual identity but through visible, on-site

environmental practices.

The research also highlights the crucial role of digital promotion and green marketing in shaping destination image among Generation Z. The moderately strong correlation between online presence and visit intention ($r = .458$, $p < 0.01$) confirms that effective communication via social media directly influences tourist perception. This supports contemporary tourism trends where digital experiences are viewed as an extension of the actual travel experience. The insufficient digital visibility of Golija underscores the need for developing digital infrastructure (web platforms, mobile applications, interactive maps) that connects visitors with local content, producers, and ecological initiatives.

Another significant finding relates to tourists' willingness to pay a higher price for sustainable accommodation ($\beta = 0.247$, $p < 0.01$), suggesting that Generation Z perceives payment as a form of ecological participation. This has important implications for destination management, as it demonstrates that the sustainable tourism market carries not only moral but also economic value.

Nevertheless, the study also identified several limitations. The sample primarily consisted of students and urban-oriented members of Generation Z, which may affect the generalizability of results to the broader population. Moreover, the research was conducted online, meaning that participants were likely already digitally aware, introducing a possible bias in favor of digital marketing. Additionally, the data were based on self-reported attitudes, which may involve a degree of social desirability bias. The research focused exclusively on Generation Z, while including other generations (Y and X) would allow for a broader comparative perspective on shifting tourism preferences. Furthermore, the study did not address seasonality or Golija's actual ecological carrying capacity, both of which would provide valuable complementary insights into destination sustainability.

Future research should expand on these findings by examining the long-term impact of sustainable rural tourism on local economies and demographics, analyzing tourist behavior regarding ecological practices, and assessing the effectiveness of digital tools (such as the Eko Golija platform) in influencing engagement and sustainable behavior. Comparative studies with successful eco-destinations in the region (such as Pokljuka, Alpbach, and Bansko) could help identify best practices and knowledge transfer models, while psychological and motivational studies could further explore the values and emotional triggers that shape Generation Z's perception of sustainability and nature.

Conclusions

Based on the conducted analysis, it can be concluded that Generation Z represents a key driver of the transformation of tourism toward sustainability, particularly in rural and nature-based destinations. Their environmental awareness, digital literacy, and willingness to support green initiatives position them as catalysts of change within Serbia's tourism industry. Golija, as a rural mountain destination rich in natural resources

and cultural identity, possesses a genuine potential to become a model of sustainable rural tourism, provided that existing resources are managed through strategic project management and an integrated approach to green marketing.

The sustainability of Golija depends not only on the preservation of natural assets but also on the way tourism development is communicated, planned, and supported through active involvement of local communities. By strengthening digital visibility, environmental education, and partnerships between public, private, and civil sectors, it is possible to establish a self-sustaining rural tourism system capable of generating economic, social, and environmental benefits.

The conducted research not only empirically confirmed the relevance of project management and green marketing for the development of sustainable tourism but also identified concrete mechanisms for their implementation in rural contexts, ranging from ecological infrastructure and educational initiatives to digital tools and evaluation systems.

These findings open space for future research and practical initiatives that could further contribute to positioning Golija as a national example of sustainable and responsible rural tourism development in Serbia.

Conflict of interests

The authors declare no conflict of interest.

References

1. Andrei, J. V., Dusmanescu, D., & Mieila, M. (2015). The influences of the cultural models on agricultural production structures in Romania and some EU-28 countries-a perspective. *Economic of Agriculture*, 62(2), 293–307.
2. Aransyah, M. F., Hermanto, B., Muftiadi, A., & Oktadiana, H. (2025). Exploring sustainability oriented innovations in tourism: insights from ecological modernization, diffusion of innovations, and the triple bottom line. *Cogent Social Sciences*, 11(1), 2447396. <https://doi.org/10.1080/23311886.2024.2447396>
3. Bošković, N., Vujičić, M., & Ristić, L. (2020). Sustainable tourism development indicators for mountain destinations in the Republic of Serbia. *Current Issues in Tourism*, 23(22), 2766-2778. <https://doi.org/10.1080/13683500.2019.1666807>
4. Chang, J. Y. S., Lim, X. J., Luo, X., Cheah, J. H., Morrison, A. M., & Hall, C. M. (2024). Modelling generation Z tourists' social responsibility toward environmentally responsible behaviour: The role of eco-travel cravings. *International Journal of Tourism Research*, 26(4), e2695. <https://doi.org/10.1002/jtr.2695>
5. Chang, W., Li, H., & Khan, W. A. (2025). Influencing eco-conscious travelers: The role of green marketing in promoting sustainable destinations. *Acta Psychologica*, 260, 105506. <https://doi.org/10.1016/j.actpsy.2025.105506>
6. Crabolu, G., Font, X., & Miller, G. (2024). The hidden power of sustainable tourism indicator schemes: Have we been measuring their effectiveness all wrong? *Journal*

- of Travel Research*, 63(7), 1741-1760. <https://doi.org/10.1177/00472875231195736>
7. Cvjetkovic, M., Cvjetković, M., & Josimović, M. (2022). The impact of quality improvement on the innovative operation of SMEs. *BizInfo Blace*, 13(2), 73-81. <https://doi.org/10.5937/bizinfo2202073C>
 8. de Araújo, A. F., Andrés-Marques, I., & López Moreno, L. (2025). No Planet-B attitudes: The main driver of Gen Z travelers' willingness to pay for sustainable tourism destinations. *Sustainability*, 17(3), 847. <https://doi.org/10.3390/su17030847>
 9. Demiris, A., Fountas, G., Fonzone, A., & Basbas, S. (2025). Generation Z's travel behavior and climate change: A comparative study for Greece and the UK. *Big Data and Cognitive Computing*, 9(3), 70. <https://doi.org/10.3390/bdcc9030070>
 10. Fandos-Herrera, C., Labuena, A., & Orús, C. (2025). Analysis of sustainability and authenticity as key elements for rural tourism. *Spanish Journal of Marketing-ESIC*. <https://doi.org/10.1108/SJME-04-2024-0098>
 11. Gasparini, M. L., & Mariotti, A. (2023). Sustainable tourism indicators as policy making tools: Lessons from ETIS implementation at destination level. *Journal of Sustainable Tourism*, 31(7), 1719-1737. <https://doi.org/10.1080/09669582.2021.1968880>
 12. González-Pozo, R., Segura, M., & del Pozo García, E. (2025). Evaluating Generation Z's environmental awareness and accommodation preferences through online travel agencies. *European Journal of Tourism Research*, 40, 4009. <https://doi.org/10.54055/ejtr.v40i.3832>
 13. Ha, N. T. V., & Hang, N. T. T. (2024). Sustainable tourism and the intention of Generation Z to choose sustainable tourism. *International Journal of Scientific Research and Management*.
 14. Hu, C., Liang, M., & Wang, X. (2023). Achieving green tourism through environmental perspectives of green digital technologies, green innovation, and green HR practices. *Environmental Science and Pollution Research*, 30(29), 73321-73334. <https://doi.org/10.1007/s11356-024-32888-9>
 15. Khmaj, A. A. M., Ostojić, B., Ilić, B., Cvjetkovic, M., & Ružić, J. (2025). Organization of green projects for the purpose of promotion and satisfaction of users in rural regions in Serbia. *Ekonomika poljoprivrede*, 72(1), 189-203. <https://doi.org/10.59267/ekoPolj2501189A>
 16. Kubíková, Ľ., & Rudý, S. (2024). Attitudes of Generation Z towards sustainable behaviour in tourism. *TEM Journal*, 13(2). DOI: 10.18421/TEM132-26,
 17. Ma, Y., Li, Y., & Han, F. (2024). Interconnected eco-consciousness: Gen Z travelers' intentions toward low-carbon transportation and hotels. *Sustainability*, 16(15).
 18. Marques, J., Gomes, S., Ferreira, M., Rebuá, M., & Marques, H. (2025). Generation Z and travel motivations: The impact of age, gender, and residence. *Tourism and Hospitality*, 6(2), 82. <https://doi.org/10.3390/tourhosp6020082>
 19. Milićević, S., Bošković, N., & Lakićević, M. (2021). Sustainable tourism development in mountain areas in Šumadija and Western Serbia. *Journal of Mountain Science*, 18(3), 735-748.

20. Miller, G., & Torres-Delgado, A. (2023). Measuring sustainable tourism: A state of the art review of sustainable tourism indicators. *Journal of Sustainable Tourism*, 31(7), 1483-1496. <https://doi.org/10.1080/09669582.2023.2213859>
21. Minazzi, R., & Grechi, D. (2025). Exploring Gen Z sustainable behavior in the hospitality industry. *Administrative Sciences*, 15(7), 266. <https://doi.org/10.3390/admsci15070266>
22. Nowacki, M., Kowalczyk-Anioł, J., & Chawla, Y. (2023). Gen Z's attitude towards green image destinations, green tourism and behavioural intention regarding green holiday destination choice: A study in Poland and India. *Sustainability*, 15(10), 7860. <https://doi.org/10.3390/su15107860>
23. Ostojić, B., Sekulić, D., & Mićović, A. (2025). *Green marketing as a factor of sustainable rural tourism in the Đurđevića Tara National Park. Ekonomika poljoprivrede*, 72(2), 645–663. <https://doi.org/10.59267/ekoPolj25026450>
24. Paraušić, V., Pantović, D., Mihailović, B., & Radosavljević, K. (2025). Digital literacy of farmers in the context of rural tourism services provision in Serbia. *Hotel and Tourism Management*, 13(1). <https://doi.org/10.5937/menhotur2500002P>
25. Parment, A., Kotler, P., & Armstrong, G. (2021). *Principles of marketing: Scandinavian edition*. Pearson Higher Education.
26. Pulido-Fernández, J. I., Casado-Montilla, J., López-Sánchez, Y., Durán-Román, J. L., & Carrillo-Hidalgo, I. (2024). Gen Zers' behaviour towards sustainability in a mature coastal destination. *International Journal of Tourism Research*, 26(5), e2758. <https://doi.org/10.1002/jtr.2758>
27. Punzo, G., Trunfio, M., Castellano, R., & Buonocore, M. (2022). A multi-modelling approach for assessing sustainable tourism. *Social Indicators Research*, 163(3), 1399-1443.
28. Radanov, P., & Lešević, I. (2020). Rural tourism in Serbia in the age of the Coronavirus epidemic. *5th International Thematic Monograph-Modern Management Tools and Economy of Tourism Sector in Present Era*, 393-408. <https://www.cceol.com/search/chapter-detail?id=1294164>
29. Ribeiro, M. A., Seyfi, S., Elhoushy, S., Woosnam, K. M., & Patwardhan, V. (2025). Determinants of Generation Z pro-environmental travel behaviour: The moderating role of green consumption values. *Journal of Sustainable Tourism*, 33(6), 1079-1099. <https://doi.org/10.1080/09669582.2023.2230389>
30. Rocio, H. G., Jaime, O. C., & Cinta, P. C. (2023). The role of management in sustainable tourism: A bibliometric analysis approach. *Sustainability*, 15(12), 9712. <https://doi.org/10.3390/su15129712>
31. Sanjaya, D., Arief, M., Setiadi, N. J., & Heriyati, P. (2024). Exploring the role of digital green marketing campaigns and environmental beliefs in shaping tourist behavior and revisit intentions in eco-tourism. *Journal of Eastern European and Central Asian Research (JEECAR)*, 11(3), 553-572. <https://doi.org/10.15549/jeecar.v11i3.1693>

32. Schwarz, A. H. (2024). *Green marketing: The influence of sustainable digital marketing content on Gen Z - A case study on Germany*.
33. Seyfi, S., Hall, C. M., & Strzelecka, M. (2025). Gen Z: Pioneers or paradox in sustainable tourism? *Journal of Sustainable Tourism*, 33(6), 987-1015. <https://doi.org/10.1080/09669582.2025.2491702>
34. Sima, V., & Gheorghe, I. G. (2015). Changing consumption patterns in green economy. In *Agricultural management strategies in a changing economy* (pp. 186-212). IGI Global Scientific Publishing.
35. Tomić, N., & Stojsavljević, R. (2013). Spatial planning and sustainable tourism - A case study of Golija Mountain (Serbia). *European Researcher*, (12-2), 2918-2929.
36. UNESCO. (2022). *Reimagining our futures together: A new social contract for education*. United Nations Educational, Scientific and Cultural Organization. <https://unesdoc.unesco.org/ark:/48223/pf0000379707>
37. Vicente, J. M. (2024). Green tourist behavior analysis and its relationship with the choice of eco-tourism destination: An empirical study. *International Journal of Geoheritage and Parks*, 12(4), 544-557. <https://doi.org/10.1016/j.ijgeop.2024.11.003>
38. Wu, H., Wang, W., Tao, Y., Shao, M., & Yu, C. (2024). Understanding the Chinese Z generation consumers' green hotel visit intention: An extended theory of planned behavior model. *Heliyon*, 10(3).
39. Xia, Z., Yunyang, L., Hanxiao, Z., & Linggang, K. (2025). Generation Z: The challenge for ancient city tourism. *The Historic Environment: Policy & Practice*, 1-28. <https://doi.org/10.1080/17567505.2025.2496559>
40. Yuedi, H., Sanagustín-Fons, V., Coronil, A. G., & Moseñe-Fierro, J. A. (2023). Analysis of tourism sustainability synthetic indicators: A case study of Aragon. *Heliyon*, 9(4).
41. Zdravković, S. ., & Peković, J. . (2020). The analysis of factors influencing tourists' choice of green hotels. *Hotel and Tourism Management*, 8(1), 69–78. <https://doi.org/10.5937/menhottur2001069Z>
42. Zhang, Y., & Deng, B. (2024). Exploring the nexus of smart technologies and sustainable ecotourism: A systematic review. *Heliyon*, 10(11), e31996.

METHODOLOGICAL AND PRACTICAL ADVANTAGES OF PLS-SEM IN MANAGEMENT RESEARCH: THE CASE OF RAKIJA

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ABSTRACT

Structural equation modeling (SEM) is widely applied in consumer behavior research; however, the methodological choice between covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM) remains contested in applied research contexts. This study compares the performance of CB-SEM and PLS-SEM using an identical theoretical model previously employed to analyze cultural factors influencing consumer purchasing behavior for rakija, a culturally embedded agricultural product. Survey data were reanalyzed using SmartPLS, focusing on measurement model evaluation and the estimation of direct and indirect structural effects. The results show that PLS-SEM yields lower path coefficient estimates but higher explained variance (R^2) compared to CB-SEM, indicating more conservative effect estimation alongside stronger explanatory performance. These findings suggest that PLS-SEM represents a methodologically appropriate and practically advantageous approach for modeling consumer behavior in culturally specific agricultural markets. The study contributes to the applied SEM literature by providing empirical guidance on method selection in agricultural economics research.

Introduction

This study focuses on the practical implementation of structural equation modeling (SEM) using SmartPLS (Ringle et al., 2024). The objective was to highlight the

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methodological advantages of Partial Least Squares Structural Equation Modeling (PLS-SEM) compared to Covariance-Based Structural Equation Modeling (CB-SEM) and to address its shortcomings. The modules of PLS-SEM in SmartPLS are explained using a previously published CB-SEM model that investigated the cultural factors influencing consumer purchasing behavior related to rakija (Adžić, 2025). This traditional plum brandy was recognized as an intangible cultural heritage by UNESCO under the title “Social practices and knowledge related to the production and use of traditional plum brandy – šljivovica” at the end of 2022 (UNESCO, 2022).

Although both CB-SEM and PLS-SEM methodologies were introduced around the same period, CB-SEM gained significantly greater adoption because of its initial accessibility via LISREL software in the late 1970s and AMOS in the 2000s. The introduction of SmartPLS 2 in 2005 led to a substantial increase in PLS-SEM utilization (Hair et al., 2024). SmartPLS is increasingly recognized as a robust alternative to AMOS for structural equation modeling, particularly because of its user-friendly interface and advanced reporting features, which enhance accessibility for researchers (Wong, 2013).

A key conceptual difference between PLS-SEM and CB-SEM lies in how latent variables are handled in the model. CB-SEM is a common factor-based structural equation modeling method that interprets constructs as common factors that explain the covariation among their associated indicators (Hair et al., 2021). In contrast, PLS-SEM asserts that the constructs of interest can be measured as composites, which classifies it as a composite-based structural equation modeling approach (Hwang et al., 2020). CB-SEM is mainly used to confirm or challenge theoretical frameworks composed of systematic relationships among different variables that can be empirically tested. This validation process assesses the accuracy of the proposed theoretical model in predicting the covariance matrix of a specific sample dataset (Hair et al., 2021).

To enhance the fit of models in CB-SEM, researchers often limit the number of indicators associated with each construct, which consequently increases uncertainty (Hair et al., 2021). PLS-SEM provides higher statistical power and can yield results when CB-SEM encounters convergence issues or fails to achieve model fit. The measurement model estimates (loadings) in PLS-SEM tend to be greater, whereas the structural model estimates (path coefficients) are comparatively lower than those derived from CB-SEM (Reinartz et al., 2009). PLS-SEM utilizes ordinary least squares regression to achieve the goal of maximizing the R^2 values of the endogenous constructs (Hair et al., 2024). Because PLS-SEM is grounded in total variance, the Average Variance Extracted (AVE) values are consistently higher than those in CB-SEM, rendering the R^2 value in PLS-SEM a more significant predictor of the variance captured by the indicators of the endogenous constructs than the R^2 value in CB-SEM.

Materials and methods

The author conducted a thorough review of academic journals and validated research scales related to various alcoholic beverages using the Business Source Premier

database for the first study in December 2023 (Adžić, 2025). This study was prompted by the absence of specifically designed scales for rakija in the existing literature. By searching for “alcohol” and “consumer,” 56 unique articles were identified and retrieved after eliminating the duplicates. These articles formed the foundation for analyzing and adapting five research scales for the current study and assisted in developing a structural equation model.

Cultural impact of rakija (CIR) scale (Yap & Nan Chen, 2017): (1) Rakija consumption is common in my community, (2) Rakija is a key part of my culture, (3) Rakija tastes good, and (4) Rakija is healthy.

Level of consumer involvement (LCI) scale (Calvo-Porrall et al., 2020): (1) beer is significant to me, (2) I have a strong interest in beer, and (3) beer matters to me, rated on a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The scale demonstrated internal reliability, with Cronbach’s alpha values exceeding .70. The term “beer” will be substituted with “rakija.”

Factors to purchase rakija (FPR) scale (Kruger & Viljoen, 2022): (1) recommendations from friends, (2) celebrity endorsements, (3) advertising, (4) positive reviews, (5) sampling at events, (6) advice from liquor store staff, (7) attractive pricing, and (8) distillery visits.

Attitudes toward rakija (ATR) scale (Spears & Singh, 2004): (1) unappealing/appealing, (2) bad/good, (3) unpleasant/pleasant, (4) unfavorable/favorable, and (5) unlikable/likable.

Rakija purchase intentions (RRI) scales (Spears & Singh, 2004): (1) never/definitely, (2) definitely do not intend to buy/definitely intend, (3) very low/high purchase interest, (4) definitely not buy it/definitely buy it, and (5) probably not/probably buy it.

The survey data was evaluated using SmartPLS version 4.1.1.2.

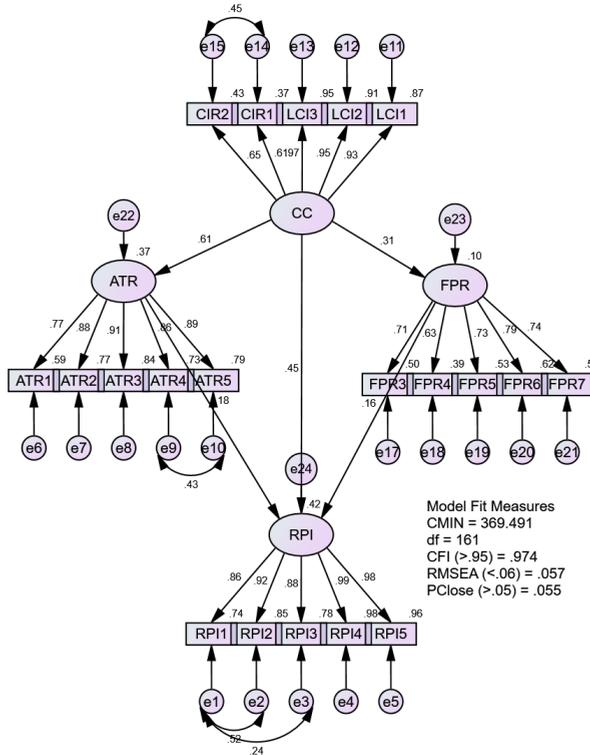
Results

CB-SEM model results

The primary aim of the published CB-SEM research (Adžić, 2025) was to develop a comprehensive latent structural equation model to investigate the cultural factors affecting consumer purchasing behaviors related to rakija, a culturally significant alcoholic beverage in Serbia. The secondary aim was to qualitatively evaluate the model’s appropriateness for examining alcoholic beverages that are specific to certain cultures and recognized nationally, as opposed to those that are universally applicable to all cultures. The key outcome of this study revealed that culture plays a substantial role in shaping consumer behavior and purchasing patterns concerning this national drink, both directly and indirectly through various mediators. Furthermore, the findings from the multigroup analysis indicated a significant difference between the group of rakija consumers who favored this culturally and nationally recognized drink and those

who continued to prefer beer. The hypothesis concerning the direct impact of culture on national alcoholic beverage purchases is well-established and has been explored in previous studies (Prendergast et al., 2010).

Figure 1. CB-SEM



Source: Adžić (2025)

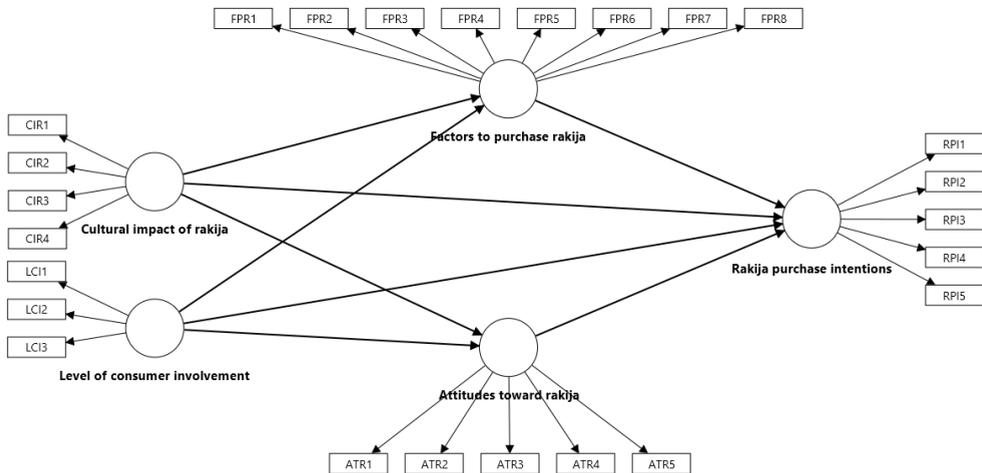
Therefore, this CB-SEM approach aimed to quantify the strength of the relationships in the model, especially in the context of rakija purchase intentions (Figure 1). Finally, all elements within the model explained .42 of the variance in consumer purchasing intentions. The direct impact of culture on the intention to purchase rakija of .45 was measured. Additionally, the model demonstrated a significant effect size, with the total direct and indirect effects of culture reaching as high as .61. Moreover, all the path coefficients were statistically significant.

Establishing PLS-SEM model

The next step was to establish a PLS-SEM model. In accordance with the characteristics of the PLS-SEM model, our objective was to achieve the highest possible R² while attaining statistical significance. As we do not have to achieve model fit, the model will contain all five latent variables with all the original 25 measured variables, unlike our CB-SEM model, where, because of reaching model fit, the number of measured

variables was reduced to 20, and the two latent variables LCI and CIR were combined into one variable, CC (consumer culture). The resulting model features two exogenous latent variables (Figure 2): the Cultural impact of rakija and the Level of consumer involvement. Preliminary analyses indicate that the R^2 value of .471 already surpasses the R^2 of .42 from the CB-SEM model. However, concerns have arisen regarding the variable Attitudes toward rakija. Namely, neither the path coefficient, that is, the direct effect of Attitudes toward rakija \rightarrow Rakija purchase intentions ($\beta = .097, t = 1.834, p = .067$), nor the specific indirect effects of Cultural impact of rakija \rightarrow Attitudes toward rakija \rightarrow Rakija purchase intentions ($\beta = .050, t = 1.779, p = .075$) and Level of consumer involvement \rightarrow Attitudes toward rakija \rightarrow Rakija purchase intentions ($\beta = .020, t = 1.537, p = .124$) achieved statistical significance. In instances where neither the direct nor indirect effects are significant within a model, we encounter a scenario referred to as no-effect non-mediation (Zhao et al., 2010). Therefore, the latent variable Attitudes toward rakija was removed from the model as an endogenous variable.

Figure 2. Preliminary PLS-SEM model



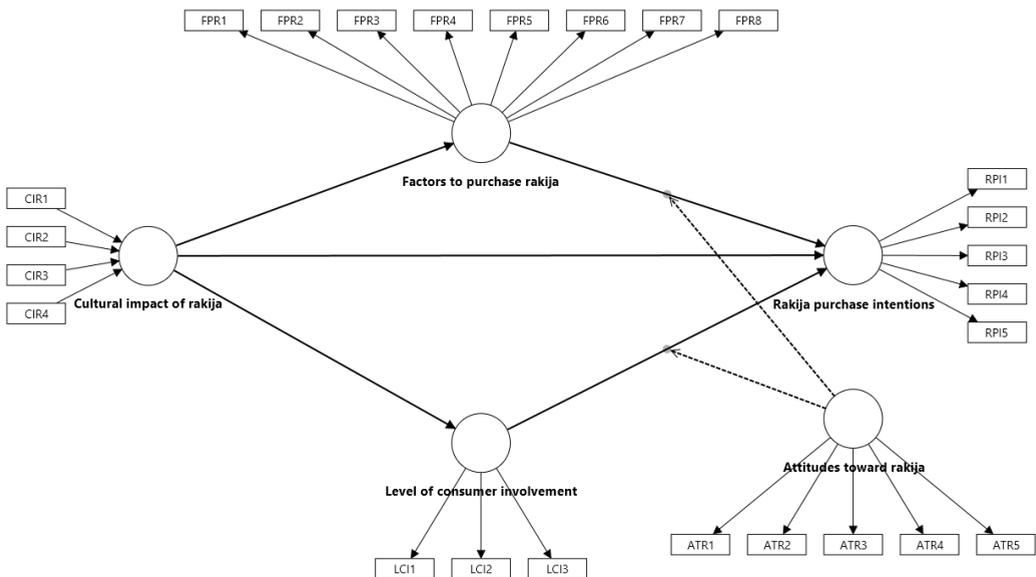
Source: Authors' calculations

Nevertheless, research indicates (Nagarjuna & Prasad, 2023; Xing & Jin, 2023) that cultural factors and values play a crucial role in shaping consumer attitudes towards products and brands; therefore, we believe that a model without this variable would be incomplete. Factors such as power distance, individualism, uncertainty avoidance, and masculinity have a positive effect on these attitudes, as they shape consumer values, beliefs, and preferences. Brand attitude frequently functions in models as a mediator or a connection between antecedents and purchase intention; however, a limited number of studies consider it as a moderator that either enhances or diminishes the relationship between predictors and purchase intention. The frameworks of consumer-brand relationships and emotional cognition provide foundational support for models in which attitudes interact with commitment, attachment, or product cues to influence

intentions (Gul et al., 2021). Consequently, research positions brand attitude as a mediator, moderator, or component within moderated mediation models, depending on the theoretical perspective and research inquiry. Razak et al. (2019) showed that brand attitude moderates the relationship between brand awareness and repurchase intention. Majeed et al. (2024) examined the moderating effects of consumer attitudes in the context of luxury brand purchases and the high retail prices of rakija (Adžić et al., 2024), which influence the fact that this drink is purchased mainly as a gift rather than for everyday consumption, certainly position this domestic alcoholic beverage as a luxury product. Consequently, the variable Attitudes toward rakija were examined in the model as a moderating variable.

The next modification of the model involved repositioning the Level of consumer involvement variable. It transitioned from an initial exogenous variable to a mediating endogenous variable in the model. Logic dictates (Hair et al., 2021) that the Cultural impact of rakija precedes the Level of consumer involvement, a perspective also supported by the existing literature. For instance, Gelbrich et al. (2023) highlighted the crucial role of cultural background in shaping consumer involvement in purchasing decisions by influencing values such as individualism, indulgence, and uncertainty avoidance. These values, in turn, affect how consumers search for, assess, and select products, thereby directing their purchasing behavior across various cultural settings. Figure 3 depicts a conclusive model suitable for further evaluation.

Figure 3. Final PLS-SEM model

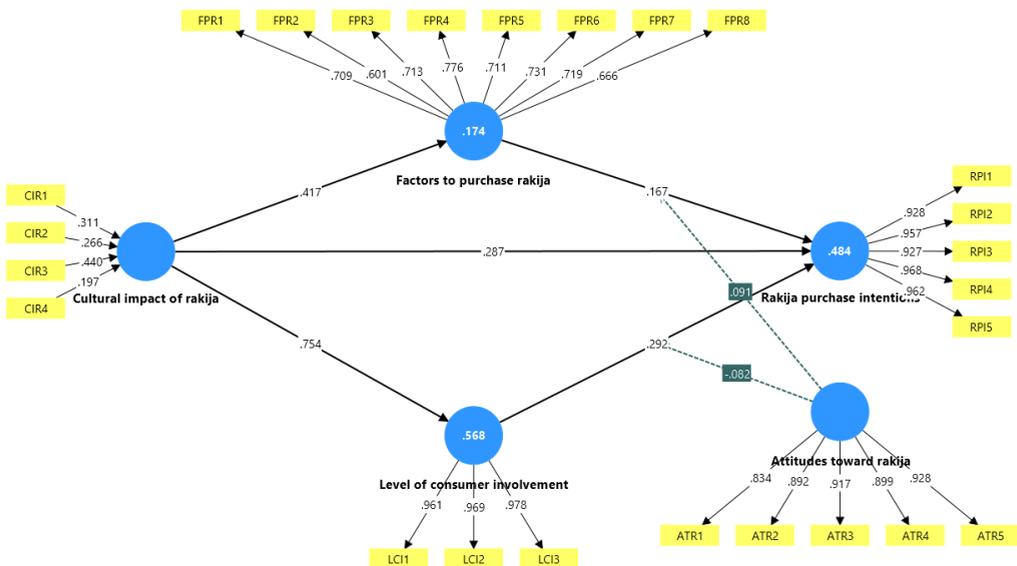


Source: Authors' calculations

Analysis of the measurement model

Given that data preparation (missing data and unengaged responses) and variable screening (skewness and kurtosis, common method bias, multicollinearity (VIF), and influentials) have already been positively verified in the CB-SEM model, we will not repeat these processes. Additionally, a demographic analysis of the respondents has already been conducted. We proceed with the multivariate analysis, beginning with the measurement model analysis. This analysis identifies the relationship between observed or measured variables and a latent variable in a specified study. It is essential to assess the reliability and validity of the measurement variables. The procedures for evaluating reflective and formative measurement models differ (Hair et al., 2021), and we began with the former model.

Figure 4. PLS-SEM algorithm



Source: Authors' calculations

The proposed *reflective measurement model* was evaluated using the PLS-SEM algorithm (Figure 4). Factor outer loading values above .708 and average variance extracted (AVE) values above .50 were used to determine convergent validity. Most of the factor loading values were greater than .708, which is considered acceptable (Table 1). Of the 21 factor loadings, two were below the strict threshold but still exceed the minimum limit of .40; thus, we will keep them. Three of the four Average Variance Extracted (AVE) values exceeded the threshold, while one was just below it (see Table 2). In fact, removing factor FPR2, which has a value of .601, would enhance the AVE score for the latent variable Factors to Purchase Rakija, bringing it above the threshold. However, this adjustment would result in a decrease of 0.1 percentage points in the R^2 value, which was not our intention. However, any adjustment would be contrary to research findings that close-fitting models may be inferior and causally

misspecified (Hayduk, 2014) and that improving model fit may come at the cost of theoretical integrity and a decrease in the replication of parameter values (Hermida, 2015). Therefore, we did not modify the originally established model. In conclusion, convergent reliability can be considered acceptable.

Table 1. Outer loadings matrix

	Attitudes toward rakija	Factors to purchase rakija	Level of consumer involvement	Rakija purchase intentions
ATR1	.834			
ATR2	.892			
ATR3	.917			
ATR4	.899			
ATR5	.928			
FPR1		.709		
FPR2		.601		
FPR3		.713		
FPR4		.776		
FPR5		.711		
FPR6		.731		
FPR7		.719		
FPR8		.666		
LCI1			.961	
LCI2			.969	
LCI3			.978	
RPI1				.928
RPI2				.957
RPI3				.927
RPI4				.968
RPI5				.962

Source: Authors' calculations

Cronbach's alpha values above .70 and composite reliability values above .70 were used to determine construct reliability. The construct reliability was confirmed as all Cronbach's alpha values for the latent variables, and all composite reliability values were green, that is, above the threshold (Table 2). Some researchers (e.g. Hair et al., 2019) suggested that a Cronbach's alpha above .9 may indicate potential concerns. However, high Cronbach's alpha values are not inherently problematic. A frequent issue in empirical research occurs when researchers include redundant items that do not provide new information, simply repeating the same aspect of the phenomenon, such as saying "I enjoy rakija" and "I really enjoy rakija." If the items capture different aspects of the constructs being assessed but still show a high correlation, it indicates a solid measurement model, as demonstrated in our study. A strong correlation among items that investigate various dimensions of constructs can signify a robust measurement model, particularly when evaluating convergent validity, which examines the connections between theoretically related constructs (Shenoy et al., 2021).

Table 2. Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Attitudes toward rakija	.937	.939	.952	.800
Factors to purchase rakija	.863	.905	.887	.497
Level of consumer involvement	.968	.968	.979	.939
Rakija purchase intentions	.972	.972	.978	.900

Source: Authors' calculations

The primary criterion (Hair et al., 2012, p. 132) for discriminant validity assessment was the Heterotrait-Monotrait Ratio (HTMT). Discriminant validity was established when the HTMT value was below .90. In this study, all HTMT values were recorded as being under .90, as illustrated in Table 3. These findings indicate that all latent variables are unique, thereby confirming discriminant validity.

Table 3. Discriminant validity – Heterotrait-monotrait ratio (HTMT) matrix

	Attitudes toward rakija	Factors to purchase rakija	Level of consumer involvement	Rakija purchase intentions	Attitudes toward rakija x Level of consumer involvement	Attitudes toward rakija x Factors to purchase rakija
Attitudes toward rakija						
Factors to purchase rakija	.322					
Level of consumer involvement	.623	.404				
Rakija purchase intentions	.529	.424	.639			
Attitudes toward rakija x Level of consumer involvement	.207	.139	.017	.111		
Attitudes toward rakija x Factors to purchase rakija	.267	.133	.134	.087	.551	

Source: Authors' calculations

In this *the formative measurement model*, the key elements for model analysis are the bootstrapped outcomes for the outer weights. If we establish that the outer weights are relevant (positive and above zero) and significant, the model is considered positively tested (if not, see Hair et al. (2021, p. 152)). To obtain these results, we applied the bootstrapping procedure in PLS-SEM using 10,000 bootstrap samples and complete (slower) procedures. Streukens and Leroi-Werelds (2016) proposed that a minimum of 10,000 bootstrap samples should be used in PLS-SEM. According to the results presented in Table 4, we can conclude that the formative construct exhibits satisfactory quality levels.

Table 4. Outer weight bootstrapped results of the formative variable Cultural impact of rakija

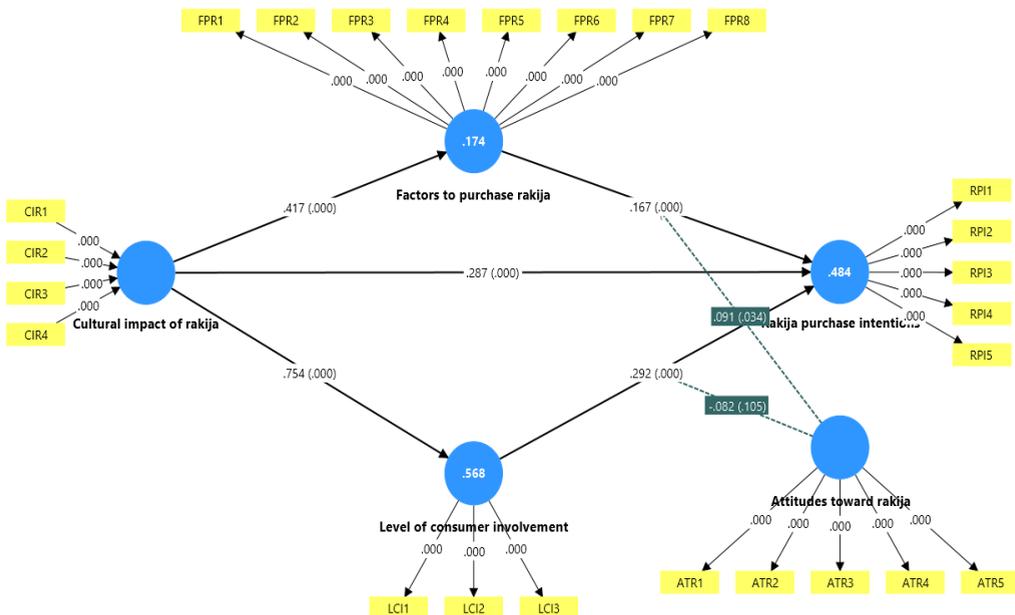
	Original sample (O)	T statistics ((O/STDEV))	P values	CI 2.5%	CI 97.5%
CIR1 -> Cultural impact of rakija	.311	4.581	.000	.177	.443
CIR2 -> Cultural impact of rakija	.266	3.708	.000	.128	.410
CIR3 -> Cultural impact of rakija	.440	6.553	.000	.306	.570
CIR4 -> Cultural impact of rakija	.197	3.690	.000	.096	.307

Source: Authors' calculations

Analysis of the structural model

The structural model was evaluated after confirming the overall validity of the measurement model. This analysis of the structural model was used to test the hypotheses (Hair et al., 2021). Nevertheless, the hypotheses were not established in this study. To obtain these results, we applied the bootstrapping procedure in PLS-SEM using 10,000 bootstrap samples and the most important (faster) procedures (Figure 5).

Figure 5. Bootstrapping output



Source: Authors' calculations

Table 5 illustrates the results of the structural model (path coefficients, i.e., direct effects), including beta, t-statistics, and p-values. The results show that all five relationships are statistically significant.

Table 5. Path coefficients (direct effects)

	Original sample (O), i.e. β	T statistics (O/STDEV)	P values
Cultural impact of rakija -> Factors to purchase rakija	.417	9.642	.000
Cultural impact of rakija -> Level of consumer involvement	.754	33.326	.000
Cultural impact of rakija -> Rakija purchase intentions	.287	4.786	.000
Factors to purchase rakija -> Rakija purchase intentions	.167	3.687	.000
Level of consumer involvement -> Rakija purchase intentions	.292	4.491	.000

Source: Authors' calculations

Analysis of the explanatory power of the model and its effect size

Next, we shifted our focus to evaluating the explanatory power of the model. To accomplish this, we revisited the results generated by SmartPLS after executing of the PLS-SEM algorithm. The explanatory power of the structural model in PLS is determined by the coefficient of determination, commonly referred to as R^2 . This value reflects the extent of the variance accounted for by all predictors of the dependent variable within the model (Hair et al., 2021). R^2 values of .75, .50, and .25 signify substantial, moderate, and weak explanatory powers, respectively. The study aimed to attain the maximum achievable R^2 for the final endogenous variable, Rakija purchase intentions. As illustrated in Table 6, the analysis shows that the model can explain approximately 48.4% of the variation in Rakija purchase intentions. Although the observed explanatory power of the Rakija purchase intentions variable is not substantial, the R^2 value of .484 from the PLS-SEM study is certainly larger than the R^2 value of .42 from the CB-SEM study.

Table 6. The explanatory power of the model R^2

	R-square	Comment
Factors to purchase rakija	.174	weak
Level of consumer involvement	.568	substantial
Rakija purchase intentions	.484	moderate

Source: Authors' calculations

Effect size f^2 aids in evaluating the extent to which an exogenous construct contributes to the R^2 value of the predictor latent variable (Hair et al., 2021). Table 12 shows the f^2 values for all combinations of endogenous constructs (represented by the columns) and the corresponding exogenous (i.e., predictor) constructs (represented by rows). The f^2 values of .02, .15, and .35 correspond to small, medium, and large effects, respectively. Effect size values below .02 suggest no measurable effects. In Table 7, substantial size

effects (medium and large) are displayed in green font, whereas small effect sizes are shown in black font. Insignificant effects are represented in red font, according to the thresholds established by Hair et al. (2012), which serve as the basis for the calculations performed by the SmartPLS software. However, Hair et al. (2021) recommend using values of .005, .01, and .025 for the moderator's f^2 effect size, which are classified as small, medium, and large, respectively, according to Kenny (2018). Accordingly, the effect size of Attitudes toward rakija x Factors to purchase rakija, which was statistically significant, was .014, indicating a medium effect size.

Table 7. The effect size f^2

	Cultural impact of rakija	Factors to purchase rakija	Level of consumer involvement	Rakija purchase intentions
Cultural impact of rakija		.210	1.314	.055
Factors to purchase rakija				.043
Level of consumer involvement				.066
Rakija purchase intentions				
Attitudes toward rakija x Level of consumer involvement				.009
Attitudes toward rakija x Factors to purchase rakija				.014

Source: Authors' calculations

For agricultural economics and agribusiness research, these results reinforce the relevance of PLS-SEM as a viable and methodologically sound alternative to CB-SEM.

Discussions and Conclusions

PLS-SEM exhibited a lower beta value for the total effects coefficient of the most significant path in the model, Cultural impact of rakija → Rakija purchase intentions, compared to CB-SEM, with values of .577 and .610, respectively. This observation, which indicates that the estimates from the PLS-SEM structural model are generally lower than those obtained from CB-SEM, was also noted by Reinartz et al. (2009). Conversely, as identified by Hair et al. (2024), the coefficients of determination, or R^2 values, for the two models diverge in the opposite manner. PLS-SEM recorded a higher R^2 value for the endogenous construct of Rakija purchase intentions than CB-SEM, with values of .484 compared to .420.

In the context of theory building, CB-SEM and AMOS are logical selections because they allow for the construction of a model and the adjustment of variables until an optimal fit is reached. Conversely, for theory testing, PLS-SEM and SmartPLS are appropriate options. Furthermore, when the objective is prediction, PLS-SEM is the preferred approach. In our case, the application of CB-SEM yielded a model that effectively analyzed the impact of culture on consumer purchasing behavior across all alcoholic beverages that hold cultural significance for consumers, extending beyond rakija. SEM-PLS identified a key factor within the model that influences consumer

purchasing behavior for the culturally specific product, Serbian rakija, highlighting an enhancement in the product's taste.

Undoubtedly, no modeling technique is without its flaws. PLS-SEM can generate formative latent variables that can be empirically validated using an advanced PLS-CTA model. In contrast, the CB-SEM does not accommodate formative variables. While CB-SEM can construct non-recursive models (with feedback loops) models, PLS-SEM is unable to do so. PLS-SEM evaluates differences among groups at the path level, whereas CB-SEM assesses differences at the group level, which is a benefit of CB-SEM.

CB-SEM is a common factor-based structural equation modeling method, with results derived from covariance and covariance matrices. In contrast, PLS-SEM employs a composite-based approach to structural equation modeling, generating results based on variance and real data. The estimation technique for CB-SEM utilizes maximum likelihood estimation, whereas PLS-SEM employs partial least squares estimation. Consequently, it is reasonable to expect that these methodologies may yield different outcomes, as evidenced by our model concerning the latent variable Attitude toward rakija.

SmartPLS also has a consistent PLS SEM (PLSc-SEM) algorithm. This algorithm can mimic CB-SEM (Hair et al., 2021). For those concerned about the discrepancies in the results between PLS-SEM and CB-SEM outputs, the two yield remarkably similar findings. Additionally, SmartPLS includes a Generalized Structured Component Analysis (GSCA) module. GSCA represents a composite-based SEM methodology similar to PLS (Hair et al., 2021). For those who prioritize this, GSCA enhances the overall model fit among composites; this does not have to be done in the SEM-PLS. Finally, SmartPLS is also capable of conducting CB-SEM analysis (Hair et al., 2025), positioning it as a versatile software that accommodates traditional, modern, and emerging SEM models (such as GSCA), establishing itself as an indispensable and comprehensive SEM software tool for researchers.

The primary contribution of this paper is methodological. The advantage of this study lies in its emphasis on the advantages and superiority of SmartPLS software and PLS-SEM over to AMOS and CB-SEM. Future research may extend this comparison to other agri-food products and cultural settings, as well as explore how methodological choices influence policy-relevant and managerial interpretations of consumer behavior models.

Conflict of interests

The authors declare no conflict of interest.

References

1. Adžić, S. (2025). Exploring cultural influences on national alcoholic beverage purchases: A full latent variable structural equation model. *International Journal of Wine Business Research*, 37(3), 445–475. <https://doi.org/10.1108/IJWBR-05-2024-0029>

2. Adžić, S., Pavlović, M., Milunović, M., Pavlović, Đ., Savić Tot, T., & Radanov, P. (2024). The impact of rakija cultural heritage and rakija marketing on the consumer purchasing decisions. *Economics of Agriculture*, 71(3), 923–941. <https://doi.org/10.59267/ekoPolj2403923A>
3. Calvo-Porrall, C., Rivaroli, S., & Orosa-Gonzalez, J. (2020). How consumer involvement influences beer flavour preferences. *International Journal of Wine Business Research*, 32(4), 537–554. Emerald Insight. <https://doi.org/10.1108/IJWBR-10-2019-0054>
4. Gelbrich, K., Müller, S., & Westjohn, S. (2023). Cross-Cultural Consumer Behavior. In *Cross-Cultural Consumer Behavior*. Edward Elgar Publishing. <https://www.elgaronline.com/monobook/book/9781803923192/9781803923192.xml>
5. Gul, G. F., Gul, G. N., Gul, G. R., Zhenxing, G., Gul, G. W., & Nawaz, T. M. (2021). The Ties That Bind: Do Brand Attachment and Brand Passion Translate Into Consumer Purchase Intention? *Journal of Management and Business Administration. Central Europe*, 29(1), 14–38.
6. Hair, J. F., Babin, B. J., Ringle, C. M., Sarstedt, M., & Becker, J.-M. (2025). Covariance-based structural equation modeling (CB-SEM): A SmartPLS 4 software tutorial. *Journal of Marketing Analytics*. <https://doi.org/10.1057/s41270-025-00414-6>
7. Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. SAGE Publications.
8. Hair, J. F., Ringle, C. M., & Sarstedt, M. (2012). Partial Least Squares: The Better Approach to Structural Equation Modeling? *Long Range Planning, Analytical Approaches to Strategic Management: Partial Least Squares Modeling in Strategy Research*, 45(5), 312–319. <https://doi.org/10.1016/j.lrp.2012.09.011>
9. Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2–24. <https://doi.org/10.1108/EBR-11-2018-0203>
10. Hair, J. F., Sarstedt, M., Ringle, C. M., & Gudergan, S. P. (2024). *Advanced Issues in Partial Least Squares Structural Equation Modeling*. SAGE Publications, Incorporated.
11. Hayduk, L. (2014). Seeing Perfectly Fitting Factor Models That Are Causally Misspecified: Understanding That Close-Fitting Models Can Be Worse. *Educational and Psychological Measurement*, 74(6), 905–926. <https://doi.org/10.1177/0013164414527449>
12. Hermida, R. (2015). The Problem of Allowing Correlated Errors in Structural Equation Modeling: Concerns and Considerations. *Computational Methods in Social Sciences*, 3, 1–17.

13. Hwang, H., Sarstedt, M., Cheah, J. H., & Ringle, C. M. (2020). A concept analysis of methodological research on composite-based structural equation modeling: Bridging PLSPM and GSCA. *Behaviormetrika*, 47(1), 219–241. <https://doi.org/10.1007/s41237-019-00085-5>
14. Kenny, D. A. (2018). *SEM: Moderation*. <https://davidakenny.net/cm/moderation.htm>
15. Kruger, M., & Viljoen, A. (2022). That old saying about wine and age: Identifying South African age-cohort preferences. *International Journal of Wine Business Research*, 34(4), 495–522. Emerald Insight. <https://doi.org/10.1108/IJWBR-06-2021-0033>
16. Majeed, M. U., Aftab, H., Arslan, A., & Shakeel, Z. (2024). Determining online consumer’s luxury purchase intention: The influence of antecedent factors and the moderating role of brand awareness, perceived risk, and web atmospherics. *PLOS ONE*, 19(2), e0295514. <https://doi.org/10.1371/journal.pone.0295514>
17. Nagarjuna, B., & Prasad, K. R. (2023). Impact of Cultural Elements on Brand Preferences An Explorative Research. *European Journal of Business and Management*, 15(10), 13–32.
18. Prendergast, G. P., Tsang, A. S. L., & Chan, C. N. W. (2010). The interactive influence of country of origin of brand and product involvement on purchase intention. *Journal of Consumer Marketing*, 27(2), 180–188. <https://doi.org/10.1108/07363761011027277>
19. Razak, N., Themba, O. S., & Sjahruddin, H. (2019). Brand awareness as predictors of repurchase intention: Brand attitude as a moderator. *Advances in Social Sciences Research Journal*, 6(2), 541–554. <https://doi.org/10.14738/assrj.62.6264>
20. Reinartz, W., Haenlein, M., & Henseler, J. (2009). An empirical comparison of the efficacy of covariance-based and variance-based SEM. *International Journal of Research in Marketing*, 26(4), 332–344. <https://doi.org/10.1016/j.ijresmar.2009.08.001>
21. Ringle, C. M., Wende, S., & Becker, J.-M. (2024). *SmartPLS* [Computer software]. Bönningstedt: SmartPLS. Retrieved from <https://www.smartpls.com>.
22. Shenoy, V., Aithal, P. S., & Raj, K. (2021). *Exploring Convergent Validity for Select Employability Skill Constructs* (SSRN Scholarly Paper No. 4079676). Social Science Research Network. <https://doi.org/10.2139/ssrn.4079676>
23. Spears, N., & Singh, S. (2004). Measuring Attitude Toward the Brand and Purchase Intentions. *Journal of Current Issues and Research in Advertising*, 26, 53–66. <https://doi.org/10.1080/10641734.2004.10505164>

24. Streukens, S., & Leroi-Werelds, S. (2016). Bootstrapping and PLS-SEM: A step-by-step guide to get more out of your bootstrap results. *European Management Journal, European Management Research Using Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 34(6), 618–632. <https://doi.org/10.1016/j.emj.2016.06.003>
25. UNESCO. (2022). *UNESCO - Social practices and knowledge related to the preparation and use of the traditional plum spirit – šljivovica*. <https://ich.unesco.org/en/RL/social-practices-and-knowledge-related-to-the-preparation-and-use-of-the-traditional-plum-spirit-ljivovica-01882>
26. Wong, K. K.-K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Marketing Bulletin*, 24(1), 1–32.
27. Xing, Y., & Jin, C.-H. (2023). The Impact of Cultural Values on Attitude Formation toward Cultural Products: Mediating Effects of Country Image. *Sustainability*, 15(14), Article 14. <https://doi.org/10.3390/su151411172>
28. Yap, M. H. T. & Nan Chen. (2017). Understanding young chinese wine consumers through innovation diffusion theory. *Tourism & Hospitality Management*, 23(1), 51–68. <https://doi.org/10.20867/thm.23.1.3>
29. Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and Truths about Mediation Analysis. *Journal of Consumer Research*, 37(2), 197–206. <https://doi.org/10.1086/651257>

FINANCIAL FRAUD RISK MANAGEMENT IN DAIRY COMPANIES IN SERBIA

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ABSTRACT

This paper examines the management of fraud risk in dairy companies. The research was conducted on a random sample of 110 respondents employed in companies operating within the dairy industry in the Republic of Serbia, who hold key managerial positions (general manager or chief financial officer) or perform roles such as internal auditor, risk controller, head of accounting, or similar positions. The Partial Least Squares Structural Equation Modelling (PLS-SEM) method was applied in the analysis. The findings indicate that awareness of operational fraud becomes a protective factor only when it leads to the concrete improvement of control and preventive mechanisms. The results contribute to a better understanding of the necessity to strengthen managerial capacities and the regulatory framework to enhance financial transparency and protect the integrity of the dairy sector in Serbia.

Introduction

In 2024, the European Union produced 161.8 million tonnes of raw milk, which is 0.9 million tonnes more than in 2023. With regard to milk production at farms, according to Eurostat data (Eurostat, 2024), Germany ranks first in terms of production value, followed by France, Turkey, Poland, and the Netherlands.

As for Serbia, which has favorable natural conditions for the development of livestock farming, particularly cow's milk production (Tomić et al., 2020), data from the Statistical

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Office of the Republic of Serbia (SORS, 2024) indicate that cow's milk production recorded a slight increase in 2024 compared to the previous year, while the production of dairy products declined. Total milk production (all types of milk) on farms amounted to 1,379,000 tonnes, of which cow's milk accounted for 1,350,000 tonnes (98%).

According to financial statements data (Business Registers Agency, 2024), companies engaged in milk processing and cheese production in Serbia generated total profits of RSD 3,936,626,000 in 2024, with 353 companies operating in this sector. Table 1 presents ten companies ranked by revenue and profit achieved in 2024. It is not sufficient to state that one dairy company is more profitable than another; rather, the causes and factors that likely influenced such outcomes must also be considered (Mitrović et al., 2015:1068). Users of financial statements can improve decision-making by applying various analytical models (Kovjanić et al., 2023).

Ten companies in milk processing and cheese production ranked by revenue and profit in 2024 are: AD IMLEK, MLEKARA-UB DOO, SOMBOLED DOO SOMBOR, GRANICE DOO MLADENOVAC, MILK HOUSE DOO, MLEKOPRODUKT ZRENJANIN, MILOVANOVIĆ DOO, MLEKARA MIHAJLOVIĆ DOO PARAĆIN, LAZAR DOO BLACE, ZORNIĆ DOO TUTIN-VELJE POLJE (Business Registers Agency, 2024).

From the complexity of supply chains, volatility of purchase prices, and underdeveloped internal control mechanisms, numerous risk factors arise. The dairy sector displays a heightened vulnerability to financial manipulation, primarily due to the predominance of cash-based transactions, recurrent inconsistencies in the measurement and processing of raw milk, and the potential for accounting irregularities in areas such as inventory valuation, supplier invoicing, and the reporting of production costs.

Common manifestations of financial fraud within the dairy sector encompass the falsification of invoices and raw material quantity records, manipulation of yield and loss indicators during production, fabrication of procurements and related-party contractual arrangements, covert misappropriation of inventories, and financial reporting distortion through inappropriate inventory valuation and the unrealized revenues recognition.

Limited process transparency, inadequate accounting controls, digital traceability, and forensic methodologies substantially elevate fraud risk. In order to mitigate these vulnerabilities, it is necessary to implement a risk management framework integrating financial forensics, strengthened internal controls, independent auditing, data analytics, and early warning systems.

In Serbia, to the best of the authors' knowledge, financial fraud in dairy enterprises remains an underexplored research area. Within a knowledge-based economy, the relevance of accounting information is increasing (Knežević et al., 2023). However, deficiencies in internal monitoring and fragmented audit oversight create systemic vulnerabilities that facilitate both the emergence and escalation of fraudulent practices.

The absence of standardized digitalization and advanced information systems across companies hinders effective detection and prevention of irregularities. Furthermore, limited forensic analysis, stemming from a shortage of specialized accounting expertise and inadequate implementation frameworks, constitutes a major barrier to addressing financial crime (Janković et al., 2023).

The purpose of this study was to explore how perceptions of different forms of fraud, ranging from financial reporting to operational and transactional misconduct, shape the extent of their adverse impact on business performance, while also assessing the mitigating role of preventive measures. Particular attention was paid to differentiating between the influence of general awareness of fraud risks and the tangible effects of formally implemented control and prevention mechanisms.

The study further sought to empirically assess whether preventive measures function exclusively by directly mitigating the adverse consequences of fraud, or whether they exert a more complex influence through moderating and mediating effects on the relationship between fraud perception and operating performance. Thereby, the paper aims to clarify the mechanisms by which fraud risk is transformed into measurable operating outcomes.

Finally, the paper aims to contribute to a better comprehension of fraud risk management from the perspective of organizational practices, emphasizing that the identification and perception of fraud are not sufficient without institutionalized preventive measures. Thus, the study provides an empirical basis for management recommendations regarding the development and strengthening of internal control and fraud prevention systems. Such an approach enables improved financial transparency, reduced losses, and increased confidence among investors and other stakeholders.

Literature Review

The dairy industry, a key segment of the food sector, is primarily engaged in the production and processing of milk and related products. Within this context, food fraud has emerged as a growing concern due to its potential to impose substantial financial losses and reputational damage. Milk, in particular, is highly susceptible to fraud and adulteration, often driven by financial gain or misguided efforts to improve hygiene standards. Such activities pose significant risks, including serious public health consequences (Handford et al., 2016).

Undergoing continuous transformation, the dairy industry is faced with a diverse set of challenges. Among the most critical issues highlighted by stakeholders are the rising demands for animal welfare, the need to improve herd health, the imperative to address environmental sustainability, the complexities of intergenerational ownership transfers, insufficient investment in pasture-focused research, the pursuit of sustainable and efficient industry structures, and the maintenance of competitive international marketing strategies (Conforten et al., 2008).

In circumstances characterized by the increasing sophistication of fraud risks and their potential consequences, dairy enterprises (as well as other companies) must develop and implement an adequate framework for the strategic mitigation of fraud risk, which in turn can have a positive impact on the optimization of financial performance. In a general sense, fraud is defined as intentional deception undertaken for financial or personal gain (Kabir Usman, 2013:4).

Fraud can be observed at two levels. The first is the corporate level, which involves abuse by internal actors and, sporadically, external collaborators, thereby undermining the company's financial position. The second level is the managerial level, which refers to deceptive practices by managers directed toward external stakeholders, usually aimed at preserving the company's reputation or its perceived performance. When defining a fraud risk management framework, it is necessary to give special consideration to these two main forms, in accordance with the organizational contexts in which they arise.

Accounting fraud has had a detrimental impact on global economies over recent decades, which underscores the assertion that fraud risk can and must be controlled. Fraudulent financial reporting generates significant losses for both corporations and individuals, and the majority of fraud cases are internal in nature. It is precisely the growing prevalence of such practices that has placed fraud detection and prevention at the center of attention of both academic researchers and practitioners. As a particularly important issue, it has also attracted substantial attention from regulators, auditors, accountants, and the general public. In this context, it is necessary to examine the scope and application of new technologies that enable the detection of fraud through real-time transaction monitoring, immediately as it occurs.

Generally speaking, integrity is an important element of organizational operations, while financial integrity represents a fundamental component of market systems, ensuring trust and stability in economic transactions. Raising awareness of organizational fraud should lead to improvements in the performance of financial integrity systems. The occurrence of financial fraud disrupts established market rules on the one hand and negatively affects financial integrity by undermining it on the other, which together results in adverse implications for the broader public interest. Integrating fraud prevention strategies with broader financial management practices requires the adoption of robust preventive and detection mechanisms, particularly in light of a turbulent and technologically dynamic business environment. This represents the most effective way to protect organizations from accounting fraud while simultaneously preserving systemic stability and enhancing efficiency.

Throughout the 1990s and early 2000s, numerous financial accounting scandals emerged in the United States and other countries. In response, jurisdictions such as the United States and Italy introduced legislative reforms to strengthen financial reporting and corporate governance frameworks (Sorensen & Miller, 2017). Historical fraud cases provide valuable insights for constructing models to identify and assess fraud risk, while the development of innovative techniques to prevent fraudulent reporting remains a critical element of comprehensive fraud risk management. All of this requires the

integration of fraud prevention strategies with broader financial management practices to improve the efficiency of this process.

Shi (2025) demonstrates that short-selling can serve as an effective mechanism for restraining corporate financial fraud, complementing regulatory oversight while functioning as a corrective force that expedites the market exit of low-quality firms and safeguards investor interests. A prominent illustration is Muddy Waters' short-selling of Huishan Dairy, ultimately leading to the company's delisting and the erosion of approximately 30 billion yuan in market value.

Ranking among the largest financial frauds in global business history is the Parmalat S.p.A. scandal, involving the Italian dairy and food corporation later acquired by the French multinational Lactalis, which is frequently described as the European counterpart to the Enron case. Exposed in 2003, the scandal revealed a €14 billion deficit arising from fraudulent practices, mismanagement, and oversight failures (Cambaza, 2024). Suspicion intensified when the firm, despite reporting substantial cash reserves, continued to seek large debt financing. On December 19, 2003, Parmalat disclosed that €3.95 billion in cash was missing from its balance sheet, while executives attempted to conceal evidence of off-balance-sheet transactions.

Materials and Methods

Sample Construction and Data

The research was conducted from February to March 2025 and included a total of 110 respondents. The study involved employees of companies operating in the Serbian dairy industry who were engaged in key managerial positions (general manager or chief financial officer) or held one of the following roles: internal auditor, risk controller, head of accounting, or similar positions. These respondents were identified as key informants with regard to the subject of the research.

The sampling process was based on a random sampling method, and respondents were approached via social media platforms. All participants were informed about the purpose and academic nature of the research, and anonymity was guaranteed. Additional assurance of anonymity and objectivity was achieved through the use of an online questionnaire for data collection.

As shown in Table 1, the sample was evenly distributed by gender, with 50% male and 50% female respondents. The majority of respondents held postgraduate degrees (52.7%), while 47.3% had completed undergraduate studies or lower levels of education. Most respondents had up to 10 years of work experience (72.7%), whereas 27.3% had more than 10 years of experience. Regarding organizational position, 47.3% of respondents were directors (general or financial directors), while 52.7% belonged to other categories of employees (internal auditors, risk controllers, heads of accounting, and others). Most respondents were employed in companies with 30 or fewer employees (54.5%), while 45.5% worked in larger companies.

Table 1. Structure of the sample

Variable		Absolute frequency	Relative frequency
Gender	Male	55	50%
	Female	55	50%
Education	Undergraduate or lower	52	47,3%
	Postgraduate (Master's/PhD)	58	52,7%
Work experience	≤ 10 years	80	72,7%
	> 10 years	30	27,3%
Position in company	Directors (General/CFO)	52	47,3%
	Other (Internal auditor/Risk controller/Head of accounting/Other)	58	52,7%
Number of employees	≤ 30	60	54,5%
	> 30	50	45,5%

Source: Authors' calculations

Research Design

The core research premise is that mere awareness of potential fraud (financial reporting and operational–transactional) is not sufficient to reduce the negative effects of fraud or to prevent it indirectly; such outcomes are achieved only when preventive measures are actively implemented. Accordingly, the following hypotheses were formulated:

H1: Perception of the existence of financial reporting fraud does not contribute to reducing the negative effects of fraud on business performance.

Awareness of the existence of fraudulent financial reporting does not in itself imply the undertaking of preventive actions. It is not sufficient for management and employees merely to identify the risk without recognizing the necessity of implementing effective control mechanisms, as in such cases, no changes will occur in the impact of fraud on business performance. It follows that the perception of fraud, if not accompanied by a concrete and operational response, will not mitigate the negative consequences for business operations.

H2: Perception of the existence of operational–transactional fraud does not contribute to reducing the negative effects of fraud on business performance.

Even when there is awareness that operational–transactional fraud exists, as it is often embedded in everyday business processes, such fraud may nevertheless persist and threaten the company's operations. Under such circumstances, mere perception of its existence, if not accompanied by enhanced internal controls and oversight, does not necessarily lead to a reduction in its negative impact on the organization's key financial performance indicators. Therefore, it is emphasized that awareness of operational–transactional fraud alone has no effect on the improvement of business performance.

H3: Preventive measures contribute to reducing the negative effects of fraud on business performance.

Preventive measures, such as strengthening internal controls, segregation of duties, and continuous employee training, represent key mechanisms for limiting the scope and consequences of fraud. Their adequate implementation may have a positive effect on the occurrence of fraud in terms of its frequency. Furthermore, such measures may lead to a reduction in financial losses resulting from fraud, as well as in reputational damage. In light of the above, it is assumed that preventive measures are relevant due to their contribution to mitigating the negative effects of fraud on the financial performance of enterprises.

H4: Preventive measures exert a significant mediating effect on the relationship between financial reporting fraud and the negative effects of fraud.

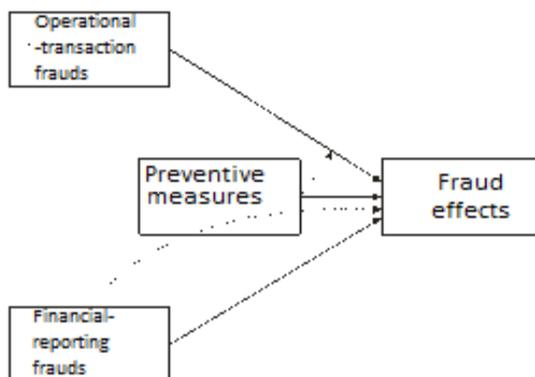
The impact of fraudulent financial reporting on business performance may be indirectly shaped through the implementation of preventive measures. Preventive activities can reduce the intensity and duration of negative consequences even when fraud is present. Therefore, it is assumed that preventive measures play a significant mediating role in the relationship between fraudulent financial reporting behavior and its negative effects.

H5: Preventive measures exert a significant mediating effect on the relationship between operational–transactional fraud and the negative effects of fraud.

Operational–transactional fraud is characterized by its direct impact on costs, efficiency, and the reliability of business processes; however, despite this, its effects may be mitigated through timely and appropriately designed preventive measures. The mechanisms that can be identified for this purpose, if properly implemented, can significantly limit the extent of damage and prevent the recurrence of similar abuses and fraudulent activities. From this, it can be inferred that preventive measures mediate the relationship between operational–transactional fraud and its negative effects on business performance.

Based on the above, a research model was constructed (Figure 1).

Figure 1. Research model



Source: Authors' calculations

Measurement of Constructs and Model

For this study, a structured questionnaire was developed, encompassing four variables: preventive measures, financial reporting fraud, operational–transactional fraud, and the effects of fraud on company performance. The questionnaire items were formulated based on relevant scientific literature (Sipayung et al., 2022; Špiler et al., 2024) and guidelines issued by leading international institutions in the field of fraud risk management (COSO & ACFE, 2023), with particular emphasis on adapting the items to the specific context of the dairy industry.

Content validity of the instrument was ensured through theoretical analysis and consultations with experts in accounting, auditing, and internal control, confirming that the statements were clearly formulated and relevant to the research framework. Each statement included in the questionnaire was assessed using a five-point Likert scale, where “1” indicated *Strongly disagree* and “5” indicated *Strongly agree*.

The first part of the questionnaire consisted of statements used to assess the status of the independent and dependent variables in the research model. The second part included questions related to the respondents’ sociodemographic characteristics (gender, education level, work experience, position in the company, number of employees, and possession of professional certifications), thereby providing data necessary to assess sample representativeness.

The constructs and measurement statistics are presented in Table 2. In accordance with the recommendations of Hair and Alamer (2022), indicators with convergent validity below 0.6, as well as those exhibiting high variance inflation factor ($VIF > 5$) values, were removed from the research model, as they indicated potential content overlap and data redundancy. The VIF values for all retained items were below 5, which is considered the strictest criterion; however, one item with a slightly higher value was retained because it satisfied other validity criteria and contributed to the overall robustness of the model. This procedure ensured that the relationships between variables were not distorted by the presence of multicollinearity (Hair & Alamer, 2022).

Table 2. Measurement of constructs

Constructs and items	Loadings	VIF	α	CR	AVE
Preventive Measures (PM)			0.911	0.938	0.604
PM1: The company undertakes consistent measures in response to reported fraud cases.	0.672	2.406			
PM2: The company has a code of conduct.	0.733	2.711			
PM3: Management’s attention is focused on fraud risk.	0.677	2.104			
PM4: Employees are included in a system for reporting suspicious activities (whistleblowing).	0.799	3.588			
PM5: Employee background checks are conducted within the company.	0.837	4.052			
PM6: Regulations are consistently enforced.	0.859	3.417			
PM7: An internal audit function exists.	0.837	3.038			

Constructs and items	Loadings	VIF	α	CR	AVE
PM8: Accounts are verified by qualified professionals.	0.784	3.084			
PM9: Employees are encouraged to report suspicious cases in good faith and with evidence (whistleblowing).	0.792	2.979			
PM10: Third parties (external auditors, fraud investigators) are regularly engaged to review transactions and accounts.	0.758	3.012			
Financial Reporting Fraud (FRF)			0.929	0.944	0.849
FRF1: Manipulation of accounting statements.	0.924	3.177			
FRF2: Falsification of documentation related to subsidies/incentives represents a significant problem.	0.921	2.980			
FRF3: Input costs (fertilizer, fuel) are often overstated to achieve financial gain.	0.920	3.103			
Operational-Transactional Fraud (OTF)			0.927	0.966	0.934
OTF1: Misappropriation of funds or assets (e.g., machinery, inventory) represents a real threat.	0.965	4.033			
OTF2: Fraud in production reporting (e.g., falsification of records on milk quantities) occurs frequently.	0.967	4.032			
Effects of Fraud (EF)			0.899	0.924	0.711
EF1: Fraud causes significant financial losses to the company.	0.865	3.177			
EF2: Fraud significantly undermines the company's reputation.	0.901	3.481			
EF3: Fraud reduces employees' trust in the company.	0.867	2.922			
EF4: Fraud may result in severe legal consequences for the company.	0.778	4.852			
EF5: Fraud may increase the risk of losing market share or competitive advantage.	0.798	5.192			

Source: Authors' calculations

Results

Data Analysis

To analyse the relationships between the constructs, the Partial Least Squares Structural Equation Modeling (PLS-SEM) method was employed. Confirmatory Factor Analysis (CFA) was conducted to examine the alignment of the measurement instruments with the theoretical constructs, and the results of the reliability and validity assessment are presented in Table 4. All constructs demonstrated satisfactory levels of internal consistency. Cronbach's alpha (α) values ranged from 0.899 to 0.929, while Composite Reliability (CR) values ranged from 0.924 to 0.966, which, according to the recommended threshold of 0.70, indicates a high level of measurement reliability.

The values of Average Variance Extracted (AVE) at the construct level ranged from 0.604 to 0.934, confirming convergent validity as well as a strong association between the observed indicators and their respective underlying constructs. Factor loadings ranged from 0.677 to 0.967, indicating satisfactory relationships between the indicators and the corresponding latent variables. The analysis of Variance Inflation Factor (VIF) values revealed no significant multicollinearity among indicators, as all values were below the recommended threshold of 5 (Hair & Alamer, 2022; Field, 2000), except for one indicator that met all other relevant criteria and was therefore retained in the model.

Based on the presented indicators, it can be concluded that the applied instruments meet the requirements of reliability, convergent validity, and theoretical consistency, thereby confirming their full suitability for conducting structural equation modelling analysis (Hair & Alamer, 2022).

Table 3. Measurement model and constructs

Constructs	1	2	3	4
1 – Effects of Fraud	0.843			
2 – Financial Reporting Fraud	0.642	0.922		
3 – Operational–Transactional Fraud	0.663	0.870	0.966	
4 – Preventive Measures	0.660	0.537	0.562	0.777

Source: Authors' calculations

Discriminant validity was assessed using the Fornell–Larcker criterion, in accordance with the recommendations of Henseler et al. (2015). The results presented in Table 4 show that the highest value appears on the diagonal (first value in each column), while all other values are lower. These findings confirm that the measurement model exhibits adequate discriminant validity, indicating that the constructs are clearly differentiated and that each measures a distinct and conceptually unique research domain.

Research Results

The SmartPLS algorithm was applied to estimate the relationships among the variables included in the model. Based on the results of the statistical analysis of direct effects presented in Table 4, it was found that the construct *Financial Reporting Fraud* is not statistically significantly associated with the construct *Effects of Fraud* ($\beta = 0.219$, $p < 0.086$). This result confirms that mere perception of the existence of financial reporting fraud does not contribute to reducing the negative effects of fraud on business performance, thereby supporting hypothesis H1.

Furthermore, the construct *Operational–Transactional Fraud* does not show a statistically significant effect on the construct *Effects of Fraud* ($\beta = 0.214$, $p < 0.081$). This finding confirms that perception of operational–transactional fraud alone does not contribute to reducing the negative effects of fraud on business performance, thus supporting hypothesis H2.

Finally, the construct *Preventive Measures* is statistically significantly associated with the construct *Effects of Fraud* ($\beta = 0.277, p < 0.001$), indicating that respondents believe the existence of preventive measures contributes to reducing the negative effects of fraud on company performance. Accordingly, hypothesis H3 is supported.

Table 4. Results of direct effects testing

	Path coefficient	t-value	95% confidence intervals (bias-corrected)	Result
H1: FIP → EP	0.219	1.720	[-0.065, 0.439]	Supported
H2: OTP → EF	0.214	1.744	[-0.026, 0.458]	Supported
H3: PM → EP	0.277***	3.312	[0.129, 0.460]	Supported
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ FRF – Financial Reporting Fraud; OTF – Operational–Transactional Fraud; PM – Preventive Measures; EF – Effects of Fraud				

Source: Authors' calculations

Based on the results presented in Table 5, it was determined that the construct *Preventive Measures* has a statistically significant negative moderating effect on the relationship between *Financial Reporting Fraud* and *Effects of Fraud*. The result of the indirect effect test ($\beta = -0.249, p = 0.001$) indicates a moderately strong moderating effect, suggesting that preventive measures not only influence the relationship between financial reporting fraud and fraud effects but also contribute to reducing the negative effects of financial reporting fraud. Accordingly, hypothesis H4 is supported.

The next result shows that the construct *Preventive Measures* has a statistically significant mediating role in the relationship between *Operational–Transactional Fraud* and *Effects of Fraud*. The indirect effect test result ($\beta = 0.156, p = 0.005$) indicates that strengthening preventive measures facilitates the relationship between operational–transactional fraud and fraud effects. In other words, the implementation of preventive measures enables the perception of operational–transactional fraud to contribute to reducing the negative effects of fraud on business performance. Thus, hypothesis H5 is supported.

Table 5. Results of indirect effects testing

	Path coefficient	t-value	95% confidence intervals (bias-corrected)	Result
H4: PM x FIP → EP	-0.205***	3.887	[-0.314, -0.107]	Supported
H5: OTP → PM → EP	0.156**	2.882	[0.098, 0.478]	Supported
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$				

Source: Authors' calculations

To assess the quality of the structural model, the Stone–Geisser’s Q^2 parameter was used, and all obtained Q^2 values were positive, indicating satisfactory model quality and predictive relevance. The coefficient of determination (R^2) values indicate that the model explains 63.3% of the variance in the *Effects of Fraud* construct and 31.6% of the variance in the *Preventive Measures* construct, which, according to the criteria of Hair and Alamer (2022), can be interpreted as strong and substantial explained variance of the endogenous constructs, respectively.

Additionally, the Goodness-of-Fit (GOF) index was calculated using the formula $\sqrt{(R^2 \times Q^2)}$. The obtained values fell within the acceptable range of 0–1 and indicated high overall model fit. The Standardized Root Mean Square Residual (SRMR) was used as an additional indicator of model fit, with the obtained value indicating good absolute model fit, as it was below the recommended threshold of 0.08 (Hu & Bentler, 1999) (Table 6).

Table 6. Model fit indices

	R^2	Stoner–Geisser Q^2	GOF
EP	0.633	0.420	0.515
PM	0.316	0.276	0.295
SRMR	0.068		
R^2 – coefficient of determination; SRMR – Standardized Root Mean Square Residual; GOF – Goodness-of-Fit index; PM – Preventive Measures; EF – Effects of Fraud			

Source: Authors’ calculations

The research results confirmed that both the measurement and structural models satisfy all standards of reliability, validity, and data fit. All internal consistency indicators exceeded the recommended thresholds, indicating high construct reliability as well as adequate convergent and discriminant validity. The values of the model fit indices further indicate good overall alignment of the model with the empirical data.

Discussion of research findings

The results of testing Hypothesis 1 (H1) indicate that the relationship between financial reporting fraud and its effects is not statistically significant ($\beta = 0.219$, $p \approx 0.086$). Consequently, the mere perception of such fraud does not reduce its adverse impact on operating performance. This suggests that awareness of financial reporting fraud, considered in isolation, lacks a protective function and fails to mitigate the resulting damage. The finding supports the study’s initial premise that risk identification alone is insufficient unless accompanied by the implementation of concrete preventive measures.

Similar to H1 results, the testing of Hypothesis 2 (H2) showed that the relationship between operational–transactional fraud and its effects is not statistically significant ($\beta = 0.214$, $p \approx 0.081$). This finding demonstrates that mere recognition of operational fraud risks does not alleviate adverse outcomes. Organizations that acknowledge the possibility of such fraud but fail to implement systematic preventive measures remain exposed to harmful consequences. The result reinforces the conclusion that effective

fraud risk management depends on institutionalized control mechanisms rather than on sole managerial or employee awareness.

The testing of Hypothesis 3 (H3) demonstrates that preventive measures show a statistically significant and negatively oriented effect on fraud outcomes ($\beta = 0.277$, $p < 0.001$), thereby confirming that their presence mitigates the adverse consequences of fraudulent activity on operations. In other words, the more comprehensive and institutionalized the system of preventive controls, procedures, and oversight, the less vulnerable firms are to the damaging effects of fraud, empirically reinforcing the view that structured mechanisms, rather than mere risk awareness, constitute the basis of effective fraud management.

The results related to Hypothesis 4 (H4) demonstrate that preventive measures play a significant moderate role in shaping the relationship between financial reporting fraud and the adverse consequences. Beyond their direct effect in reducing harm, these mechanisms alter the dynamics through which fraudulent reporting translates into tangible operating outcomes. In environments with stronger preventive systems, the link between fraud and negative performance weakens, underscoring that institutionalized controls, oversight structures, and formalized procedures not only mitigate damage when fraud occurs but also fundamentally reshape the pathways through which fraud risk impacts organizational stability and integrity.

The testing of Hypothesis 5 (H5) confirms that operational–transactional fraud exerts a statistically significant indirect effect on fraud outcomes through the channel of preventive measures ($\beta = 0.156$, $p = 0.005$). This result highlights that the perception of operational fraud can catalyze strengthening preventive systems, which in turn alleviates the adverse consequences of fraud. In this sense, awareness of operational–transactional risks becomes a protective factor only when it is translated into concrete institutional responses, such as enhanced controls, monitoring procedures, and oversight mechanisms, underscoring the importance of transforming risk recognition into actionable preventive strategies.

Conclusion

In recent decades, significant efforts have been made at both the theoretical and practical levels to identify and apply effective approaches to risk management. These efforts have resulted in substantial progress in the field of risk management. In this context, it is emphasized that effective fraud risk management should be based on the principles of corporate governance, operational ethics, and oversight. Taken together, these three factors represent the fundamental pillars of trust and economic stability. It is also emphasized that fraud risk management has emerged as a key component of organizational resilience.

The findings of this study indicate that the mere existence of awareness of financial reporting fraud and operational–transactional fraud does not lead to a reduction in their negative impact on operational performance in dairy industry enterprises. In

other words, a perception of risk that is limited to passive recognition does not result in loss mitigation or protection against the occurrence of fraud risk. This implies that effective fraud management requires more than awareness alone. It entails the institutionalization of preventive measures, structured controls, and proactive oversight mechanisms. Together, these elements should translate identified risks into tangible organizational safeguards.

On the one hand, the limited role of risk perception is evident, while on the other hand, preventive measures are observed as a decisive factor in mitigating the negative consequences of fraud. It is important to emphasize that robust systems of controls, procedures, and oversight have a direct and statistically significant impact on reducing harmful outcomes, thereby highlighting the necessity of institutionalized risk management frameworks. The findings indicate that effective protection against fraud risk requires clearly identified mechanisms that extend beyond individual awareness, relying instead on formalized policies, internal controls, and continuous monitoring, supported by modern technological solutions as the structural foundation of business resilience.

The results reveal a sophisticated role of preventive measures in safeguarding financial integrity, acting not only as direct protective instruments but also as moderators and mediators in the relationship between fraud and its consequences. It is necessary to obtain detailed information on the areas that pose the highest risk of fraud within a specific dairy enterprise. Strong preventive systems reduce the severity of financial reporting fraud, while in the case of operational–transactional fraud, they transform risk perception into actionable protective strategies. Common challenges in this process include organizational resistance, technological integration, and resource constraints. The overall conclusion is that the findings confirm that sustainable fraud risk management can be achieved when awareness is systematically transformed into concrete, formalized, and enduring preventive mechanisms that strengthen financial integrity and organizational stability. Each activity associated with risk carries unique implications for the financial health of the organization, which should also be taken into account when defining a fraud risk management strategy.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Agencija za privredne registre [in English: Business Registers Agency]. Retrieved from <https://www.apr.gov.rs> (January 10, 2025)
2. Cambaza, E. M. (2024). The Parmalat Scandal: An Analysis of Financial Deception and Its Implications for Global Business. *REVES - Revista Relações Sociais*, 7(1), doi:10.18540/revesv17iss1pp18165

3. Conforte, D., Garnevska, E., Kilgour, M., Locke, S., & Scrimgeour, F. (2008). Key elements of success and failure in the NZ dairy industry: Lincoln University. *Agribusiness and Economics Research Unit*, 1-72.
4. Field, A. P. (2000). *Discovering Statistics Using SPSS for Windows: Advanced Techniques for the Beginner*, Sage Publications.
5. Fraud Risk Management Guide (2023). *The Committee of Sponsoring Organizations of the Treadway Commission (COSO)*, Research Commissioned by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) and Co-Published by the ACFE.
6. Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modelling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research Methods in Applied Linguistics*, 1(3), 100027.
7. Handford, C. E., Campbell, K., & Elliott, C. T. (2016). Impacts of milk fraud on food safety and nutrition with special emphasis on developing countries. *Comprehensive Reviews in Food Science and Food Safety*, 15(1), 130-142.
8. Henseler, J., Ringle, C. M., Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modelling. *Journal of the academy of marketing science*, 43(1), 115-135, doi: 10.1007/s11747-014-0403-8
9. Hu, L., Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modelling: A Multidisciplinary Journal*, 6(1), 1-55, DOI: <https://doi.org/10.61173/gevnt12>
10. Janković, B., Knežević, S., & Milojević, S. (2023). Uloga računovodstvenog forenzičara u krivičnom postupku, *Revizor - Časopis za upravljanje organizacijama, finansije i reviziju*, 26(101), 1–9. <https://doi.org/10.56362/Rev23101001J>
11. Kabir Usman, A. (2013). Critical Success Factors for Preventing E-banking Fraud. *Journal of Internet Banking and Commerce*, 18(2), 1–16.
12. Knežević, S., Milojević, S., & Grivec, M. (2023). Računovođe i etička pitanja: trendovi i problemi. *Revizor - Časopis za upravljanje organizacijama, finansije i reviziju*, 26(102-103), 9–24. <https://doi.org/10.56362/Rev23102009K>
13. Kovjanić, M., Vukadinović, P., Knežević, S., Obradović, T., Mitrović, A., Grgur, A., Milašinović, M. (2023). A FAHP and VIKOR method for evaluation of the financial performance of agriculture companies listed on the Belgrade Stock Exchange. *Economic of Agriculture*, 70(1), 185–199. <https://doi.org/10.59267/ekoPolj2301185K>
14. Milk and milk product statistics, Eurostat, 2024, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Milk_and_milk_product_statistics, (January 11, 2025)
15. Milk products, Meta Data, 2024, Statistički zavod Republike Srbije, [in English: Statistical Office of the Republic of Serbia (SORS)], https://data.stat.gov.rs/Metadata/13_Poljoprivreda/Html/130202010404_ESMS_G0_2024_3.html?utm_source=chatgpt.com (January 11, 2025)

16. Mitrović, A., Knežević, S., & Veličković, M. (2015). Ratio analysis specifics of the family dairies' financial statements. *Ekonomika poljoprivede*, 62(4), 1061-1078.
17. Shi, X. (2025). Can the short-selling mechanism curb corporate financial fraud - taking Muddy Waters' short selling Huishan Dairy as an example. *Finance & Economics*, 11, 1-5.
18. Sipayung, E. S. N., Yanti, H. B., & Setya, A. B. (2022, December). Impact of Anti-Fraud Awareness, Fraud Detection Procedures, and Technology to Fraud Detection Skill. In the *3rd Borobudur International Symposium on Humanities and Social Science 2021 (BIS-HSS 2021)* (pp. 783-787), Atlantis Press.
19. Sorensen, D. P., & Miller, S. E. (2017). Financial accounting scandals and the reform of corporate governance in the United States and in Italy. *Corporate Governance: The International Journal of Business in Society*, 17(1), 77-88. DOI: <https://doi.org/10.61173/gevgnt12>
20. Špiler, M., Knežević, S., Milojević, S., Slavković, M., Mitrović, A., & Šebek, V. (2024). Does the Internal Control System Play a Strong Safeguarding Role Against Fraud in Local Communities?. *Lex Localis: Journal of Local Self-Government*, 22(3), 188-208.
21. Tomić, V., Milić, D., & Janković, D. (2020). Economic aspects of milk production and traditional dairy products on agricultural farms in the Republic of Serbia. *Economic of Agriculture*, 67(3), 881-893. <https://doi.org/10.5937/ekoPolj2003881T>

ANALYSIS OF THE ECONOMIC JUSTIFICATION OF THE APPLICATION OF SPIROTETRAMAT IN THE CONTROL OF THE WHITE BUTTERFLY APHID (*TRIALEURODES VAPORARIORUM*) IN GREENHOUSE TOMATO PRODUCTION

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ABSTRACT

The aim of this research was to evaluate the economic efficiency of the spirotetramat 100 g/L SC in controlling the white butterfly aphid (*Trialeurodes vaporariorum*) in greenhouse tomato production within the framework of Integrated Pest Management (IPM). All applied insecticide treatments led to a statistically significant reduction of the pest population in comparison to the untreated control, as well as an increase in the number of healthy fruits and commercial yield. A dose of 0.45 l/ha did not provide a satisfactory level of control (<90%), while a dose of 0.75 l/ha showed high efficiency, comparable to the standard preparation Movento 100 SC. The systemic properties of spirotetramat allow to act on all developmental stages of the pest, including individuals in the inner parts of the leaf, with good compatibility with beneficial organisms. Economic analysis, based on gross margin and other indicators, confirms that the application of spirotetramat in greenhouse tomato production is economically justified and contributes to the sustainable control of *T. vaporariorum*.

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Introduction

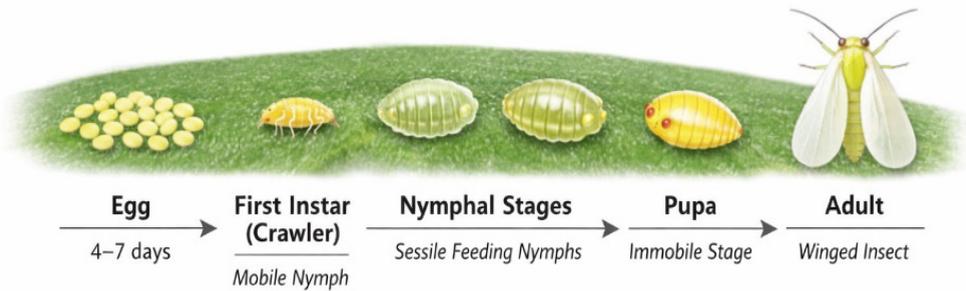
The global development directions, which are adopted by the member country of the United Nations, are based on the strategic framework of sustainable development defined until 2030. Withing this concept, providing sufficient and health-safe food is one of the priority challenges of modern society. Despite this, World Health Organization reports indicate that the problem of hunger and inadequate nutrition still affects a large part of humanity (WHO, 2020). This state of affairs largely stems from difficulties in agricultural production, especially due to the uncontrolled spread of harmful organisms and weed communities, which negatively affect yields. In order to alleviate the mentioned problems, various crop protection strategies are applied in modern agricultural practice (Bajagić et al., 2023; Šević et al., 2025), whereby the use of chemical preparations, especially pesticides of inorganic origin, is usually relied upon.

Tomato (*Lycopersicon esculentum* L.) is an annual herbaceous plant that has an extremely important place in the diet of people worldwide. The fruits are used in different stages of development, from unripe to complete technological maturity, depending on the purpose. The use of tomatoes is based on the use of the fruit in its fresh state, with the growing number of tomato fruits for industrial processing, which implies the intensification of production in protected areas, primarily greenhouses (Cvijanović et al., 2021).

The production of vegetable crops under protected conditions is burdened by numerous biotic stress factors, among which *Trialeurodes vaporariorum* plays a dominant role as the most economically important pest in greenhouse production. This insect achieves a harmful effect primarily by feeding on plant sap, which directly disrupts the physiological processes of plants, which manifests itself by reducing vegetative growth, vitality and marketable quality of fruits. Indirect damage is caused by the secretion of honeydew, which favors the development of sooty fungi from the genus *Asporium*, which reduces the photosynthetic potential of the leaf mass. In addition to the above, *T. vaporariorum* is an efficient vector of various phytopathogenic viruses, further endangering the health status of crops (Liu et al., 2015; Liu and Wang, 2020). The long-term and intensive application of insecticides has led to the appearance of pronounced resistance in the populations of this harmful organism, which significantly complicates its control (Zarev et al., 2025). Although biological agents are increasingly used in modern production for the purpose of population regulation, their effectiveness is often variable and slow-acting, which in conditions of increased number of pests requires additional application of chemical insecticides.

Trialeurodes vaporariorum is a widespread pest that poses a serious threat to greenhouse and greenhouse tomato production. Its developmental cycle includes five clearly defined stages (eggs, larvae, nymph, adult and adult insect) (Figure 1). Depending on the temperature and relative humidity, the duration of the entire cycle ranges from 20 to 30 days, while in optimal microclimatic conditions of the greenhouse it can be shortened to 15–18 days. Such conditions enable the formation of 10–15 generations per year, which leads to a rapid increase in the number of the population and an increased risk of a mass appearance of the pest.

Figure 1. Developmental stages of white butterfly aphid (*Trialeurodes vaporariorum*): eggs, four larval stages and imago - adult



Developmental Stages of the Greenhouse Whitefly (*Trialeurodes vaporariorum*)

Source: <https://www.koppert.com>

Harmful effects of *T. vaporariorum* can be direct or indirect. Direct damage is caused by feeding on plant juice, which reduces the vitality of plants, slows down vegetative growth and reduces the quality of fruits. Indirect damage is due to the secretion of honeydew, which favors the development of sooty fungi (*Apisorium spp.*), reducing the photosynthetic potential of the leaves. In addition, the adults of this harmful insect act as vectors of numerous phytopathogenic viruses, further threatening the health status of crops (Liu et al., 2015; Liu and Wang, 2020). The attack of the pest leads to an aesthetic deterioration of the fruits, while the leaves gradually lose chlorophyll, die and fall off.

The control of *T. vaporariorum* is a challenge due to its pronounced resistance to chemical insecticides. In modern greenhouse systems, biological agents, including predators and parasitoids, that can regulate pest populations are increasingly applied, but their effectiveness is often slower and variable. When populations exceed the economic damage threshold, additional application of selective chemical insecticides is necessary, as part of Integrated Pest Management (IPM). Such an approach makes it possible to maintain the population below a critical level, reduces the negative impact on beneficial organisms and the environment, and contributes to sustainable tomato production in protected areas. Although the assessment of the direct impact of white butterfly aphid on tomato yield is difficult due to the combined effects of other biotic and abiotic factors, available data indicate a significant economic loss in greenhouse production. Fast reproduction and the possibility of forming several generations per year enable populations to exceed the economic threshold of harm in a relatively short period of time. When the abundance of the pest exceeds the threshold, there is a decrease in the photosynthetic potential of the leaf mass, degradation of the fruits and a decrease in the overall yield. Therefore, monitoring population dynamics and timely application

of integrated plant protection measures, including biological and selective chemical methods, is a key strategy to maintain populations below critical levels and minimize economic losses. Such an approach enables sustainable greenhouse production of tomatoes, reducing the negative effects on beneficial organisms and the environment, while at the same time ensuring a stable and high-quality yield.

Combining chemical and biological insecticides has great potential in pest control, but it can lead to different outcomes, from synergistic to antagonistic effects (Elanchezhyan et al., 2025). Improper application of insecticides can cause damage or total loss of yield. In addition to achieving the desired level of efficiency, the application of chemical agents is also limited by the risk of phytotoxic effects on plants.

Spirotetramat is a systemic insecticide from tetramic acid (IRAC group 23) with a unique mechanism of action - inhibition of lipid biosynthesis in targeted harmful organisms, especially in mammals, such as whiteflies, aphids and other similar pests in a wide spectrum of crops (vegetables, fruits, vines, etc.). By acting on lipid metabolism, this compound hinders the development of young stages and reduces the reproductive potential of pests, thereby contributing to their effective control in agricultural crops. Additional importance is reflected in its systematic bilateral translocation through the plant, which effectively enables the action and control of insects hiding on the inside of leaves or young shoots, thus reducing the need for frequent repeated spraying (Dearlove et al., 2024). For example, in oil palm, treatment with spirotetramat (Movento® 150 g/L OD) significantly reduced the population of *Aleurodicus rugioperculatus*, leading to an 81.99–93.30% reduction in the number of larvae and an improved yield by 52.86–70.41%, without noticeable phytotoxic effects and with the preservation of natural enemies *Encarsia* spp. (Badari Prasad et al., 2025). Studies of residues in tomato fruits indicate that spirotetramat and its metabolites degrade relatively quickly and that, when applied in accordance with the recommended doses and withdrawal period, they remain below the maximum allowed residue levels (MRL), which makes it acceptable from the aspect of food safety (EFSA, 2022).

Several studies indicate that spirotetramat can cause sublethal biochemical and physiological changes in non-target organisms and the ability of beneficial entities in agroecosystems. In beneficial parasitoid wasps (*Encarsia formosa*), experimental exposure to spirotetramat caused decreased survival rates, shortened lifespan, and impaired parasitic capacity, suggesting negative effects on biological pest controllers (Yang et al., 2024). These results indicate that residual concentrations of spirotetramat can impair the ability of natural enemies of insect pests to effectively control pest populations. In addition, tests indicate that under long-term exposure, spirotetramat can alter the activity of protective enzymes and cause oxidative stress in earthworms (*Eisenia fetida*), which is an indicator of potential genotoxic and biochemical stress in soil-dwelling organisms (Zhang et al., 2015).

Although the acute toxicity of spirotetramat to mammals is considered to be relatively low and does not indicate a highly acute hazard to humans or large mammals at standard

exposures, its sublethal and ecotoxic effects on non-target organisms indicate the need for careful use and risk assessment, especially in the context of IPM (Integrated Pest Management) programs (Kim et al., 2024).

Vegetable production represents one of the most economically intensive and potentially profitable branches of agricultural production, with a significant impact on the overall development of the agricultural sector (Subić et al., 2007). The high level of production intensity, short production cycles and the possibility of achieving several harvests during the year make vegetable growing an important source of income for agricultural farms, especially in conditions of limited land resources (Cvijanović and Petrović, 2025). At the same time, the economic results of this production depend to a large extent on the general level of economic development, the availability of modern inputs and the level of technological equipment of the producers. Vegetable production requires significant employment of labor and a high level of investment in raw materials, machinery and irrigation systems, which further emphasizes the importance of rational cost management (Rajić et al, 2023). Intensive land use, with the possibility of changing two to three different vegetable crops during the year, allows for an increase in the economic efficiency of production, but at the same time increases the risks of the appearance of harmful organisms and significant economic losses. In such conditions, the choice of effective and economically justified plant protection measures is one of the key factors in preserving yield, product quality and overall profitability of vegetable production.

The area under vegetable crops in the Republic of Serbia in 2024 was 74.2 thousand hectares, which represents a decrease of 10.1% compared to 2023, as well as a drop of approximately 20% compared to the average five-year level. Despite the reduction of total areas, vegetable production in 2024 reached a total volume of 1.47 million tons, which is 12.2% more than the previous year and about 9% above the five-year average (Statistical Office of the Republic of Serbia). Such indicators point to productivity growth and production intensification, but at the same time emphasize the increased exposure of production to economic and production risks. The structure of sown areas under vegetable crops shows that potatoes have a dominant share with 30.3% of the total area (22.5 thousand ha). They are followed by peppers with a share of 12% (8.9 thousand ha) and tomatoes with 9.4% (7 thousand ha). The significant participation of tomatoes in the structure of vegetable production, especially in intensive cultivation systems, additionally confirms its economic importance and the need for the application of effective and economically justified plant protection measures, in order to preserve the yield, product quality and overall profitability of production (Petrović et al, 2024).

Yields in the sector of vegetable production in 2024 increased by 16.2% compared to 2023. Productivity growth is most pronounced in peppers, which achieved an average yield higher by 67% (20.1 t/ha) compared to the previous year, as well as in tomatoes, whose average yield increased by 60.5% (23.5 t/ha), although the areas under these crops were 3–4% smaller than in 2023 (Statistical Office of the Republic of Serbia). These data indicate a significant increase in the intensity of production and a more

efficient use of production factors in the vegetable sector. The reasons for the growth of production in this sector, in addition to the favorable agro-climatic conditions during 2024, can be largely attributed to the application of modern technologies and improved production inputs (Petrović et al., 2024). Their application directly affects the increase in yield and the improvement of product quality, thus achieving higher profitability of production (Cvijanović et al., 2023). In the conditions of reduced sowing areas, yield growth becomes a key factor in preserving the economic viability of production, where the rational choice of technological measures and means for plant protection is of particular importance in intensive cultivation systems, such as the production of tomatoes in a protected area (Cvijanović et al., 2023).

When it comes to the economic efficiency of vegetable production in the Republic of Serbia, the best economic and financial results are recorded by the production of peppers and tomatoes (Petrović et al., 2021), and the biggest influence on the results is yield and price, which vary from year to year. The fluctuation of tomato prices has a pronounced seasonal character (Petrović et al., 2022), and depends on whether the market sells tomatoes produced in Serbia or from imports, as well as whether the tomatoes are produced in an open field or in a protected area where production costs are significantly higher. Also, production costs have a significant effect on the achieved results, which must be controlled so that the consumption of inputs in tomato production will be optimal, as well as the optimal use of labor. Transportation costs can also be a significant cost in production (Savić et al., 2020), which can increase costs and thus the price of the product. One of the measures that can influence the reduction of the risk of production, i.e. the realized profit, is certainly production insurance, which to a large extent can influence the loss due to the occurrence of certain harmful events, to some extent to be covered (Petrović et al., 2020).

The aim of this research is the economic evaluation of the sustainable production of tomatoes in a closed system, based on the principles of integral plant protection, with special reference to the biological effectiveness of the insecticide Spirotetramat 100 g/L SC in the control of white butterfly aphids (*Trialeurodes vaporariorum*).

Materials and methods

Analyzes of the effectiveness of insecticides based on spirotetramat in the production of tomatoes in protected areas were carried out on four experimental fields (locations) according to a completely random block system in 4 repetitions, where the tested treatments are given in Table 1, and the basic parameters of the application of the treatment in Table 2. The active substance spirotetramat was applied in an amount of 0.45-0.75 l/ha. The amount of water used for treatments was 300 l/ha. The ready-made working solution for treating tomatoes contained 0.225–0.370% of the active substance spirotetramat.

Table 1. Treatments tested in trials

Treatment	Application amount in 300 l/ha H ₂ O
Control (untreated area)	-
Spirotetramat 100G/L SC	0.45 l/ha
Spirotetramat 100G/L SC	0.75 l/ha
Movento 100 SC	0.75 l/ha

Source: Authors' own research

Table 2. Basic parameters of treatment application

Location	Mužlja	Omoljica	Valjevska kamenica	Bela Crkva
Number of treatments	1	1	1	1
Date	13.06.2022.	14.06.2022.	29.07.2023.	24.07.2023.
Phenophase of plants	BBCH 75-76	BBCH 75-77	BBCH 67-81	BBCH 68-81
Method of application	Foliar application			
Applicatin device	Back sprayer Euro Pulve (France)			
Variety/hybrid	Runner	Pink rock	Novosadski jabučar	Big Beef
First assessment – before treatment	13.06.2022	14.06.2022.	29.07.2023.	24.07.2023.
Second assessment	21.06.2022.	22.06.2022.	05.08.2023.	01.08.2023.

Source: Authors' own research

Biological efficacy testing was conducted according to standardized EPPO methods: PP 1/36 (3) – Evaluation of insecticide efficacy; PP 1/152 (4) – Evaluation of the efficacy of plant protection products: study design and analysis; PP 1/181 (5) – Evaluation of plant protection product efficacy: performance and reporting; PP 1/135 (4) – Phytotoxicity assessment; PP 1/225 (2) – Determination of the minimum effective dose; PP 1/239 (3) – Expression of the dose of plant protection products. According to the EPPO method PP 1/36, live larvae and adults were counted on the leaves. The number of larvae was determined on one, previously marked and fully opened leaf per plant in the experimental plot (10 leaves in total), while the number of adults (imagos) was recorded on the tops of the plants, including the first fully opened leaves, taking care not to disturb the insects in order to make the count as accurate as possible. Finally, healthy fruits were counted, which directly affect the quality and quantity of the yield. Fruits were counted on 10 test plants, by counting 10 fruits from the bottom up. Assessments were performed immediately before treatment and 8 days after treatment.

The statistical processing of the results was carried out in accordance with the recommendations of the EPPO method PP 1/152 (4). The significance of differences between means was tested by analysis of variance (ANOVA). If the analysis showed a statistically significant difference ($p < 0.05$), further comparisons of pairs of mean

values were carried out using the LSD test (Fisher's method) at the significance level $\alpha = 0.05$, in order to determine between which, mean values there is a significant difference (post hoc test). Mean values marked with the same letter do not differ statistically significantly, while values marked with different letters show a significant difference. Statistical analysis (ANOVA and LSD post hoc test) was performed in the Minitab 18 software package.

The efficiency of the insecticide was determined using the Henderson-Tilton formula:

$$\text{Efficacy \%} = 1 - \frac{n \text{ in control before treatment} \times n \text{ in treatment after treatment}}{n \text{ in control after treatment} \times n \text{ in treatment before treatment}} \times 100$$

For the purposes of analyzing the economic efficiency of tomato production with the use of spirotetramat as part of the integral protection of plants from the white butterfly aphid (*Trialeurodes vaporariorum*), a calculation methodology based on variable costs, i.e. gross margin analysis, was applied. This approach makes it possible to see the direct economic effects of insecticide application through the ratio of realized income and variable production costs (Gogić, 2014).

The data used in the economic analysis were obtained on the basis of the results of multi-location trials conducted in four localities. The calculation of the gross margin included variable costs relevant to the production of tomatoes in the protected area, including the costs of plant protection, as well as the yield and quality of the fruits.

Based on the results of the gross margin calculation, additional economic indicators of tomato production were calculated, including the profitability of production, the lower breakeven point and the cost price of tomato production. These indicators enable a comprehensive assessment of the economic justification of the use of spirotetramat in the integral protection of tomatoes, as well as an overview of its impact on the overall economic sustainability of production.

Results

The results of testing the biological efficiency of the preparation Spirotetramat 100 G/L SC in controlling larvae and adults of *Trialeurodes vaporariorum* species on tomatoes grown in a protected area are shown in tables 3–10. Tables 3-4, 5-6, 7-8 and 9-10 show the results obtained in the localities of Mužlja, Omoljica, Valjevska Kamenica and Bela Crkva. Specifically, Tables 3, 5, 7 and 9 show the number of live larvae and adults before treatment, while Tables 4, 6, 8 and 10 show the abundance and efficacy of insecticides eight days after treatment.

All insecticide treatments, in all post-treatment evaluations and in all localities, showed statistically highly significant differences compared to the untreated control. Spirotetramat 100 G/L SC at a concentration of 0.45 l/ha at all four locations showed an efficiency lower than 90%, which is why this dose cannot be recommended for successful control of *T. vaporariorum*. In

the amount of 0.75 l/ha, the examined preparation Spirotetramat 100 G/L SC showed high efficiency in suppressing *T. vaporariorum*, which was at the level of the standard Movento 100 SC, applied in the amount of 0.75 l/ha. At the minimum effective amount of 0.45 kg/ha, the examined preparation Spirotetramat 100 G/L SC showed a significantly lower efficiency compared to the standard Movento 100 SC.

The number of greenhouse whitefly individuals on tomato plants differed depending on the locality and experimental plot (Tables 3–10). The species *T. vaporariorum* was mostly homogeneously present within the experimental plots. The average number of larvae on 10 leaves, in the untreated control immediately before treatment, ranged from 286 at the Mužlja location to 554 at the Valjevska kamenica location, while the average number of imagos ranged from 69.5 at the Mužlja location to 110 at the Bela Crkva location. The number of larvae and adults of *T. vaporariorum* after treatment was significantly reduced in all treated plots.

Table 3. The number of live larvae and imagoes of the species *T. vaporariorum* determined immediately before the treatment - preliminary assessment at the Mužlja locality

No.	Treatment		The number of live larvae and imagoes of <i>T. vaporariorum</i>				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	324	286	441	502	1553.0	388.25ab	100.5
		imagoes	84	42	73	79	278.0	69.50a	18.9
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	595	410	417	548	1970.0	492.50a	93.3
		imagoes	114	73	62	113	362.0	90.50a	26.9
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	486	298	478	513	1775.0	433.75ab	98.3
		imagoes	74	84	106	94	358.0	89.50a	13.7
4	Movento 100 SC (0.75 l/ha)	larvae	310	345	413	329	1397.0	349.25b	44.8
		imagoes	70	123	83	84	360.0	90.00a	22.9

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p=0.452$; mean values marked with the same letter do not differ statistically significantly.

Table 4. The number of live larvae and adults of the species *T. vaporariorum* and the effectiveness of insecticides in the Mužlja locality 8 days after treatment

No.	Treatment		The number of live larvae and imagoes of <i>T. vaporariorum</i>				Σ	Ms	Sd	Efficiency (%)	Efficiency compared to standard (%)
			A	B	C	D					
1	Untreated larvae	control	414	399	595	637	2045.0	511.25a	122.3	-	-
		imagoes	125	111	142	174	552.0	138.00a	27.1	-	-
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	137	94	81	152	464.0	116.00b	33.9	82.11	85.02
		imagoes	28	22	39	34	123.0	30.75b	7.4	82.89	84.55
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	35	17	35	48	135.0	33.75bc	12.7	94.22	97.56
		imagoes	3	0	10	5	18.0	4.50c	4.2	97.47	99.42

No.	Treatment		The number of live larvae and imagos of <i>T. vaporariorum</i>				Σ	Ms	Sd	Efficiency (%)	Efficiency compared to standard (%)
			A	B	C	D					
4	Movento 100 SC (0.75 l/ha)	larvae	4	17	22	20	63.0	15.75c	8.1	96.58	100.0
		imagos	0	6	7	1	14.0	3.50c	3.5	98.04	100.0

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.000$ for larvae $p_2=0.000$, mean values marked with the same letter do not differ statistically significantly.

Table 5. The number of live larvae and adults of the species *T. vaporariorum* determined immediately before the treatment - preliminary assessment at the Omoljica site

No.	Treatment		The number of live larvae and imagos of <i>T. vaporariorum</i>				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	101	87	54	62	304.0	76.00a	21.8
		imagos	19	31	10	19	79.0	19.75a	8.6
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	47	56	88	114	305.0	76.25a	30.7
		imagos	17	7	18	20	62.0	15.50a	5.8
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	127	73	66	104	370.0	92.50a	28.3
		imagos	42	29	8	17	96.0	24.00a	14.8
4	Movento 100 SC (0.75 l/ha)	larvae	109	81	99	67	356.0	89.00a	18.7
		imagos	39	28	11	31	109.0	27.25a	11.8

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.717$ for larvae $p_2=0.470$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 6. The number of live larvae and adults of the species *T. vaporariorum* and the effectiveness of insecticides at the Omoljica location 8 days after treatment

No.	Treatment		The number of live larvae and imagos of <i>T. vaporariorum</i>				Σ	Ms	Sd	Efficiency (%)	Efficiency compared to standard (%)
			A	B	C	D					
1	Untreated larvae	control	179	201	144	174	698.0	174.50a	23.5	-	-
		imagos	44	51	26	30	151.0	37.75a	11.7	-	-
2	Spirotetramat 100 G/LSC (0.45 l/ha)	larvae	43	35	47	39	164.0	41.00b	5.2	76.58	76.58
		imagos	7	3	5	6	21.0	5.25	1.7	82.28	82.28
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	0	0	0	0	0.0	0.00b	0.0	100.0	100.0
		imagos	1	0	1	0	2.0	0.50b	0.6	98.91	99.39
4	Movento 100 SC (0.75 l/ha)	larvae	0	0	0	0	0.0	0.00b	0.0	100.0	100.0
		imagos	0	1	0	0	1.0	0.25b	0.5	99.52	100.0

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.000$ for larvae $p_2=0.000$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 7. The number of live larvae and imagos of the species *T. vaporariorum* determined immediately before treatment - preliminary assessment at the Valjevka kamenica site

No.	Treatment		The number of live larvae and imagos of <i>T. vaporariorum</i>				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	342	211	396	298	1247.0	311.75a	78.2
		imagos	117	144	98	81	440.0	110.00a	27.0
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	255	196	232	304	987.0	246.75a	45.2
		imagos	94	108	74	114	390.0	97.50a	17.8
3	Spirotetramat 100 G/LSC (0.75 l/ha)	larvae	239	347	187	202	975.0	243.75a	72.2
		imagos	68	87	121	110	386.0	96.50a	23.7
4	Movento 100 SC (0.75 l/ha)	larvae	179	208	300	154	841.0	210.25a	63.8
		imagos	88	70	111	76	345.0	86.25a	18.1

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.230$ for larvae $p_2=0.527$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 8. The number of live larvae and adults of the species *T. vaporariorum* and the effectiveness of insecticides at the Valjevka kamenica location 8 days after treatment

No.	Treatment		The number of live larvae and imagos of <i>T. vaporariorum</i>				Σ	Ms	Sd	Efficiency (%)	Efficiency compared to standard (%)
			A	B	C	D					
1	Untreated larvae	control	471	362	554	425	1812.0	453.00a	80.8	-	-
		imagos	222	269	213	181	885.0	221.25a	36.4	-	-
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	69	42	72	81	264.0	66.00b	16.8	81.59	82.67
		imagos	26	37	24	31	118.0	29.50b	5.8	84.96	82.67
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	7	13	10	8	38.0	9.50b	2.6	97.32	98.61
		imagos	4	7	5	0	16.0	4.00b	2.9	97.94	98.61
4	Movento 100 SC (0.75 l/ha)	larvae	4	0	7	5	16.0	4.00b	2.9	96.69	100.0
		imagos	2	4	0	0	6.0	1.50b	1.9	99.14	100.0

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.000$ for larvae $p_2=0.000$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 9. The number of live larvae and imagoes of the species *T. vaporariorum* determined immediately before the treatment - preliminary assessment at the Bela Crkva site

No.	Treatment		The number of live larvae and imagoes of <i>T. vaporariorum</i>				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	277	199	315	303	1094.0	273.50ab	52.1
		imagoes	186	119	231	210	746.0	186.50a	48.6
2	Spirotetramat 100 G/L SC (0,45 l/ha)	larvae	302	189	247	265	1003.0	250.75b	47.1
		imagoes	114	98	150	86	448.0	112.00b	27.8
3	Spirotetramat 100 G/L SC (0,75 l/ha)	larvae	384	407	322	290	1403.0	350.75a	54.1
		imagoes	220	133	80	185	618.0	154.50ab	61.2
4	Movento 100 SC (0,75 l/ha)	larvae	266	323	410	333	1332.0	333.00a	59.2
		imagoes	95	150	203	142	590.0	147.50ab	44.2

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.063$ for larvae $p_2=0.222$ for imagoes; mean values marked with the same letter do not differ statistically significantly

Table 10. The number of live larvae and adults of *T. vaporariorum* species and the effectiveness of insecticides at the Bela Crkva location 8 days after treatment

No.	Treatment		The number of live larvae and imagoes of <i>T. vaporariorum</i>				Σ	Ms	Sd	Efficiency (%)	Efficiency compared to standard (%)
			A	B	C	D					
1	Untreated larvae	control	413	301	420	411	1545.0	386.25a	57.0	-	-
		imagoes	279	233	350	317	1179.0	294.75a	50.4	-	-
2	Spirotetramat 100 G/L SC (0.45 l/ha)	larvae	96	74	82	77	329.0	82.25b	9.7	76.77	78.06
		imagoes	38	39	52	44	173.0	43.25b	6.4	75.57	76.39
3	Spirotetramat 100 G/L SC (0.75 l/ha)	larvae	15	18	20	14	67.0	16.75c	2.8	96.62	98.24
		imagoes	7	3	10	5	25.0	6.25bc	3.0	97.44	98.49
4	Movento 100 SC (0.75 l/ha)	larvae	8	9	8	6	31.0	7.75c	1.3	98.35	100.0
		imagoes	3	0	5	2	10.0	2.50c	2.1	98.93	100.0

Source: Authors' own research. Ms- mean value, Σ - sum, Sd- standard deviation $p_1=0.000$ for larvae $p_2=0.000$ for imagoes; mean values marked with the same letter do not differ statistically significantly

If the preparation Spirotetramat 100 G/L SC is applied in accordance with the instructions for use, it does not show phytotoxic effects on the tomato crop in the protected area. The assessment of the quality of the fruits is expressed in Table 11, as well as the yield per unit of measure (kg/500 m²) (Table 12), where it can be concluded that the insecticide Spirotetramat 100 G/L SC, in a concentration of 0.75 l/ha, is reliable in the protection of tomatoes, given that during the counting, no negative impact through the phytotoxicity of tomatoes was noted, and the yield of tomatoes achieved by applying the investigated preparation was comparable to the standard live preparation.

Table 11. The number of mature healthy tomato fruits

Location	Mužlja	Omoljica	Valjevska kamenica	Bela Crkva
Untreated larvae	0/10	0/10	0/10	0/10
Spirotetramat 100 G/L SC (0.45 l/ha)	4/10	2/10	5/10	5/10
Spirotetramat 100 G/L SC (0.75 l/ha)	10/10	10/10	9/10	10/10
Movento 100 SC (0.75 l/ha)	9/10	9/10	9/10	9/10

Source: Authors' own research

Table 12. Tomato yield (kg/500 m²) at different locations

Location	Mužlja	Omoljica	Valjevska kamenica	Bela Crkva
Untreated larvae	1,200	1,250	1,100	1,150
Spirotetramat 100 G/L SC (0.45 l/ha)	1,800	1,850	1,700	1,750
Spirotetramat 100 G/L SC (0.75 l/ha)	7,100	7,150	7,000	7,050
Movento 100 SC (0.75 l/ha)	7,050	7,100	7,000	7,020

Source: Authors' own research

Discussions

The systemic insecticide spirotetramat has emerged as an effective tool in the integrated management of borer and sucker pests, including whiteflies, on protected vegetable crops such as tomatoes. Field and greenhouse applications of spirotetramat show significant reductions in whitefly populations when applied during larval emergence. These results are in agreement with the research conducted by Zarev et al. (2025), it is very important to continuously monitor and control the whitefly and thereby reduce losses in tomato yield in protected areas. In commercial protected tomato production systems, growers have reported significant reductions in whitefly numbers following spirotetramat treatment, with population reductions observed within one to two weeks of application. In one of the studies on strawberry (*Fragaria ananassa*), treatments with spirotetramat significantly reduced the number of eggs and immature forms of the white butterfly aphid under field conditions, where reductions in the number of insect stages were up to 92% at certain stages after treatment, which confirms the broad potential of this active agent in controlling plant sapsuckers (Bi & Toscano, 2007). Comparative studies involving mixtures of spirotetramates, such as spirotetramate in combination with imidacloprid, also illustrate promising efficacy against whitefly on tomato in the greenhouse, suggesting that combining modes of action may improve control under

certain pest pressures (Dearlove et al., 2024). The integration of spirotetramat into Integrated Pest Management (IPM) programs is further supported by its relatively selective action that allows compatibility with beneficial arthropods in some systems, helping to delay the development of resistance in whitefly populations (Agrovodic, 2025). While whiteflies have shown the ability to develop resistance to older chemicals, such as neonicotinoids, the adoption of new systemic insecticides with different modes of action – such as spirotetramat – represents an important resistance management strategy (First report of Bemisia tabaci resistance, 2024).

Table 13. Calculation of the gross margin of tomato production in a protected area (calculation for a 500m² greenhouse)

Location	Omoljica	Mužlja	Bela Crkva	Valjevska Kamenica
Production value (RSD)	929,500	923,000	916,500	910,000
Variable costs (RSD)	278,350	299,350	257,350	243,350
Gross margin (RSD)	651,150	623,650	659,150	666,650

Source: Author's calculation based on data from the experiment

Table 13 shows the data of the gross margin calculations in the localities where trials were conducted to control white butterfly aphid (*Trialeurodes vaporariorum*) using spirotetramat. Data on the production value were presented, calculated based on the obtained yields in the greenhouses where the experiment was conducted, as well as the purchase price, which at the time of the experiment amounted to 130 RSD/kg. The tomato yields in the treatments where spirotetramat was applied ranged between 7 and 7.15 tons. Based on the monitoring of all variable costs during the duration of the experiment, the total variable costs were calculated. The gross margin of tomato production in the protected area at the locations where the trials were conducted, represents the difference between the production value and the variable costs. The data presented in the table show that positive financial results were achieved at all 4 locations, i.e. in all 4 greenhouses, and that the gross margin ranges from 623,650 dinars for the trial conducted in Mužlja to 666,650 dinars for the trial conducted in Valjevska Kamenica. Different amounts of gross margin are due primarily to insignificant differences in production costs, which are primarily related to labor costs, because workers' daily wages differed from place to place.

Table 14. Economic indicators of tomato production in a protected area based on calculated variable costs

Location	Omoljica	Mužlja	Bela Crkva	Valjevska Kamenica
Cost of production (RSD/kg)	38.93	42.16	36.50	34.76
Production profitability (%)	233.93%	208.33%	256.13%	273.95%
Break-even point (kg)	2,141	2,303	1,980	1,872

Source: Author's calculation based on the data obtained in the experiment

The economic indicators of tomato production in a protected area for the control trial of white butterfly aphids (*Trialeurodes vaporariorum*) using spirotetramat, shown in Table 14, confirm the extremely favorable economic results obtained by applying the calculation based on variable costs. Based on the analyzed data, it can be concluded that the production cost of one kilogram of tomatoes in all observed localities is significantly lower than the purchase price, which indicates a high level of economic efficiency of production. The cost price ranged from 34.76 RSD/kg at the Valjevska Kamenica location to 42.16 RSD/kg in Mužlja, while other locations achieved values of 36.50 RSD/kg in Bela Crkva and 38.93 RSD/kg in Omoljica.

Extremely high levels of production profitability, which ranged from 208.33% in Mužlja to 273.95% in Valjevska Kamenica, indicate that the realized gross margin exceeds variable production costs many times over. This means that for every 100 RSD invested in production, between 208 and 274 RSD of profit is realized, which confirms the exceptional economic justification of the applied growing technology in a protected area. In the context of agricultural production, where profitability above 50% is considered very successful, such high indicators indicate a stable and highly competitive production system.

The indicator of the lower coverage point represents the minimum volume of production necessary to cover variable costs at a given purchase price of 130 RSD/kg. In the tests conducted, the lower coverage point ranged from 1,872 kg at the Valjevska Kamenica site to 2,303 kg in Mužlja, while the values for Bela Crkva and Omoljica were 1,980 kg and 2,141 kg, respectively. Compared to the achieved yields, which ranged between 7 and 7.15 tons per 500 m² greenhouse, the minimum yield required to cover variable costs was approximately three to four times lower, indicating low production risk and a high level of investment security in the analyzed greenhouse tomato production system.

Conclusions

The application of spirotetramat 100g/L SC at a dose of 0.75l/ha showed high efficiency in suppressing the white butterfly aphid (*Trialeurodes vaporariorum*) in the greenhouse production of tomatoes. Lower dosages (0.45l/ha) did not provide satisfactory control, which emphasizes the importance of optimal dosage. The systemic properties of spirotetramat enable action on all stages of the pest and compatibility with IPM strategies, while combinations with other insecticides or biological agents can further improve control. The results confirm that spirotetramat is an effective and valuable tool in protecting tomatoes from economic losses caused by *T. vaporariorum*. Based on the obtained results, it can be concluded that the production of tomatoes in the protected area, under the observed production conditions and the purchase price of RSD 130/kg, achieves extremely favorable economic results in all the analyzed localities. Realized gross margins, which range from approximately 650,000 RSD per greenhouse of 500 m², together with extremely high levels of production profitability, confirm the economic justification and stability of this cultivation system. The low cost price per kilogram of product in relation to the market price, as well as the relatively low level of the lower cover point, many times lower than the projected yield, indicate a high degree of investment security and a

significant scope for making a profit even in conditions of reduced yield or unfavorable market trends. The obtained results confirm that the production of tomatoes in a protected area, with the use of spirotetramat in the control of white butterfly laphid (*Trialeurodes vaporariorum*), is economically highly justified and competitive in modern conditions of intensive agricultural production.

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Conflict of interests

The authors declare no conflict of interest.

References

1. Agrovodic. (2025). Movento 100 SC – Spirotetramat (100 g/L). Preuzeto sa <https://www.agrovodic.com/products/Movento%20100%20SC>
2. Badari Prasad, B., Karthikeyan, G., & Chandrasekaran, R. (2025). Efficacy of spirotetramat (Movento® 150 OD) against rugose spiralling whitefly (*Aleurodicus rugioperculatus*) in oil palm ecosystem. *Uttar Pradesh Journal of Zoology*, 46(2), 1–10.
3. Bajagić M., Đukić V., Miladinov Mamlić Z., Sekulić J., Cvijanović V., Đurić N., Cvijanović G (2023): Effect of pulsed electromagnetic field on yield of grain, yield of protein and oil of soybean, *Plant Soil Environ*, Vol. 69, No. (12): 577–585 DOI: 10.17221/336/2023-PSE
4. Bi, J. L., & Toscano, N. C. (2007). Efficacy of spiromesifen against greenhouse whitefly (Homoptera: Aleyrodidae) on strawberry. *HortScience*, 42(2), 285–288. <https://agris.fao.org/search/en/providers/122535/records/65df6bcf7c7033e84bed9f0f>
5. Cvijanović, V., Bajagić, M., Petrović, M., Stanković, M., Cvijanović, G. (2023): The influence of the application of modern technologies on the production and morphological characteristics of two tomato hybrids, *Knowledge-International Journal*, Institute of Knowledge Management, North Macedonia, 61 (3): 417-423. ISSN: 2545-4439
6. Cvijanović, V., Petrović, M. (2025): Application of modern tomato cultivation systems in protected areas and their impact on economic viability, The 10th international conference of the Faculty of Economics Brčko “Global challenges of the economy”, Brčko, Bosnia and Herzegovina, July 2025, pp. 57-64, UDK: 635.64:330.341, ISBN 978-99938-95-65-7

7. Cvijanović, V., Petrović, M., Momirović, N., Moravčević, Đ., Bajagić, M. (2023): The effect of different systems of growing tomatoes in a protected area on morphological properties and business results, *Agro – knowledge Journal*, Faculty of Agriculture, University of Banja Luka, Bosnia and Herzegovina, 24 (4): 169-178, <https://doi.org/10.7251/AGREN2304169C>, UDC:635.64:613.2.
8. Cvijanović, V., Sarić, B., Dramićanin, A., Kodranov, I., Manojlović, D., Momirović, N., Momirović, N., Miljković-Opsenica, D. (2021): Content and distribution of macroelements, microelements, and rare-earth elements in different tomato varieties as a promising tool for monitoring the distinction between the integral and organic systems of production in Zeleni hit—Official enza and vitalis trial and breeding station. – *Agriculture* 11(10): 1009. <https://doi.org/10.3390/agriculture11101009>
9. Dearlove, E. L., Chandler, D., Edgington, S., Raybould, A., & Pell, J. K. (2024). Improved control of *Trialeurodes vaporariorum* using mixture combinations of entomopathogenic fungi and the chemical insecticide spirotetramat. *Scientific Reports*, 14, 15259. <https://doi.org/10.1038/s41598-024-66051-8>
10. EFSA (2022): <https://www.efsa.europa.eu>; accessed January 2026
11. Elanchezhyan, K., Rajinimala, N., Lenin Raja, D., & Suba Sri Gokila, A. (2025). Farm-made pesticides-degrading lactic acid bacterial formulation for pest management in okra, *Abelmoschus esculentus* (L.) Moench. *Applied Ecology & Environmental Research*, 23(2).
12. European Food Safety Authority (EFSA). (2022). Peer review of the pesticide risk assessment of the active substance spirotetramat. *EFSA Journal*, 20(1), e07010. <https://doi.org/10.2903/j.efsa.2022.7010>
13. First report of *Bemisia tabaci* MEAM1 (Hemiptera: Aleyrodidae) resistance to spirotetramat in Florida. (2024). *Crop Protection*, 180, 106661. <https://doi.org/10.1016/j.cropro.2024.106661>
14. Gogić, P. (2014). *Theory of costs with calculations in production and processing of agricultural products*, Poljoprivredni fakultet, Beograd. [In Serbian: Гогоић, П. (2014). Теорија трошкова са калкулацијама у производњи и преради пољопривредних производа].
15. <https://www.koppert.com>; accessed January 2026
16. Kim, S. E., Kim, H. K., & Hah, G. (2024). Sublethal effects of spirotetramat, cyantraniliprole, and pymetrozine on *Aphis gossypii* (Hemiptera: Aphididae). *Insects*, 15(4), 247.
17. Koppert Biological Systems. (n.d.). Developmental stages of the greenhouse whitefly (*Trialeurodes vaporariorum*). Preuzeto Januar 2026. <https://www.koppert.com>
18. Liu, J., Wang, X. (2020): Tomato Diseases and Pests Detection Based on Improved Yolo V3 Convolutional Neural Network. – *Frontiers in Plant Science* 11: 898.
19. Liu, T., Stansly, P. A., Gerling, D. (2015): Whitefly parasitoids: Distribution, life history, bionomics, and utilization. – *Annual Review of Entomology* 60: 273-392.

20. Petrović, M., Dimitrijević, B., Cvijanović, V. (2024): Economic aspects of tomato production on family farms in the Republic of Serbia, Second International Conference GIRR 2024, Šabac, Book of Proceedings, 10th May, 2024, pp. 132-141, ISBN 978-86-80417-96-7.
21. Petrović, M., Janković Šoja, S., Savić, B., Tomić, V., Cvijanović, V., Perović, N. (2022): Forecasting tomato prices on markets in the republic of serbia using the arima model, XIII International Scientific Agriculture Symposium “Agrosym 2022”, Jahorina, Book of Proceedings, Bosnia and Herzegovina, 6. - 9. October 2022., pp. 1271 – 1276., ISBN 978-99976-987-3-5.
22. Petrović, M., Marina, I., Jeločnik, M. (2024): The significance and role of using innovative technologies in modern agricultural production, Journal of Research and Innovation for Sustainable Society (JRISS), 6 (2): 289-303. <https://doi.org/10.33727/jriss.2024.2.32:289-303>
23. Petrović, M., Savić, B., Cvijanović, V. (2021): Financial aspects of pepper (*Capsicum annum L*) production on family farms in Serbia, Economic of Agriculture, Institute of Agricultural Economics, Belgrade, 68 (4): 1015-1028, <https://doi.org/10.5937/ekoPolj2104015P>, UDC 338.314:635.649 (497.11).
24. Petrović, M., Tomić, V., Radišić, R., Ljiljanić, N. (2020): Analysis of insurance in agriculture of the Republic of Serbia in the period 2009-2018, Western Balkan Journal of Agricultural Economics and Rural Development, Institute of Agricultural Economics, Belgrade, 2 (2): 99 – 109, <https://doi.org/10.5937/WBJAE2002099P>, ISSN 2683 – 4693.
25. Rajić, Z., Ljiljanić, N., Petrović, M. (2023): Production and economic aspects of vegetable production in the Republic of Serbia, Book of Proceedings, Scientific symposium with international participation “Agribusiness, Food and Rural Areas - Perspectives and Challenges of Agenda 4.0.”, 21.-22. September 2023., Faculty of Agriculture, University of Belgrade, pp. 240 – 250, ISBN 978-86-7834-424-4.
26. Savić, B., Petrović, M., Vasiljević, Z. (2020): The impact of transportation costs on economic performance in crop production, Economics of Agriculture, Institute of Agricultural Economics, Belgrade, 67 (3): 683–697, <https://doi.org/10.5937/ekoPolj2003683S>, UDC 331.346.2:633.321/.324, ISSN 0352-3462.
27. Šević B., Dolijanović Ž., Bajagić M., Rajčić V., Tupajić I., Cvijanović V., Stojiljković J. (2025). Cover crops as a tool for improving the nutritional properties and antioxidant activity of kernel sweet corn, Romanian Agricultural Research, No. 42, DII 2067-5720 RAR 2025-199, pp. 883-894. <https://new.inceda-fundulea.ro/images/rar/nr42/rar42.75.pdf>
28. Statistical Office of the Republic of Serbia, <https://data.stat.gov.rs/Home/Result/130102?languageCode=sr-Cyrl> (pristupljeno 20.01.2026.)
29. Subić, J., Cecić, N., & Kuzman, B. (2007). *Economic Aspects of Vegetable Production in Greenhouses – Results of Mini Projects*. Economics of Agriculture, Vol. 54, No. 22, pp. 231–240.

30. WHO (2020): <https://www.who.int>, accessed January 2026
31. Yang, S. W., et al. (2024). Effects of injudicious use of spirotetramat on *Encarsia formosa*'s ability to control *Bemisia tabaci*. *Science of The Total Environment*, 950, 175324.
32. Zarev D., Nesovic S., Filipovic K., Paunovic D., Krstic J., Cvijanovic V., Zarev M. (2025): Evaluation of the Biological and Economic Efficacy of Acetamiprid 20% SP in the Control of *Trialeurodes Vaporariorum* in Greenhouse Tomato Production. *Applied Ecology and Environmental Research*. ISSN:1589-1623, vol. 23 br. 6 str. 11675-11690. 10.15666/aeer/2306_1167511690.
33. Zhang Q, Zhang G, Yin P, Lv Y, Yuan S, Chen J, Wei B, Wang C. (2015): Toxicological effects of soil contaminated with spirotetramat to the earthworm *Eisenia fetida*. *Chemosphere*. 139:138-45. doi: 10.1016/j.chemosphere.2015.05.091

INTEGRATION OF SUSTAINABLE INNOVATIONS IN AGRI-FOOD TRADE STRATEGIES AND THEIR IMPACT ON CONSUMER

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ABSTRACT

The aim of this paper is to examine the impact of sustainable innovations in agri-food retail on consumer satisfaction and the moderating role of retail store image. A quantitative survey with a structured questionnaire was conducted on 381 consumers. Data were analyzed using correlation, multiple regression, and moderation regression analyses in IBM SPSS Statistics. Results show that environmental sustainability, product and marketing innovations significantly affect consumer satisfaction. Findings suggest that managers can enhance competitiveness and resource efficiency by integrating sustainability into product and marketing innovations, especially for organic and sustainably sourced products. The study introduces novelty by analyzing retail store image as a moderator, providing insights into interdependent relationships that have been largely overlooked in existing literature. This research offers practical implications for strategic decision-making in agri-food retail, promoting sustainable practices and healthy consumer choices.

Introduction

The agri-food sector plays a crucial role in ensuring food security and generating economic benefits, particularly in developing countries. Due to the strong interconnection between agriculture and environmental sustainability, this sector represents an important

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driver of sustainable socio-economic development, whereby the implementation of sustainable innovations within agri-food trade strategies is becoming increasingly significant, as it affects both the competitiveness of the sector and consumer responses and satisfaction (Marković & Simonović, 2025). Food production represents a significant export potential of Serbia, but its full capacity has not yet been realized, whereby the improvement of business performance through sustainable innovations and modern agri-food trade strategies can further strengthen the competitiveness of the sector (Bešić et al., 2014, Pantović et al., 2026).

Sustainability entails the integration of values, beliefs, and practices aimed at the responsible use of social, economic, and environmental resources, whereby retail that aspires to sustainable development goes beyond financial considerations to include environmental stewardship and community well-being in its operations (Vadakkepatt et al., 2021). A sustainable mindset is a key factor in fostering innovation, serving as the basis for lasting and competitive solutions (Lalošević et al., 2013).

A trend has emerged toward the implementation of sustainable practices, with companies striving to actively reduce waste, minimize negative environmental impacts, enhance sustainable food sourcing, and promote a broader range of organic products (Wong, 2023). The increasing importance of sustainability is also discussed by Caccialanza (2024), who highlights a growing interest in its various aspects and dimensions, especially regarding its application within social and governance frameworks.

Recent research has shown a significant link between sustainable innovation and consumer satisfaction (Gil-Saura et al., 2023; Mazzioni et al., 2021; Marin-Garcia et al., 2023; Fuentes-Blasco et al., 2017; Omri, 2020; Naidoo & Gasparatos, 2023; Milovanović et al., 2023). In this regard, the subject of the research in this paper is the consideration of the relationship between sustainable innovations in the agri-food retail sector and consumer satisfaction, with the focus on aspects of social, economic, environmental sustainability and product innovation, marketing innovation, process innovation on the one hand, and consumer satisfaction on the other. In addition, the moderating role of the image of the retail facility on the aforementioned relationship was also observed.

Based on the defined research subject, the main aim of this study is to examine the impact of sustainable innovations in agri-food retail on consumer satisfaction and to analyze the moderating role of retail store image in this relationship. Special emphasis is placed on assessing the synergistic effect of different sustainability dimensions and types of innovation on consumer satisfaction, as well as on determining whether retail store image strengthens or weakens this relationship through empirical analysis.

In examining the previous literature on agri-food retail, it was found that most studies have examined the effects of innovation and sustainability separately, while there is a small number of studies that examine the synergistic effect of innovation and sustainability, so it is not entirely clear how the combined effect of these two factors affects consumer behavior and satisfaction in the agri-food sector. In particular, Gil-

Saura et al. (2023) indicate that there are no clear explanations for the joint effect of innovation and sustainability on consumer perception and attitude towards retail and that the retail literature has not yet taken into account the synergistic effects that can arise from the analysis of innovation and sustainability from a holistic perspective.

Literature Review

Sustainability-oriented innovation in agri-food trade

Sustainability-oriented innovations in the agri-food sector are crucial for enhancing firm competitiveness and improving economic and social performance, as this is one of the most influential sectors in the country, contributing to national welfare, food security, and employment growth, while at the same time exerting pressure on the environment, thus posing an ecological challenge (Ponta et al., 2022). Furthermore, Ponta et al. (2022) emphasize that the improvement of sustainable practices in food production and consumption is of paramount importance, and that sustainability-oriented innovations and such an approach represent the main driver of the transformation of agri-food systems.

With the growth of the global population, there is an increasing need for a sustainable approach in the agri-food sector to reduce negative social, environmental, and economic impacts, as unsustainable practices in food production and consumption cause serious adverse effects, including greenhouse gas emissions, biodiversity loss, soil degradation, and pollution, while the use of GMOs poses additional environmental risks (Testa et al., 2022). Same, the growing global population and increasing demand for food highlight the need to transition from the traditional “productivist” model of agriculture to more sustainable agri-food systems, which integrate environmental and social dimensions, thereby promoting better resource management, reducing negative environmental impacts, and strengthening the role of local communities in decision-making (Jia, 2021).

Excessive industrialization of the agri-food sector often leads to environmental and social challenges, which is why sustainability-oriented innovations are considered a key instrument for balancing productivity with ecological and social sustainability (El Bilali, 2018). According to Schumpeter, innovation arises from new ideas and leads to the creation of economic value, and nowadays innovation is a key factor of competitiveness and success, where in addition to the economic dimension of innovation, the social and environmental dimensions are increasingly important, due to the growing need for rational use of resources and the creation of economically sustainable development, which can only be ensured through a combination of the above dimensions of innovation (Gao et al., 2017). Sustainable development is a paradigm designed as a model that will create a compromise between economic growth and the need to protect resources and the environment (Matešić, 2020).

Ottenbacher et al. (2019) point out that contemporary economic development is marked by rising levels of consumption, strain on natural resources, and disruption of ecological stability, while consumers increasingly realize how their actions impact the environment and recognize the seriousness of environmental challenges. This is precisely what further directs retailers to adapt their business strategy to the development and promotion of environmentally responsible products. Sustainability extends from global governance to consumer action groups, where companies recognize the benefits of engaging in sustainability, through improving performance and creating sustainable competitive advantage in the market, where sustainability is advancing from market niches to general awareness (Ritch 2020).

Vuković et al. (2025) indicate in their research that sustainable innovations encompass the development or significant improvement of products, processes, business models or management methods, aiming to achieve a positive impact not only on the economy, but also on society and the environment. Mazzioni et al. (2021) point out that process innovations represent an improved methods of delivering products to end consumers, using enhanced logistics, equipment, or techniques that contribute to more efficient business operations.

The aforementioned innovations at the organizational level require the implementation of strategic sustainability behavior, through the integration of the appropriate strategy into the organizational culture (Rodríguez-Espíndola et al., 2022). Retail can be seen as a service-oriented industry, which is subject to constant innovation and a very important factor of competitive advantage is information technology, which contributes to meeting consumer demand for innovative and qualitative products and services, as well as processes where the quality of service increases through increased consumer participation in these processes (Pantano, 2014).

For sustainable development, it is very important to adopt the principles and practices of sustainable consumption and production, and retailers play a key role in this by influencing and shaping consumer behavior and accordingly incorporating this approach into their business, especially in terms of environmentally-oriented strategies (Naidoo & Gasparatos, 2023). Berry et al. (2010) in their research point out that in retail, innovations in providing interactive services to consumers, through various marketing channels, are critical and represent the key to long-term success, with innovations in theory becoming innovations in practice when they lead to a change in consumer or retailer behavior. Sustainable practices influence the market to respect future generations, by reducing the harmful impact on the resources of the natural environment and by creating a positive impact on the community and society as a whole (Peterson et al., 2021).

Economic sustainability can be defined as the achievement of economic sustainable growth, efficiency and rational allocation of resources, while social sustainability is moderated by respecting communities and improving the quality of life, and finally environmental sustainability refers to the rational and responsible use of natural

resources (Mladenović-Sokolov 2017). These are precisely the aspects of sustainability that will be observed in this research. Moreover, given that retail has a huge share in the economy, this further indicates the importance of observing sustainable innovations in this sector.

The influence of sustainable innovations in agri-food retail |n consumer satisfaction

Research by Ponta et al. (2022) shows that sustainability-oriented innovations in the agri-food sector positively impact firm economic performance, and that joint patent development can further enhance this relationship. In the agri-food sector, such innovations involve the integration of technical, production, social, and organizational dimensions, as only through this holistic approach can innovations support the transformation of the system by increasing production, promoting social equity, and engaging local communities (El Bilali, 2018).

A study by Gil-Saura et al. (2023) examined the impact of the SOCI model (which includes six basic components: economic sustainability, social sustainability, environmental sustainability, product innovation, marketing innovation, and relationship innovation) on consumer satisfaction, and the results confirmed the direct impact of the SOCI model on consumer. Mazzioni et al. (2021) showed that process and organizational innovations, which improve products and technology, indirectly contribute to social and environmental sustainability through enhanced organizational performance, where organizations with better performance apply sustainable practices in the pursuit of global corporate sustainability.

The results of a study conducted by Marin-Garcia et al. (2023) in Spain on consumers of food retail establishments show that technological innovations strengthen sustainability and that sustainability is a very important factor in the image and loyalty of a retail establishment, with the intensity of these relationships varying depending on the commercial format. In this study, technological innovations from the consumer perspective are observed through product innovations, as the most visible element of technological innovations, through the introduction of new products or variations of existing products that meet consumer needs.

Fuentes-Blasco et al. (2017) conducted a study and the results obtained showed that both technological innovations and marketing innovations enable the improvement of the image of a retail facility as perceived by consumers and that the image of the facility is the factor that influences consumer satisfaction the most, and satisfaction is a significant factor that precedes word-of-mouth. According to Omri (2020), technological innovations primarily support economic, social, and environmental development in developed countries, while in middle-income countries they mainly affect the economic and environmental aspects, whereas their impact in low-income countries has not been clearly demonstrate.

Naidoo & Gasparatos (2023) conducted a study and the results obtained showed that consumers have a positive attitude towards different approaches to sustainability, with recycling being the most noticeable strategy. However, they point out that this may not always lead to sustainable consumer behavior and that the socio-demographic characteristics of consumers influence their lifestyle, which can further influence their perception of sustainably oriented innovations. Zlatanović et al. (2022) shows that the environmental aspects of corporate social responsibility have a statistically significant impact on organizational performance. The research by Milovanović et al. (2023) demonstrated that adopting a comprehensive environmental strategy helps align both social responsibility and marketing strategies, which in turn enhances the organization's environmental accountability and supports the attainment of a sustainable competitive advantage over the long term.

Prdić et al. (2025) confirm the importance of wholesale trade as a primary factor in the marketing of agricultural products and indicate that innovations in production and distribution processes are essential for the competitiveness and sustainability of this sector. This is an important implication given the growing consumer orientation towards organic agricultural products. This paper explores the hypotheses outlined below:

H1: Social sustainability has a positive and statistically significant impact on consumer satisfaction.

H2: Economic sustainability has a positive and statistically significant impact on consumer satisfaction.

H3: Environmental sustainability has a positive and statistically significant effect on consumer satisfaction.

H4: Product innovation has a positive and statistically significant effect on consumer satisfaction.

H5: Marketing innovation has a positive and statistically significant effect on consumer satisfaction.

H6: Process innovation has a positive and statistically significant effect on consumer satisfaction.

The moderating role of retail store image

Image management is an important strategic task. Amgad et al. (2021) represent image as the perception and identity of a retail store in the mind of consumers based on previous tangible and intangible experience, highlighting a number of factors that influence image creation, such as atmosphere, product display, assortment, prices, quality of service provision, etc. The study also showed that technological innovations play a more significant role than marketing innovations in influencing customer satisfaction, and the retail store's image was identified as the strongest determinant of consumer satisfaction.

Thomas (2013) demonstrated that retail store image has a positive and statistically significant impact on customer loyalty, mediated by customer satisfaction. The

study indicates that store image can influence the choice of a particular retail store by reducing perceived purchase risk, shaping the overall customer experience, and subsequently affecting satisfaction. Bashir & Amir (2019) in their research indicate that the implementation of sustainable practices in terms of social, economic and environmental perspectives contributes to the creation of a better image, which can further affect consumer attraction and satisfaction. In addition, they point out that image can have an indirect effect between socially responsible behavior (which implies the implementation of sustainable practices) and satisfaction.

Research conducted by Ahn & Seo (2015) on a sample of 371 respondents showed that social responsibility in sustainability management (economic, social and environmental sustainability through innovation) has a statistically impact on the image of the facility and behavioral intention, which indicates the positive effect that sustainable practices have on the development of the image of the facility from the consumer perspective.

Based on the literature review, we can conclude that there is a high degree of interdependence between image, sustainable innovations and satisfaction. It is clear that sustainable innovations affect consumer satisfaction, through the creation of an adequate image of a retail facility, which can significantly affect consumer perception of the facility itself. It is more common to observe how sustainable practices affect image, and then how image further affects consumer satisfaction and loyalty, with a positive relationship emerging here. In this study, image is positioned in the model as a moderator, precisely because it is useful to see whether the relationship between sustainable innovations and consumer satisfaction changes depending on the quality of the retail facility's image. Accordingly, another hypothesis was defined:

H7: The image of a retail store represents a factor that conditions the relationship between sustainable innovations and consumer satisfaction.

Materials and methods

In order to examine the impact of sustainable innovations in agro-food retail on consumer satisfaction, the empirical research used a survey method to collect primary data. A questionnaire was developed containing relevant statements to assess sustainable innovations in retail and consumer satisfaction. The degree of agreement of the respondents with these statements was measured using a Likert scale. Based on a review of the extensive literature dealing with this area, the selection and adaptation of questions (statements) was carried out, which resulted in the design of a research questionnaire (Gil-Saura et al., 2023; Marin-Garcia et al., 2023; Khalid et al., 2023; Fuentes-Blasco et al., 2017; Nikolić et al., 2022; Zlatanović et al., 2022).

The questionnaire was distributed electronically, and the responses to the questionnaire were collected using a convenience sample of 381 respondents (*Table 1*). The data were collected in the period from 25 November 2025. to 18 December 2025. in the territory of central Serbia.

Table 1: Profile of study participants

RESPONDENT PROFILE		Numerically	%
GENDER	Female	237	62,2%
	Male	144	37,8%
AGE	18-25	57	15%
	26-35	151	39,6%
	36-50	85	22,3%
	51+	88	23.1%
EDUCATION	Elementary	0	0%
	Middle	136	35,7%
	Higher	245	64.3%
RETAIL FORMAT	Supermarket	152	39,9%
	Hypermarket	229	60,1%

Source: Author's research

Statistical analysis of the data was conducted using IBM SPSS software. Reliability analysis was used to determine the reliability of variables, i.e. the internal consistency of the statements through which they were measured, followed by correlation analysis to determine the degree of linear dependence between the formed variables of sustainable innovations. Regression analysis was used to determine the impact of sustainable innovations in retail on consumer satisfaction, and moderation regression analysis was used to examine the moderating role of the image of the retail facility.

Results

Results are the third section of an IMRAD paper. Its purpose is to present the new information gained in the study being reported. It should be clear and concise. The Results are core of the paper. You shouldn't start the Results section by describing methods that you inadvertently omitted from the Materials and Methods section. The Results must be writing in past tense.

The results of the reliability analysis were satisfactory for all observed factors, except for the one related to economic sustainability. The Cronbach's alpha coefficient for this factor was 0.600, indicating questionable internal consistency. As a result, this factor was excluded from further analysis, leading to the rejection of hypothesis H2. The results of the reliability analysis are shown in *Table 2*.

Table 2: Results of factor analysis

FACTORS	CRONBACH'S ALPHA
Social Sustainability	0.715
Environmental Sustainability	0.771
Economic Sustainability	0.600

FACTORS	CRONBACH'S ALPHA
Product Innovation	0.790
Marketing Innovation	0.782
Process Innovation	0.780
Retail Store Image	0.753
Satisfaction	0.718

Source: Author's research

The research also included a correlation analysis and the results obtained show that the positive correlation values obtained between the observed factors are statistically significant at the 0.01 level, i.e. with a probability of 99%, except for the correlation between the retail store image factor and satisfaction, where the value is statistically significant at the 0.05 level, i.e. with a probability of 95%. A strong positive statistically significant linear correlation is present between the following factors: process innovation and marketing innovation ($r=0.776$, $p<0.01$), product innovation and marketing innovation ($r=0.705$, $p<0.01$), product innovation and process innovation ($r=0.694$, $p<0.01$), marketing innovation and satisfaction ($r=0.658$, $p<0.01$), product innovation and satisfaction ($r=0.625$, $p<0.01$). The weakest positive statistically significant linear correlation is present between satisfaction and the image of the retail facility ($r=0.112$, $p<0.05$).

Table 3: Results of correlation analysis

FACTOR	1	2	3	4	5	6	7
1	1	0.346**	0.348**	0.553**	0.318**	0.298**	0.437**
2	0.346**	1	0.202**	0.214**	0.161**	0.240**	0.173**
3	0.348**	0.202**	1	0.705**	0.694**	0.304**	0.625**
4	0.553**	0.214**	0.705**	1	0.776**	0.431**	0.658**
5	0.318**	0.161**	0.694**	0.776**	1	0.390**	0.526**
6	0.298**	0.240**	0.304**	0.431**	0.390**	1	0.112*
7	0.437**	0.173**	0.625**	0.658**	0.526**	0.112*	1

Note: 1 - Environmental sustainability; 2 - Social sustainability; 3 - Product innovation; 4 - Marketing innovation; 5 - Process innovation; 6 - Retail store image; 7 - Satisfaction
 ** Significance at the $p < 0.01$ level
 * Significance at the $p < 0.05$ level

Source: Author's research

Based on the results of the regression analysis (*Table 4.*), it is concluded that 49.6% of the variability of satisfaction is described by this regression model, i.e. under the influence of these factors of sustainable innovations in trade (coefficient of determination $R^2=0.496$), while 50.4% of the variability of the dependent variable is described by other factors that are not included in this regression model. It should be noted that the value of this coefficient is significant at the 0.01 level and that multicollinearity does not exist in the analysis.

The regression analysis determined that environmental sustainability has a statistically significant positive impact on satisfaction ($\beta=0.122$, $p < 0.05$), which confirms hypothesis H3. In addition, multiple regression analysis showed that product innovation ($\beta=0.349$, $p < 0.01$) and marketing innovation ($\beta=0.391$, $p < 0.01$) have a statistically significant positive impact on consumer satisfaction, thus confirming hypotheses H4 and H5. Marketing innovation has a greater impact on consumer satisfaction, as shown by the higher beta coefficient value, followed by product innovation. On the other hand, it was found that social sustainability does not have a statistically significant impact on consumer satisfaction ($p > 0.05$). This rejects hypothesis H1. Hypothesis H6 is also rejected, as regression analysis showed that process innovation does not have a statistically significant impact on consumer satisfaction.

The results of the multiple regression analysis show that incorporating environmental sustainability through product innovation and marketing innovation can lead to a synergistic effect, leading to numerous benefits that can go beyond consumer satisfaction and lead to the creation of consumer loyalty, which is precisely the goal of every retailer, as they are the source of profitability. Accordingly, Naidoo and Gasparatos (2023) emphasize in their study that retailers are primarily focused on environmental issues, which corresponds to the environmental sustainability dimension confirmed in this research.

Table 4: Multiple regression analysis

VARIABLE	SATISFACTION			VIF
	B	T	P	
Social Sustainability	-0.014	-0.360	0.719	1.149
Environmental Sustainability	0.122	2.596	0.010	1.644
Product Innovation	0.349	6.353	0.000	2.246
Marketing Innovation	0.391	5.465	0.000	3.816
Process Innovation	-0.057	-0.900	0.369	2.945
$R^2 = 0,496$; $F = 73.938$ ($p < 0,01$)				

Source: Author's research

To examine the image of a retail facility as a factor that conditions the relationship between sustainable innovations and consumer satisfaction, a moderator analysis was conducted (Table 5), in which the coefficient of determination is statistically significant and amounts to 0.574, with the VIF value also being within the permissible range (> 10). The moderation regression analysis showed that image has a statistically significant negative moderating effect on the relationship between social sustainability and satisfaction ($p=0.001 < 0.01$), ($\beta=-0.455$). This means that image has a moderating role, i.e., by strengthening the image of a retail facility, the relationship between social sustainability and consumer satisfaction weakens (for example, if a retail facility does not fully adapt to the needs of society, consumers will still be satisfied due to a strong image).

Same effect also occurs on the relationship between environmental sustainability and satisfaction ($p=0.001 < 0.01$), ($\beta=-0.148$). This further means that by strengthening the image of a retail facility, the relationship between environmental sustainability and consumer satisfaction weakens (for example, if a retail facility does not use materials that contribute to sustainable development, consumers will still be satisfied due to the strength of the existing image).

The results obtained further showed that image has a positive statistically significant moderating role in the relationship between marketing innovation and consumer satisfaction ($p=0.001 < 0.01$), ($\beta=0.506$). This indicates that by strengthening the image of a retail outlet, the relationship between marketing innovation and consumer satisfaction also strengthens. In the other relationships between product and process innovation on the one hand and consumer satisfaction on the other hand, image does not have a moderating role ($p > 0.1$), i.e. the quality of the image does not affect the strength of the aforementioned relationships.

Hypothesis 7 is accepted when it comes to the relationship of integration between social and environmental sustainability and marketing innovations on the one hand, and consumer satisfaction on the other. In other cases, the moderating influence of image on the observed relationships was not confirmed.

Table 5. Moderation regression analysis

VARIABLE	SATISFACTION			
	B	T	P	VIF
Social Sustainability	-0.024	-0.631	0.528	1.274
Environmental Sustainability	0.221	4.566	0.000	2.028
Product Innovation	0.216	4.026	0.000	2.492
Marketing Innovation	0.426	6.190	0.000	4.105
Process Innovation	-0.143	-2.409	0.017	3.046
Image * Social Sustainability	-0.455	-6.342	0.000	4.460
Image * Environmental Sustainability	-0.148	-2.902	0.004	2.266
Image * Product Innovation	0.065	0.838	0.402	5.283
Image * Marketing Innovation	0.506	4.975	0.000	8.984
Image * Process Innovation	-0.031	-0.416	0.678	4.868
$R^2 = 0,574$; $F = 49.828$ ($p < 0,01$)				

Source: Author's research

Discussions

The analysis of the results showed that environmental sustainability has a statistically significant positive impact on consumer satisfaction. This finding suggests that consumers have a more favorable perception of agri-food retail outlets that align their operations with environmental principles, particularly when offering sustainably produced and organic agricultural products, which are often associated with higher quality and safety standards. Such practices not only meet consumer expectations but also support rural development and local farming communities. On the other hand, social sustainability does not have a statistically significant direct impact on consumer satisfaction. However, it may indirectly enhance the consumer experience by fostering a positive image of the retail outlet, especially in communities where social responsibility and support for local producers are increasingly valued.

Product innovation has a statistically significant positive impact on consumer satisfaction, within the agri-food retail sector. This indicates that product innovation affects consumer satisfaction by improving the consumer experience, by solving a specific problem that contributes to satisfying a need, such as the demand for sustainably produced, organic or locally sourced food, by prestige and status, and by influencing consumer emotion (e.g., excitement) that leads to the need to try something new. In addition, regression analysis showed that marketing innovation has a statistically significant positive impact on consumer satisfaction, which further indicates that consumers are very sensitive to various promotions and marketing tricks, including transparent communication of product origin, sustainability labels and certifications, as well as the great influence of loyalty programs. All of this is related to price, and price is one of the most important factors in making a purchase decision, particularly when purchasing food products, and in addition, the marketing mix ensures differentiation in the market and competitive advantage for agri-food retail outlets.

Research has shown that process innovation does not have a statistically significant impact on consumer satisfaction, particularly in the agri-food retail context, which can be explained by the fact that consumers better perceive and remember tangible elements that provide a direct and quantitative result, such as a product that is tangible and directly satisfies a specific need, including food quality, freshness, safety, or sustainability attributes, or marketing innovations, where promotions, for example, discounts, free packaging and other methods of improving sales or loyalty programs, directly affect consumer satisfaction, which can also lead to the creation of consumer loyalty (Isse, 2019; Triyadi, 2020). On the other hand, process innovations are less tangible for consumers, especially when related to internal operations in agri-food retail, where if there is no direct benefit from it, then consumers perceive that innovation less well. Certainly, process innovation is more visible to retailers themselves, as it can improve and accelerate numerous processes, such as logistics processes, with the help of technological processes, which further leads to lower costs, reduced food waste and a sustainable approach to business.

Image as a moderator in trade, affects consumer satisfaction differently. Namely, a well-built image reduces the effect of social and ecological sustainability on satisfaction, because consumers already have a positive perception and expect such values, and even if the activities in these domains are not at a high level, this does not change the consumer's opinion. On the other hand, a strong image strengthens the impact of marketing innovations such as personalized offers, loyalty programs, mobile applications and the like on satisfaction. Consumers directly evaluate product and process innovations, without the influence of image perception.

Conclusions

The goal of every retailer is to achieve consumer satisfaction and loyalty, which increasingly depends on the ability to implement innovative solutions aligned with sustainable practices. Such an approach is particularly relevant in the context of agri-food retail and agricultural products, where consumers show growing interest in the origin, quality, and ecological footprint of what they buy. By integrating sustainability into innovations within the agri-food sector - whether through environmentally friendly packaging, support for local producers, or promotion of organic and sustainably sourced food - retailers can contribute not only to environmental protection and social responsibility but also to the creation of added value for consumers. As emphasized throughout the paper, adapting business strategies in agri-food retail to the principles of social, economic, and environmental sustainability is essential for long-term success and for supporting sustainable agricultural and economic development.

The theoretical contribution of the work is reflected in the acquisition of new knowledge in the field of consumer behavior and is reflected in the elimination of the observed gap in the literature. Previous research indicates that there are no clear explanations for the joint effect of innovation and sustainability on consumer perception and attitude towards retailing, particularly within the agri-food retail sector, and that the literature dealing with retailing has not yet taken into account the synergistic effects that may arise from the aforementioned relationship, but previous research tends to look at these two factors separately. In this regard, this research contributes to a better understanding of the synergistic effect between sustainability and innovation in the context of agri-food products on consumer satisfaction. In addition, there are few studies that test the moderating role of image in the relationship between sustainable innovations and consumer satisfaction in agri-food retail outlets. Previous research has mainly focused on examining main, rather than interaction effects, and has mainly examined the impact of sustainable practices on the image of a retail outlet, and then how this further affects satisfaction. Based on this, the originality of this research lies in examining how the image of a retail facility moderates the relationship between sustainable innovations and consumer satisfaction. This is particularly significant given the limited number of studies, both domestic and international, that have explored this topic.

The paper also provides some practical implications that may be useful for marketers and retail managers, businesses, consumers, and future research on this or similar

topics. The research highlights the importance of sustainable innovations for consumer satisfaction, especially in the agri-food retail sector. Creating business success and sustainable competitive advantage today requires the existence of satisfied and loyal consumers, which can be achieved through the incorporation of sustainability into innovations, so as to achieve a long-term strategic effect. However, a prerequisite for creating consumer satisfaction is knowing the needs and attitudes of consumers regarding sustainable innovations, i.e. which sustainable innovations have a statistically significant impact on their purchase intention. The results of this research have identified that the integration of environmental sustainability and product innovation and marketing innovation, through their synergistic effect, have a statistically significant impact on creating consumer satisfaction, which may enable retailers in the agri-food sector to invest more and focus on the aforementioned relationship in future business. This would lead to numerous benefits such as attracting and satisfying consumers who value sustainable agri-food products and services, strengthening the competitive position in the market and strengthening the image, rational use of resources and minimizing costs, which contributes to economic sustainability.

Given that the results showed that image has a positive moderating role in the relationship between marketing innovation and consumer satisfaction, this further indicates the great importance of marketing innovation and that retailers should pay special attention to it, i.e. focus their business strategy on marketing innovations.

The study faces certain constraints. First, the scope of the sample was not broad enough, which may limit the depth of the analysis. Second, the research area was geographically narrow, covering only central Serbia. Additionally, the focus was limited to only three types of innovation, leaving out other potentially relevant categories.

Future research directions arise from the above limitations. The research could be conducted over a longer period of time, or in multiple time series on a larger sample. In addition, the research could be repeated in other parts of the Republic of Serbia, but also outside the borders of Serbia, and then conduct a comparative analysis of the effectiveness of sustainable innovations aimed at consumer satisfaction both in our country and in neighboring countries. In addition, future research could include other types of innovations in the research, such as technological innovations or relationship innovations, and it is proposed to include the economic dimension of sustainability in the regression model. Future research could focus on observing the impact of sustainable innovations on consumer loyalty, which could be interesting, because satisfaction precedes loyalty, but does not necessarily lead to it.

Conflict of interests

The authors declare no conflict of interest.

References

1. Ahn, J., & Seo, S. (2015). The influences of sustainability management at institutional foodservice on store image and behavioral intention. *Journal of Nutrition and Health*, 48 (2), pp. 199-210. <http://dx.doi.org/10.4163/jnh.2015.48.2.199>
2. Amgad, S. D., Khaled, D.S.A., Ahmed, S., Khan, M. A., Al Homaidi, E. A., Moh'd Mansour, A., & Foroudi, R. (2021). Exploring the relationship of marketing & technological innovation on store equity, word of mouth and satisfaction, *Cogent Business & Management*, 8(1), pp.1-21,
3. Bashir, A., & Amir, A. (2019). CSR dimensions and customer satisfaction: the mediating role of brand image from the perspective of the hotel industry. *European Online Journal of Natural and Social Sciences*, 8 (4), pp. 184-198. ISSN 1805-3602
4. Berry, L.L., Bolton, N.R., Bridges, H. CH., Meyer, J., Parasuraman, A., & Seiders, K. (2010). Opportunities for Innovation in the Delivery of Interactive Retail Services. *Journal of Interactive Marketing*, 24, pp. 155–167. <http://dx.doi.org/10.1016/j.intmar.2010.02.001>
5. Bešić, C., Čočkalović, D., Đorđević, D., & Bogetić, S. (2014). The analysis of aspects of food industry competitiveness in serbia. *Economic of Agriculture*, 61(3), pp. 647–659. <https://doi.org/10.5937/ekoPolj1403647B>
6. Caccialanza, A. (2024). Sustainability performance disclosure and family businesses: a perspective article. *Journal of Family Business Management*, 15(1), pp. 48–56. <https://doi.org/10.1108/JFBM-10-2023-0250>
7. DOI: 10.1080/23311975.2020.1861752
8. El Bilali, H. (2018). Relation between innovation and sustainability in the agro-food system. *Italian Journal of Food Science*, 30(2), pp. 200-225. <https://doi.org/10.14674/IJFS-1096>
9. Fuentes-Blasco, M., Moliner-Velázquez, B., Servera-Francés, D., & Gil-Saura, I. (2017). Role of marketing and technological innovation on store equity, satisfaction and word-of-mouth in retailing. *Journal of Product & Brand Management*, 26/6, pp. 650–666. <http://dx.doi.org/10.1108/JPBM-07-2016-1279>
10. Gao, D., Xu, Z.D., Ruan, Y.L.Z., & Lu, H.Y. (2017). From a systematic literature review to integrated, definition for sustainable supply chain innovation (SSCI). *Journal of Cleaner Production* 142 (4), pp. 1518-1538.
11. Gil-Saura, I., Ruiz-Molina, M.E., Marin-Garcia, A., & Geraldine, M. (2023). Sustainability-oriented commerce innovation: How does it influence consumer satisfaction?. *International Journal of Retail & Distribution Management*, 51 (11), pp. 1477-1496. <https://doi.org/10.1108/IJRDM-07-2022-0267>
12. Isse, M. M. (2019). The impact of sales promotion and customer satisfaction in some selected Mogadishu shopping centers. *International Journal of Science and Research*, 8(1), pp. 1024-1025. <https://doi.org/10.21275/ART20194446>

13. Jia, X. (2021). Agro-Food Innovation and Sustainability Transition: A Conceptual Synthesis. *Sustainability*, 13(12), 6897, <https://doi.org/10.3390/su13126897>
14. Khalid, A., Awan, A.R., Ali, R., & Sarmad, I. (2023). The antecedent cognitions of brand love and its impact on brand loyalty: the moderating role of sustainability marketing. *Corporate governance*, Emerald Publishing Limited, ISSN 1472-0701, <http://dx.doi.org/10.1108/CG-06-2023-0230>
15. Lalošević, M., Pokrajac, S., & Miloš, M. (2013). Integralna održivost kao bazicni preduslov (urbo) inovacija. *Stručni radovi*, pp. 78-83. [Lalošević, M., Pokrajac, S., & Miloš, M. (2013). Integral Sustainability as a Fundamental Prerequisite for (Urban) Innovation. *Professional Papers*, pp. 78–83. <https://doi.org/10.5937/a-u38-5150>]
16. Marin-Garcia, A., Gil-Saura, I., Ruiz-Molina, M.E., & Berenguer-Contrí, G. (2023). Capturing consumer loyalty through technological innovation and sustainability: the moderating effect of the grocery commercial format. *British Food Journal*, 125(8), pp. 2764-2784. <https://doi.org/10.1108/BFJ-12-2021-1317>
17. Marković, M., & Simonović, Z. (2025). Competitiveness of the agri-food sector of serbia through the perspective of unit values of exports and imports. *Economic of Agriculture*, 72(2), pp. 469–481. <https://doi.org/10.59267/ekoPolj2502469M>
18. Matešić, M. (2020). Eko-inovacije za održivi razvoj. *Socijalna ekologija*. 29 (2), pp. 153-177. [Matešić, M. (2020). Eco-Innovations for Sustainable Development. *Social Ecology*, 29 (2), pp. 153–177. <https://www.researchgate.net/publication/343789463>]
19. Mazzioni, S., Baú Dal Magro, C., Dagostim Picolo, J., & Bertolletti Johann, G. (2021). The power of innovation on performanse and socioenvironmental sustainability. *International Journal for Innovation Education and Research*, 9 (05), pp 515-525. ISSN 2411-2933.
20. Milovanović, V., Bučalina-Matić, A., & Jurić, A. (2023). The internal green marketing dimensions, employees' satisfaction, and employees' organizational identification, *Oditor*, 9(1), pp. 47-70. doi:10.5937/Oditor2301047M
21. Mladenović-Sokolov, S. (2017). Održivost i održivi razvoj u maloprodaji – međunarodna i domaća iskustva. *Društvo ekonomista Ekonomika*. 1(1), pp. 47–55. [Mladenović-Sokolov, S. (2017). Sustainability and Sustainable Development in Retail – International and Domestic Experiences. *Society of Economist "Ekonomika"*, 1(1), pp. 47–55.] <http://www.ekonomika.org.rs/>
22. Naidoo, M., & Gasparatos, A. (2023). Consumer worldviews and perspectives on environmental sustainability initiatives in the South African supermarket sector. *Journal of Cleaner Production*, 413, pp. 2-12. <https://doi.org/10.1016/j.jclepro.2023.137496>
23. Nikolić, J., Mirić, M., & Zlatanović, D. (2022). Does ownership type matter for innovativeness and learning orientation? Empirical evidence from Serbai. *Teme*, XLVI (4), pp. 995–1009. <https://doi.org/10.22190/TEME211001052N>

24. Omri, A. (2020). Technological innovation and sustainable development: Does the stage of development matter? *Environmental Impact Assessment Review*, 83, pp. 2-10. <https://doi.org/10.1016/j.eiar.2020.106398>
25. Ottenbacher, C. M., Kansas, M., Kuechle, G., Harrington, J.R., & Kim, W.H. (2019). QSR customer sustainable behaviors and brand practice perceptions on willingness to pay a premium. *International Hospitality Review*, 33 (2), pp. 106-125. DOI 10.1108/IHR-03-2019-0006
26. Pantano, E. (2014). Innovation drivers in retail industry. *International Journal of Information Management*, 34, pp. 344–350. <http://dx.doi.org/10.1016/j.ijinfomgt.2014.03.002>
27. Pantović, D., Lojanica, N., Bojnec, Š., & Gričar, S. (2026). Assessing Disparities in Climate and Energy Agri-Environmental Indicators Among EU Countries Using the PROMETHEE–GAIA Method and the Entropy Index. *Agriculture*, 16(4), 463, <https://doi.org/10.3390/agriculture16040463>
28. Peterson, M., Aminton, A. E. Lui, L. R., & Bartholomew, E. D. (2021). Sustainable Marketing and Consumer Support for Sustainable Businesses. *Sustainable Production and Consumption* 27, pp. 157–168. <https://doi.org/10.1016/j.spc.2020.10.018>
29. Ponta, L., Puliga, G., Manzini, R., & Cincotti, S. (2022). Sustainability-oriented innovation and co-patenting role in agri-food sector: Empirical analysis with patents. *Technological Forecasting and Social Change*, 178, 121595. <https://doi.org/10.1016/j.techfore.2022.121595>
30. Prdić, N., Gajić, T., & Stepanov, S. (2025). Wholesale markets as supply channels for green markets and their impact on rural development in Serbia. *Ekonomika Poljoprivrede*, 72 (1), pp. 63–87. <https://doi.org/10.59267/ekoPolj250163P>
31. Ritch, L.E. (2020). Experiencing fashion: the interplay between consumer value and sustainability. *Qualitative Market Research: An International Journal*, 23 (2), pp. 265-285. <http://dx.doi.org/10.1108/QMR-09-2019-0113>
32. Rodríguez-Espíndola, O., Cuevas-Romo, A., Chowdhury, S., Díaz-Acevedo, N., Albores, P., Despoudi, S., Malesiosf, C., & Dey, P. (2022). The role of circular economy principles and sustainable-oriented innovation to enhance social, economic and environmental performance: Evidence from Mexican SMEs. *International Journal of Production Economics* 248, pp. 2-14. <https://doi.org/10.1016/j.ijpe.2022.108495>
33. Testa, S., Nielsen, K. R., Vallentin, S., & Ciccullo, F. (2022). Sustainability-oriented innovation in the agri-food system: Current issues and the road ahead. *Technological Forecasting and Social Change*, 179, 121653. <https://doi.org/10.1016/j.techfore.2022.121653>
34. Thomas, S. (2013). Linking customer loyalty to customer satisfaction and store image: a structural model for retail stores. *Decision*. 40 (1/2), pp. 15-25. DOI 10.1007/s40622-013-0007-z

35. Triyadi, P.T. (2020). Effect of Promotion and Service Quality on Customer Satisfaction at PT. Surya Karya Prima in Jakarta. *Jurnal Administrare: Jurnal Pemikiran Ilmiah dan Pendidikan Administrasi Perkantoran*, 7(1), pp. 65-72. <https://doi.org/10.26858/ja.v7i1.13584>
36. Vadakkepatt, G. G., Page Winterich, K., Mittal, V., Zinn, W., Beitelspacher, L., Aloysius, J., Ginger, J., & Reilman, J. (2021). Sustainable Retailing. *Journal of Retailing*. 97 (1), pp. 62-80. <https://doi.org/10.1016/j.jretai.2020.10.008>
37. Vuković, D., Dukić, A., Urošević, A., & Ilić, B. (2025). The impact of product and process innovation and technological dimensions on the sustainable competitive advantage of manufacturing companies. *Ekonomika Poljoprivrede*, 72 (1), pp. 241–254. <https://doi.org/10.59267/ekoPolj2501241V>
38. Wong, A. (2023). How green sustainability efforts affect brand-related outcomes. *Asia-Pacific Journal of Business Administration*, 16 (5), pp. 1182–1201. <https://doi.org/10.1108/APJBA-03-2023-0104>
39. Zlatanović, D., Domanović, V., & Slavković, M. (2022). Uticaj ekoloških aspekata korporativne društvene odgovornosti na organizacione performanse. *Ekologika*, 29 (108), pp. 469-474. [Zlatanović, D., Domanović, V., & Slavković, M. (2022). The Impact of Environmental Aspects of Corporate Social Responsibility on Organizational Performance. *Ekologika*, 29 (108), 469–474.] <https://www.researchgate.net/publication/366629587>

THE ROLE OF STRATEGIC DOCUMENTS IN LOCAL TOURISM DEVELOPMENT: A COMPARATIVE ANALYSIS AND METHODOLOGICAL INSIGHT INTO THE APPLICATION OF STRATEGIC TOOLS IN SERBIA

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ABSTRACT

This paper examines the alignment between local tourism development strategies and the current national strategy in Serbia, with a focus on the application of key strategic planning tools. The purpose is to assess how effectively local governments implement these tools and to what extent their strategies reflect national priorities. The study applies comparative analysis to selected municipalities with adopted tourism strategies and includes a control case without such a document. The methodology incorporates qualitative assessment and quantitative ranking using a multi-criteria decision-making approach. The results highlight significant variations in the use of strategic tools, limited institutional coordination, and the lack of monitoring mechanisms. The findings suggest that existing strategies often prioritize formal compliance over practical functionality. The paper concludes that enhancing institutional capacity and participatory planning is essential for improving strategic outcomes. It recommends developing a more integrated and responsive planning framework to support sustainable tourism growth in Serbia.

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Introduction

In the context of modern market competition, rapidly changing tourism trends, and the growing need for sustainable development, strategic tourism planning emerges as a key instrument for shaping development policies at the local level. Local governments in Serbia increasingly face the challenge of how to use available resources effectively, ensure the long-term competitiveness of their destinations, and at the same time protect cultural identity and natural heritage in line with the principles of sustainability (Kaikara, 2020). Strategic planning represents a systematic and anticipatory approach to development management under conditions of uncertainty and rapid change (Markiewicz, 2011). It enables the formation of shared development visions, the setting of priorities, and the alignment of public and private initiatives toward clearly established objectives. In tourism, strategic documents integrate sectoral policies, improve institutional coordination, and create preconditions for the long-term market positioning of destinations.

In practice, many Serbian cities and municipalities either lack valid local tourism strategies or apply them without clearly defined monitoring and evaluation mechanisms; despite legal obligations, the documents are thus used mainly in a declarative way, with limited influence on management practice. Focusing on post-2016 documents, this paper determines the extent of their substantive alignment with the National Tourism Development Strategy (2016–2025), assesses whether rural interventions are articulated and implemented with the same rigor as urban ones, and contrasts the deployment of strategic tools in predominantly rural and predominantly urban settings to illuminate differences in current practice (Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia, 2016). In this context, we pose the following research questions:

RQ1: To what extent do post-2016 local strategies substantively align with the goals and measures of the National Strategy (2016 -2025)?

RQ2: Are rural measures (e.g., agritourism, village households, local product routes) operationalized with indicators, targets, budgets, timelines, and accountability to a degree comparable to urban measures?

RQ3: How do patterns of strategic tool use (SWOT, PEST, TOWS, stakeholder participation, competition analysis, goal-oriented planning, destination branding) differ between predominantly rural and predominantly urban local governments in terms of depth, consistency, stakeholder engagement, and integration into operational plans?

Guided by these questions, we examine the presence and degree of operationalization of seven strategic tools (SWOT, PEST, TOWS, stakeholder participation, competition analysis, goal-oriented planning, destination branding) in national and local documents adopted or revised after 2016. We apply qualitative content coding tool presence and evidence of operational use summarized in a binary/ordinal matrix, and synthesize cross-city differences using the VIKOR multi-criteria decision method, where lower Q indicates a better compromise position relative to an ideal model (Ozkaya &

Demirhan, 2022; Nádasí et al., 2024). In this way, the study moves beyond formal compliance to assess practical functionality, with particular attention to the rural, urban balance and to monitoring and evaluation practices in local strategy implementation. The findings point to revising outdated local strategies and to the need to strengthen capacities, participatory planning, and M&E frameworks for sustainable, place-based tourism development. The paper thus underscores redefining strategic approaches and empowering local institutions so that tourism in Serbian cities advances through thoughtful planning, sustainability, and stronger international competitiveness.

Literature and Conceptual Review

Tourism has become a key component of modern society, primarily as a result of intensified globalization processes and increased human mobility (Sereda et.al, 2024). These factors exert multifaceted impacts, economic, socio-cultural, and environmental and further emphasize the need for a strategic approach to tourism development. In this context, strategic management is playing an increasingly important role in shaping an efficient, sustainable, and competitive tourism sector (Bayev et.al, 2022).

The consideration of strategic approaches in tourism encompasses a wide range of issues, from planning the development of specific destinations to identifying effective methods for attracting and retaining customers (Lozano-Oyola et.al, 2019). This study pays particular attention to the analysis of the competitive environment, identification of key competitive advantages, and the formulation of strategies aimed at enhancing the performance of tourism enterprises. In urban areas, the development of tourism increasingly relies on strategic planning based on systematically developed documents such as local development strategies, action plans, and sectoral policies (Čerović, 2002). These documents serve as essential tools for directing growth and improving the competitiveness of cities as tourist destinations. Their primary function is to identify key development potentials, define strategic priorities, and establish an institutional framework for sustainable and inclusive tourism governance (Hill et al., 2004). According to Javier and Elazigue (2011) local government units play a crucial role in the implementation of strategic documents, as they are responsible for translating national policies into concrete local measures. The effective implementation of these documents depends on several factors, including institutional capacity, political will, availability of budgetary and external resources, and active participation of the local community.

The literature emphasizes the importance of strategic management as a continuous process that analyzes environmental conditions and defines long-term development directions, with the goal of achieving competitive advantage (Wheelen& Hunger, 2012). In the context of urban tourism, strategic management also involves aligning tourism-related activities with urban policies, spatial planning, and sustainable development objectives. The modern context of urban tourism is marked by fierce competition, evolving visitor expectations, and a growing imperative for cities to establish a distinct and recognizable tourism identity (Grant, 2016). To address these complexities, strategic frameworks for urban tourism development must be grounded in thorough

assessments of macro-environmental factors and internal capacities, utilizing analytical models such as PEST, SWOT, and TOWS. Equally important is the incorporation of participatory governance processes that ensure inclusive and context-sensitive planning (Benzaghta et.al, 2021).

These analytical approaches and planning instruments enable urban destinations to clarify their unique strengths, anticipate potential obstacles, and chart development directions that are both realistic and responsive to shifting market dynamics. Tools aimed at target-oriented development, competitive profiling, and image-building contribute to more effective prioritization of initiatives and alignment with long-term goals (Basar, 2024). By applying such methodologies, city administrations and tourism stakeholders are better positioned to optimize the use of available assets, foster collaboration across different sectors, and craft policies that promote sustainability and broad-based benefits. Tourism, as an integral component of urban development, requires a holistic and multisectoral approach that involves coordinated management of natural, infrastructural, cultural, and human resources, while simultaneously preserving the environment (Atalay& Gülersoy, 2023). In this sense, the application of strategic tools, such as goal-oriented planning, competition analysis, and destination image management instruments, enables local governments to efficiently identify comparative advantages, assess development risks, and define sustainable growth trajectories.

By utilizing these tools, municipal authorities and local tourism organizations not only enhance the allocation of available resources but also raise the level of cross-sectoral cooperation and institutional coordination. This creates a foundation for building inclusive, long-term sustainable tourism policies that strengthen the competitiveness of urban destinations in an increasingly dynamic global tourism environment (Kisi, 2019). The application of strategic tools in urban tourism development requires the involvement of all local system actors from public administration decision-makers and professional services to operational teams in the tourism sector. A clear development vision, precisely defined objectives, and well-structured strategies reflecting the local context are essential prerequisites for effective strategic governance (Font et.al, 2006). In this way, strategic documents are not merely formal planning instruments but become active tools for managing change and improving the positioning of cities in the tourism market. According to Buble et al. (2005), strategic management can be defined as a set of decisions and activities aimed at formulating and implementing strategies to achieve long-term organizational objectives. This approach highlights the necessity of aligning internal capacities with external environmental dynamics an especially important consideration in the tourism sector, where shifts in market demand, consumer behavior, and global trends are frequent and impactful.

The modern tourism industry operates in a highly dynamic environment shaped by digital transformation, sustainability imperatives, and intensifying international competition. Within this framework, strategic management serves as a vital tool for identifying emerging opportunities, anticipating potential threats, and crafting innovative responses that enhance the distinctiveness and attractiveness of tourist

destinations. In the case of Serbia, despite the availability of substantial natural and cultural resources and a favorable geographical location, the current level of tourism development remains below its full potential. Persistent structural barriers such as weak institutional coordination across governance levels, limited synergy between public and private actors, and insufficient integration of tourism with related sectors like agriculture (notably organic food production), transportation, artisanal crafts, viticulture, and fisheries continue to hinder more robust progress (Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia, 2016).

Addressing these shortcomings requires a more pronounced role for destination management entities, enhanced support from specialized public institutions, and greater engagement of industry associations. Key development priorities include capacity building at all levels, continuous professional training for sectoral actors, and the full-scale deployment of digital infrastructure. Equally important is the creation of a unified tourism statistics system with internationally comparable indicators (e.g., accommodation capacity, tourist traffic, and foreign exchange inflows), which would enable evidence-based decision-making and more effective performance monitoring (EC, 2019). Ultimately, strategic tools in tourism should not be regarded merely as formal planning instruments. Instead, they must be seen as dynamic mechanisms for managing change, directing investments, and positioning urban destinations within the global tourism marketplace. For cities in Serbia, the consistent and context-sensitive application of these instruments represents a strategic imperative for building long-term competitiveness, fostering sustainable growth, and reinforcing their presence as recognizable and appealing destinations.

Research Context

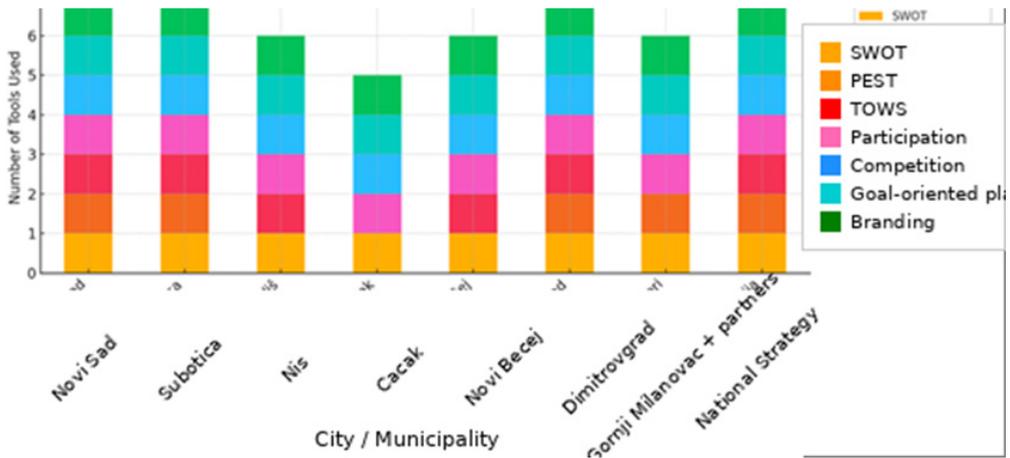
This paper identifies and compares local strategic planning approaches to tourism development in Serbia, with explicit reference to the National Tourism Development Strategy (2016-2025). Alongside municipalities with an adopted strategy, Loznica is included as a control case due to the absence of a formal local tourism strategy. The analyzed units are: Novi Sad, Subotica, Niš, Čačak, Gornji Milanovac, Dimitrovgrad, Novi Bečej, plus the national strategic framework. In line with the research questions, the analysis considers not only the presence but also the operationalization of strategic tools and measures.

Specifically, we review national and post-2016 local documents for seven strategic tools (as listed above). Coding proceeds on two layers: (1) tool presence (0/1) and (2) an operationalization index (0-3) for priority measures that captures SMART indicators (baselines/targets), budget lines, timelines, and clear accountability, with explicit attention to rural interventions (e.g., agritourism, village households, local product routes).

Documents were double-coded and reconciled by consensus. Descriptive results are shown in a matrix and in comparative visuals Figure 1. on tool breadth and Figure 2. on the urban-rural operationalization index. To synthesize differences across cities, we

apply VIKOR to rank alternatives relative to an ideal solution (lower Q = better), using normalized criteria and equal baseline weights: existence of a current strategy, toolset breadth, operationalization (urban; rural), participation depth, evidence of competition analysis, brand articulation, and basic tourism-performance proxies. This method directly supports the research questions by testing post-2016 alignment with the national framework, contrasting rural and urban operationalization, and comparing tool-use patterns across predominantly rural and predominantly urban local governments.

Figure 1. Comparative Chart: Use of Strategic Tools in Tourism Planning



Source: Authors' calculations

Consistent with *RQ1*, Figure 1 documents the formal presence of seven strategic tools across cities and the national framework. In line with *RQ2*, subsequent figures report the operationalization index (SMART indicators, budgets, timelines, accountability) separately for urban and rural measures; here, the stacked bars capture tool breadth only. For *RQ3*, we later contrast predominantly rural vs. predominantly urban municipalities and synthesize differences via VIKOR (lower Q = better).

The data indicate a high level of alignment and a comprehensive approach in cities such as Novi Sad, Subotica, Gornji Milanovac, and Dimitrovgrad, which apply all or nearly all of the listed tools. In contrast, the strategies of Čačak and Niš show a somewhat lower level of implementation, with certain tools such as PEST or TOWS analysis being omitted. The national strategy stands out as a comprehensive example, as it includes all analyzed tools, including branding and goal-oriented planning components, indicating an effort to create an integrated and competitive national tourism identity. These findings point to significant differences in approaches to strategic planning at the local level, where success may be linked to the breadth of applied methodological frameworks and the degree to which tools are integrated into concrete development measures. As part of the qualitative analysis of strategic tourism planning at the local level in Serbia, attention is focused on the implementation measures defined in the action

plans of selected cities, as well as their concrete effects. Novi Sad, as one of the leading urban centers, emphasizes infrastructural and ecological interventions in its Tourism Development Program for the period 2023-2025 (City of Novi Sad - City Assembly, 2023-2025). These include the construction of a pedestrian-bicycle bridge over the Danube, procurement of electric buses, and development of cycling infrastructure. In parallel, the Petrovaradin Fortress is being renovated, the construction of a botanical garden is planned, and a model of tourism zoning is being developed. Specialized areas such as congress and gastro-oenological tourism form the basis for diversifying the city's offer. These measures have produced visible results in positioning Novi Sad as a vibrant urban, cultural, and festival destination recognized internationally.

Subotica relies on preserving its architectural and cultural heritage, promoting a multicultural identity through events such as Dužijanica and the Children's Theatre Festival (City of Subotica, 2013-2022). The focus is also placed on the development of family tourism, with implemented measures including improvements around Lake Palić and the introduction of certifications for hospitality providers offering family accommodation services. Through these activities, the city has achieved international recognition at tourism fairs and positioned itself as an attractive destination in northern Serbia.

Niš, as a historical and cultural center of southeastern Serbia, has taken significant steps toward modernizing its tourism offer. By improving the facilities of Niška Banja spa and implementing digital tools such as mobile applications and QR codes at tourist sites, the city strengthens its visibility in both health and cultural tourism (City of Niš - City Administration, 2018-2020). Events like the Nišville Jazz Festival and the Film Meetings further reinforce its cultural identity, while staff education in tourism is conducted as part of long-term human resource development.

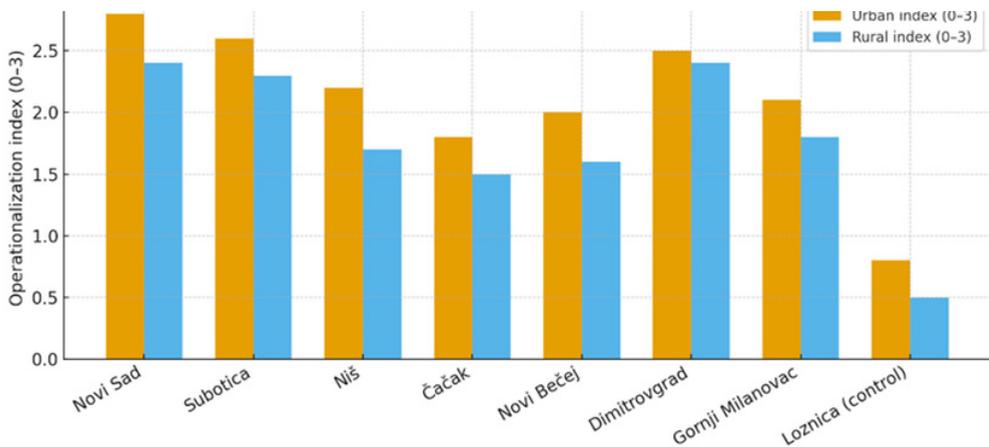
Čačak strategically relies on natural resources and cultural heritage, with a particular focus on the Ovčar-Kablar Gorge. The enhancement of this area's infrastructure including tourist trails, viewpoints, and informational signage supports the development of active and religious tourism (City of Čačak, 2019-2024). At the same time, festivals such as the Cabbage Festival and Dis's Spring contribute to preserving local traditions, while promotional efforts via digital tools and mobile applications align with modern tourism communication trends.

Dimitrovgrad stands out through the comprehensive application of all key strategic planning tools, pointing to a high degree of professionalism and consistency in developing its local tourism strategy. The municipality has a clearly defined identity based on thematic differentiation and borderland cultural tourism, supported by activities such as trail development, the promotion of local heritage, and community involvement (Municipality of Dimitrovgrad, 2018-2025). These elements reflect strong institutional capacity and a deliberate effort to align local tourism development with national strategic goals. The integrated approach to branding, planning, and stakeholder participation reinforces the perception of Dimitrovgrad as a destination rooted in authentic values and sustainable rural tourism models.

Novi Bečej, although not applying all analyzed tools equally, has demonstrated significant progress in branding and action-based planning. The local tourism development concept centers around the Tisa River and the recognizable identity of the “Tiski cvet” manifestation (Municipality of Novi Bečej, 2022-2025). Through infrastructure improvements, promotion of natural assets, and cooperation with cultural institutions, the municipality has created a tourism model oriented toward events, heritage valorization, and river-based experiences. Despite the absence of broader macro-environmental analysis in its strategic documentation, Novi Bečej maintains a clear vision and brand-driven direction, positioning itself as a dynamic cultural and ecological destination in the central Banat region.

Figure 2. reports the operationalization index (0-3) for urban and rural measures by city/municipality. The index captures whether measures are supported by SMART indicators (baseline/targets), budget lines, timelines, and clear accountability (0 = none; 3 = complete). Side-by-side bars show the relative depth of elaboration of urban versus rural interventions, directly addressing RQ2.

Figure 2. Operationalization Index by Urban vs. Rural Measures (0–3)



Source: Authors’ calculations

Figure 2. shows that, across most municipalities, operationalization is stronger on the urban than on the rural dimension. Novi Sad and Subotica score high with only a small gap between the two, whereas Niš and Čačak are moderate to lower, with rural interventions less clearly specified (indicators, budgets, timelines, accountability). Dimitrovgrad stands out for a balanced and relatively high profile across both dimensions, while Gornji Milanovac reaches a mid-level with a slightly stronger urban component. Novi Bečej demonstrates progress anchored in branding and events, yet its rural track remains shallower. As a control unit without a formal strategy, Loznica records low values in both dimensions. These patterns directly corroborate RQ2: the depth of elaboration varies across cities and, on average, tends to favor urban over rural measures.

Across all analyzed cities, implemented measures display a substantial nominal alignment with the National Tourism Development Strategy of the Republic of Serbia 2016–2025 (Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia, 2016). However, the depth of implementation is uneven: in several jurisdictions strategies are expired or not updated, while monitoring and evaluation (M&E) arrangements are partial or missing, and rural measures are typically less operationalized than urban ones (indicators, budgets, timelines, accountability). As a result, alignment is often stronger in form than in function. The coding scheme and the operationalization index introduced below capture these nuances, and the subsequent VIKOR ranking synthesizes them into a comparable measure of proximity to an ideal model (lower Q = better). Local initiatives reveal institutional capacity to operationalize strategic documents, evidenced by qualitative improvements such as enhanced destination visibility, infrastructure upgrades, and a strengthened sense of local identity. Yet, without systematic M&E especially for rural as well as urban measures these outcomes serve as plausible signals of success rather than verified effects.

Discussion of Results with Comparative Analysis

The comparative analysis of strategic tools applied in selected cities has provided valuable insights into the extent to which the existence and quality of strategic documents contribute to tourism development at the local level. The analysis was further enhanced by introducing Loznica as a control case a medium-sized city in western Serbia with considerable tourism potential, including spa tourism (Banja Koviljača), cultural-historical tourism (Tršić, the birthplace of Vuk Karadžić), and nature-based tourism (Gučevo Mountain).

Despite being known for its cultural manifestations, Loznica lacks an integrated strategic tourism development plan that would unify its diverse potentials into a coherent development vision. This institutional gap has several consequences. Firstly, tourism development particularly in the spa segment relies predominantly on private initiatives, lacking centralized strategic coordination. Secondly, there is a noticeable absence of synergy among key stakeholders: the local tourist organization, spa complexes, and cultural institutions operate independently, without shared objectives or coordination mechanisms. Additionally, the city lacks a distinctive tourism brand, resulting in fragmented and locally confined promotion. The absence of a strategic framework also hinders access to EU funds and public-private partnership mechanisms, limiting opportunities for tourism investments. Consequently, despite its resource potential, Loznica has shown inconsistent performance in terms of tourist arrivals and overnight stays.

When compared to cities such as Novi Sad, Niš, or Subotica, which have adopted structured and strategic approaches to tourism development, Loznica lags behind in several key areas: institutional coordination and efficiency, market visibility, access to development funding, and long-term sustainability of tourism growth. To further substantiate this comparative evaluation, the authors applied the VIKOR method, a Multi-Criteria Decision-Making (MCDM) tool designed to handle problems involving

conflicting and incommensurable criteria (Opricovic & Tzeng, 2004; Ozkaya & Demirhan, 2022; Nádasi et al., 2024). The objective of VIKOR is to identify a compromise solution that is closest to the ideal by considering all criteria simultaneously. It applies the Lp-metric approach to evaluate and rank the alternatives. To determine the best solution, VIKOR applies the Lp-metric as part of its core computational process. The general form of the Lp-metric used in VIKOR is given as:

$$S_i = \sum_j w_j * [(f_j^{j*} - f_{ij}) / (f_j^{j*} - f_j^{j-})]$$

Where:

- S_i : total distance of the i-th alternative from the ideal solution,
- f_j^{j*} : best value of criterion j,
- f_j^{j-} : worst value of criterion j,
- f_{ij} : value of the j-th criterion for the i-th alternative,
- w_j : weight coefficient for criterion j.

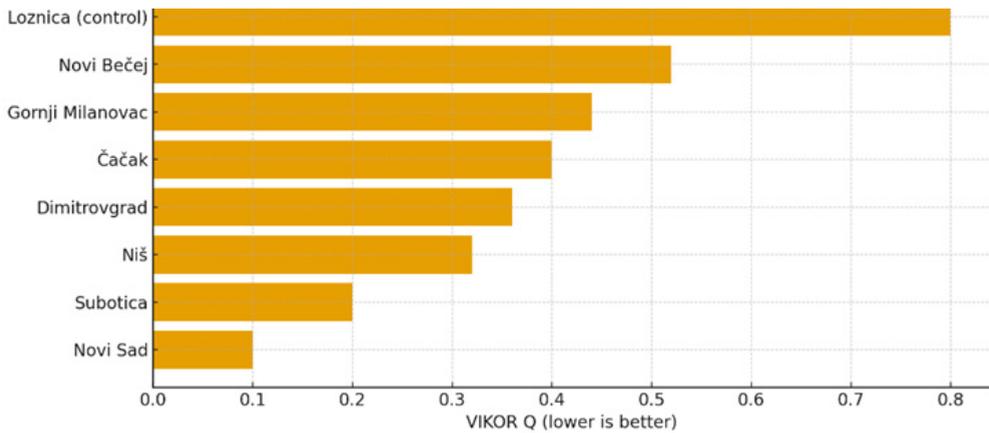
The analysis covered eight cities/municipalities: Novi Sad, Subotica, Niš, Čačak, Gornji Milanovac, Dimitrovgrad, Novi Bečej, and Loznica (control). Loznica is included as a control unit due to the absence of a formal local tourism strategy. The evaluation relies on benefit-type criteria: (i) existence of a current strategy (post-2016/revision), (ii) breadth of the strategic toolset, (iii) operationalization indices for urban and rural measures (SMART indicators, budgets, timelines, accountability), (iv) stakeholder participation depth, (v) evidence of competition analysis, (vi) destination branding articulation, and (vii) basic tourism performance proxies. In Table 1. we present a single consolidated table with the VIKOR results (S, R, Q) for eight units, lower Q values indicate a better compromise position relative to the ideal solution.

Table 1. VIKOR Ranking Results

City / Municipality	S (Group Utility)	R (Individual Regret)	Q (Compromise Index)	Rank
Novi Sad	0.12	0.18	0.10	1
Subotica	0.28	0.26	0.20	2
Niš	0.33	0.24	0.32	3
Dimitrovgrad	0.36	0.27	0.36	4
Čačak	0.40	0.30	0.40	5
Gornji Milanovac	0.45	0.31	0.45	6
Novi Bečej	0.52	0.34	0.52	7
Loznica (control)	0.62	0.65	0.80	8

Source: Author's calculation

The city with the lowest Q value represents the most balanced solution relative to the ideal tourism development model. In this sample, Novi Sad ranks first (lowest Q), followed by Subotica, Niš, and Dimitrovgrad, Čačak and Gornji Milanovac occupy mid positions, while Novi Bečej is more distant. As a control unit without a formal strategy, Loznica records the highest Q and ranks last. Normalization ensures comparability across criteria and does not invert the ranking rule.

Figure 3. VIKOR Ranking (Q)- Lower is Better

Source: Author's calculation

In the comparative analysis of local tourism development policies, Loznica was used as a control unit due to the absence of a formal strategic document to guide and integrate tourism development. Despite significant natural, cultural-historical, and spa-related assets Banja Koviljača, Tršić (the birthplace of Vuk Karadžić), and Mount Gučevo the lack of strategy has produced a fragmented and reactive approach: activities are largely ad hoc, constraining investment attraction, participation in international projects, and coordination among key stakeholders.

This pattern is consistent with the VIKOR results. Under the rule that lower Q indicates a better compromise position, Loznica without a valid strategy and with shallow operationalization records the highest Q and ranks last in the sample. Normalization serves only to ensure cross-criterion comparability and does not alter the ranking rule. In practical terms, Loznica's status underscores the risks of operating without a strategy and reinforces the need to adopt a local document as the foundation for coherent, sustainable, and competitive tourism development.

A cross-cutting observation is that several municipalities have expired or non-updated strategies, while monitoring and evaluation (M&E) arrangements are partial or missing especially for rural measures (indicators, budgets, timelines, accountability). These findings mirror systemic governance constraints noted in the region insufficient coordination, uneven administrative capacity, and limited performance tracking which hinder effective policy implementation and learning (OECD, 2024). Absent robust M&E, improvements such as higher destination visibility, infrastructure upgrades, and a stronger sense of local identity remain indicative rather than demonstrably attributable (UNWTO, 2023).

The sample confirms that rural components are often less fully operationalized than urban ones: measures frequently remain declarative, lacking SMART indicators, budget lines, timeframes, and clear accountability. This aligns with recent evidence on

rural tourism's role in revitalization and sustainability, where key barriers include weak institutional capacity, fragmented offerings, and insufficient integration of local actors (Živković et al, 2025). At the same time, financial instruments for rural interventions such as IPARD II are necessary but not sufficient: beyond access to funds, selection criteria, project preparation, and administrative support are critical to translate financing into measurable outcomes (Radović et al, 2024).

Patterns vary across units. Dimitrovgrad most consistently links rural assets (thematic trails, local heritage, community participation) with branding and actionable plans consistent with its relatively favorable VIKOR profile. Novi Bečej builds identity around the Tisa River and the *Tiski cvet* festival but retains a partially elaborated rural set. Čačak has strong hinterland potential in the Ovčar-Kablar area (households, active and religious tourism) yet needs a clearer operational framework and performance indicators. Niš touches rural dynamics primarily via Niška Banja and peri-urban settlements, while Novi Sad could further valorize peri-urban and Fruška Gora resources (wine/gastro routes) through measurable programs. Gornji Milanovac holds substantial craft cultural heritage and monastic assets but lacks a systematized rural matrix of measures. Loznica, despite high rural and spa potential, shows the weakest rural operationalization and ranks last due to the absence of a strategy.

Operationally, improving rural policy quality requires: (1) integration with the agri value chain (agro/eno-gastronomy, short supply chains, product certification); (2) program packages for rural households (service standards, training, digital visibility and online booking); (3) thematic routes (wine, craft, cultural, natural) with minimum maintenance and signage standards; (4) a mix of local budgets and external sources (e.g., IPARD, cross-border programs) with clear allocation criteria and advisory support; and (5) an M&E framework that systematically tracks: registered rural households, overnights in rural accommodation, revenues and capacity utilization, maintenance/length of trails and routes, participation of local producers in tourism offerings, and the absorption rate of external funds (Živković et al, 2025; Radović et al, 2024).

The evidence points to the need for a strategic shift in local planning and management. While some cities exhibit high alignment with national documents and contemporary methodological frameworks, continuity, systems thinking, and operational implementation are uneven. Municipalities with expired or outdated strategies should prepare new or revised documents that:

- re-assess development trajectories;
- integrate digitalization and the green transition;
- institutionalize participatory planning; and
- embed SMART indicators with baselines/targets, budgets, and clear accountability.

Destination branding should be strategically anchored in authentic local values and differentiation, and action plans must function as operational tools with deadlines,

responsible actors, funding sources, and measurable outcomes. Strengthening institutional and professional capacity for execution is essential (Maksimović & Tornjanski, 2022), and aligning local documents with national and European frameworks can enhance competitiveness and integration into international tourism flows. In short, local strategies must move from formal texts to dynamic management instruments for long-term sustainability, competitiveness, and destination identity.

Conclusion

Tourism is rightly recognized as a development lever in Serbia, particularly at the local level where abundant natural, cultural, and social resources provide a strong basis for sustainable growth. Strategic planning, therefore, is not a technical add-on but a decision-making process that aligns community needs with broader market dynamics and global trends. Our comparative analysis limited to local strategies adopted or revised after 2016 and benchmarked against the National Tourism Development Strategy (2016–2025) shows uneven integration and operationalization of strategic tools. Novi Sad, Subotica, and Dimitrovgrad display higher methodological maturity and closer alignment, while others (e.g., Čačak) apply complex tools more sparingly. Using VIKOR (where lower Q indicates a better compromise position), the ranking confirms this picture: leading cities approach the ideal solution, whereas Loznica, analyzed as a control unit without a formal strategy, records the highest Q and ranks last underscoring the practical risks of operating without a strategy. A central finding concerns monitoring and evaluation (M&E): in many jurisdictions, strategies are expired or not updated, and M&E arrangements especially for rural measures, are partial or absent. As a result, gains in destination visibility, infrastructure, and local identity remain indicative rather than demonstrably attributable. Addressing this gap requires embedding SMART indicators (with baselines/targets), budget lines, timelines, and clear accountability in all local strategies and action plans.

Policy implications follow naturally from the findings. Municipalities whose strategies have expired or fallen out of date should develop new or revised documents that balance urban and rural priorities, weave digitalization and the green transition into their design, and embed participatory planning that meaningfully involves rural communities and SMEs. Rural tourism needs to move from declarative aims to programmed action: integrating with agricultural value chains, standardizing services and training for rural households, and developing thematic routes with clear maintenance and signage standards, supported by a financing mix that combines local budgets with IPARD and cross-border funds under transparent selection criteria and advisory support. Strengthening the capabilities of local administrations remains essential so that plans translate into measurable results and the absorption of external financing improves. Limitations of this study include reliance on document content and publicly available indicators, as well as equal baseline weights in the main VIKOR specification; however, sensitivity checks (alternative weights and v -parameters) suggest that the principal ranking is robust. Future research should test causal links between specific strategic

design features (e.g., participation depth, brand articulation, rural productization) and performance, and pilot living M&E dashboards that municipal teams can use to learn and adapt in real time.

In sum, local tourism strategies in Serbia must evolve from formal texts to dynamic management instruments. Strengthening institutional capacity, mainstreaming M&E, and elevating rural interventions from vision to execution are the most direct pathways to long-term sustainability, competitiveness, and a distinctive destination identity. It is therefore of vital importance that future research focuses on identifying models for community participation in strategic planning, developing tools for tracking strategy implementation, and examining how institutional capacity influences the effectiveness of tourism policy execution. Only through such an approach can sustainable and inclusive policies be shaped to meet the complex challenges and evolving needs of tourism development in Serbia.

Conflict of interests

The authors declare no conflict of interests

References

1. Atalay,H., Gülersoy, N.Z. (2023).Developing Social Sustainability Criteria and Indicators in Urban Planning: A Holistic and Integrated Perspective. *ICONARP Int. J. Archit. Plan.* No 11, 01–23.
2. Basar;A.A. (2024). Participatory Urban Planning for Social Sustainability:A Combination of the Analytic Hierarchy Process, withStrengths, Weaknesses, Opportunities, Threats Analysis,and the Technique for Order Preference by Similarity toIdeal Solution (A'WOT-TOPSIS). *MDPI, Sustainability 2024, 16, 10862.* <https://doi.org/10.3390/su162410862>, 2-15.
3. Bayev, V. V., Bakhov, I. S., Mirzodaieva, T. V., Rozmetova, O., Boretskaya, N., (2022). Theoretical and methodological fundamentals of the modern paradigm of quality management in the field od tourism. *Journal of Environmental Management and Tourism, 13(2), 338-345, 338-345.*
4. Benzaghta, M. A., Elwalda, A., Mousa, M., Erkan, I., Rahman,M. (2021). SWOT analysis applications: An integrative literature review. *Global Business and Economics Review, 23(1), 1-20.*
5. Buble, M., Pavlić, D., Pavić, I. (2005).*Strategic management.* Split: Faculty of Economics, University of Split.
6. City of Čačak. (2019-2024). *Tourism Development Program of the City of Čačak .* Retrieved from:<https://www.cacak.org.rs>.
7. City of Niš – City Administration. (2018-2020). *Tourism Development Program of the City of Niš .* Retrieved from: <https://www.gu.ni.rs>.

8. City of Novi Sad – City Assembly. (2023-2025). *Tourism Development Program of the City of Novi Sad for the period* . Retrieved from: <https://skupstina.novisad.rs>.
9. City of Subotica. (2013-2022). *Local Sustainable Development Strategy of the City of Subotica*. Retrieved from: <https://www.subotica.rs>.
10. Čerović,S. (2002). *Strategic management of the tourist economy of Serbia*. Belgrade: Želnid.
11. European Commission EC (2019). *Serbia -EU for Competitiveness through Innovation and Tourism Development*. European Commission, Annual Report. Retrieved from: https://commission.europa.eu/publications/annual-activity-reports-2019_en
12. Font, X.,Tapper, R.,Cochrane, J. (2006). Competitive Strategy in a Global Industry: Tourism. *Handbook of Bussines Strategy (7)1*, 51-55.
13. Grant,R.M. (2016). *Contemporary Strategy Analysis: Text and Cases Edition (9th ed.)*. Wiley & Sons.
14. Hill C., W., L., Jones G., R., Galvin P. (2004). *Strategic Management - An integrated approach*., Milton, John Wiley&Sons, Australia. .
15. Javier, F., & Elazigue, D. B (2011). *Promoting local economic development through strategic planning in local government, Strategic Planning — Volume 1: Quick Guide*. Vancouver, BC Canada: United Nations Human Settlements Programme (UN-HABITAT).
16. Kaikara,O. (2020).Tourism Development Strategy . *International Journal Papier,Public Review, Volume 1, Issue 1,ISSN: 2709-023X* , 20-25.
17. Kisi,N.A. (2019). Strategic Approach to Sustainable Tourism Development Using the A'WOT Hybrid Method: A Case Study of Zonguldak, Turkey. *Sustainability, 11(4)*, 964.
18. Lozano-Oyola, M., Blancas, F. J., González, M., Caballero, R. (2019). Sustainable tourism tags to reward destination management. *Journal of Environmental Management*, , 250, 109458. <https://doi.org/10.1016/j.jenvman.2019.10945>.
19. Maksimović,S:, Tornjanski,A. (2022).Managing od business performance during a pandemic crisis – a review of literature and practice,. *Thematic Compendium, PERSPECTIVES OF SUSTAINABLE DEVELOPMENT AND SECURITY – GLOBALLY AND LOCALLY –International Scientific Forum “Danube – River of Cooperation”*., Belgrade, Serbia: ISBN-978-86-82825-23-4,danube-cooperation.com.
20. Markiewicz,P. (2011). Change management in the strategy implementation process. *Intelektinē ekonomika, 5(2)*, 257-267.
21. Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia. (2016). *Tourism Development Strategy of the Republic of Serbia for the period 2016–2025*. Retrieved from:<https://mtt.gov.rs>.
22. Municipality of Dimitrovgrad. (2018-2025). *Strategic Development Plan of the Municipality of Dimitrovgrad* . Retrieved from: <https://www.dimitrovgrad.rs>.

23. Municipality of Novi Bečej. (2022-2025). *Local Tourism Development Program of the Municipality of Novi Bečej*. Retrieved from: <https://www.novibecej.rs>.
24. Nádasi, L., Kovács, S. & Szöllős-Tóth, A. The extent of overtourism in some European locations using multi-criteria decision-making methods between 2014 and 2023. *Emerald, International Journal of Tourism Cities* (2024).
25. OECD (2024). *Western Balkans Competitiveness Outlook 2024*. Paris: OECD Publishing.
26. Opricovic, S., & Tzeng, G.-H. (2004). The Compromise Solution by MCDM Methods: A Comparative Analysis of VIKOR and TOPSIS. *European Journal of Operational Research*, 156(2), 445–455.
27. Ozkaya, G. & Demirhan, A. Multi-Criteria Analysis of Sustainable Travel and Tourism Competitiveness in Europe and Eurasia. *Sustainability* 14(22), 15396.
28. Radović, G., Subić, J., & Pejanović, V. (2024). Analysis of Implementation of the IPARD II Programme in Serbia. *Economics of Agriculture*, 71(3), 1017–1031
29. Sereda, N., Albeshchenko, O., Krupitsa, I., Biletska, N., Krasnik, A. (2024). Strategic approaches to tourism development: Crafting competitive strategies for business growth in the tourism sector *Multidisciplinary Reviews*, 7:e2024spe004.
30. Stamatović, M., Maksimović, S., Stamatović, Lj (2021). Monitoring and evaluation of the adopted strategic documents in Serbia. *Megatrend revija, ISSN 1820-3159*, 1-23.
31. UN Tourism (UNWTO) (2023). *World Tourism Barometer*, 21(4). Madrid: UN Tourism.
32. Wheelen, T. L., Hunger, J. D. (2012). *Strategic Management and Business Policy: Toward Global Sustainability*. (13th ed.). Pearson Education.
33. Živković, M. B., Marinković, V., Popović, V., & Milićević, S. Rural Tourism as a Factor of Rural Revitalization and Sustainability: Evidence from Serbia and Bosnia and Herzegovina. *Sustainability*, 17(11), 5127.

THE PHARMACEUTICAL SECTOR IN SERBIA'S BIOECONOMY: EVIDENCE FROM THE AGRI-FOOD VALUE CHAIN

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ABSTRACT

The aim of the paper is to analyse the pharmaceutical sector in the Republic of Serbia's agro-based production system through a comparative analysis with the food industry over the period 2016–2024. The analysis relies on aggregated sectoral financial data and uses various financial indicators. The findings show that the pharmaceutical sector consistently achieves higher value added, stronger export orientation, faster long-term growth dynamics, and more stable performance than the food industry. This confirms the existence of a pronounced structural gap within Serbia's bio-economy between traditional agro-industrial sectors and knowledge-intensive bio-based industries. The findings provide a quantitative basis for assessing the role of the pharmaceutical sector as a carrier of higher value-added stages in the agro-based production system.

Introduction

In modern development strategies, increasing attention has been paid to the concept of the bioeconomy and the role of agro-based sectors in creating sustainable economic growth (Rodrik, 2004). In order to respond to population growth, environmental challenges and the need for sustainability, development models are increasingly redirected toward renewable energy sources and biological resources. The food industry plays an important role in this process through the valorization of agricultural and food waste and by-products, generating not only food products, but also inputs for feed, cosmetics,

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pharmaceuticals, energy, and agronomy. Nevertheless, in most empirical analyses, the focus remains predominantly on primary agriculture and the food industry, while the role of knowledge- and technology-intensive sectors within bio-based value chains is still insufficiently explored, especially in developing and transition economies. At the same time, there is a lack of methodological standardization and limited integration of the environmental, economic, and social dimensions of sustainability (Vasić, Ristić, & Vasić Garić, 2025).

The existing literature largely points to the problem of the low degree of finalization of agricultural products and the limited ability of agro-food systems to generate high value-added products. In a broader perspective, this issue fits into the general debate on structural transformation and the transition from lower- to higher-productivity activities (Rodrik, 2004). However, empirical studies that quantitatively examine structural differences between classical agro-industrial sectors and technologically advanced bio-based industries remain relatively rare.

In this context, the pharmaceutical industry represents a particularly interesting case. Although it is commonly classified within the chemical or health industries, its production and technological profile is closely linked to the broader bio-based system and industrial biotechnology (Wydra, 2019). Despite this, its position within agro-based value chains has rarely been the subject of systematic empirical analysis, especially in direct comparison with the food industry.

In the case of the Republic of Serbia, this research gap gains additional importance. Despite a strong agricultural resource base and a long-standing reliance on the food industry, the economy remains largely oriented toward lower stages of processing and products with relatively modest added value. Increasing productivity therefore requires stronger investment in new technologies, modernization of existing capacities, and the development of activities that generate higher value added (Aničić et al., 2025). The food industry represents a significant segment of the Serbian economy (Božić & Nikolić, 2023), with exports dominated by primary and semi-processed agricultural and food products (Vapa Tankosić & Mirkov, 2025). Certain knowledge-intensive sectors, such as pharmaceuticals, exhibit significantly higher levels of productivity, export orientation, and technological complexity, yet their role within the broader bioeconomy framework has not been systematically and quantitatively assessed.

Starting from this problem, this paper conducts a comparative empirical analysis of the food sector (C10) and the pharmaceutical sector (C21) in Serbia over the period 2016–2024, in order to assess their relative positions within the agro-based value chain. Therefore, the aim is to analyse the pharmaceutical sector in Serbia as a structurally higher, knowledge- and technology-intensive segment of the agro-based value chain compared to the food sector, and to quantify the differences in their development patterns, levels of value added, and international competitiveness. The analysis is based on sectoral financial and performance indicators, including measures of value added, labor productivity, export intensity, growth dynamics, and performance stability.

Literature review

Bioeconomy represents a multidisciplinary framework for economic development based on renewable biological resources and their transformation through science- and technology-intensive processes (Wydra, 2019; Wang et al., 2022). It encompasses not only primary agriculture, but also a wide range of industrial activities in which biological inputs are used to produce food, materials, energy, and other bio-based products. In this sense, the bioeconomy is commonly defined as an economic system relying on research, innovation, and biological knowledge to generate economic activity and public benefit (The White House, 2012; OECD, 2009). Within the European Union, the Pharmaceutical Strategy for Europe further emphasizes the role of pharmaceuticals as a strategic and innovation-intensive segment of this broader bio-based system, aligned with the objectives of the European Green Deal and the New Industrial Strategy (European Commission, Pharmaceutical Strategy for Europe, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0761>).

In the agro-bio context, the agri-food value chain links agricultural production, processing, distribution, and final consumption. Although modern trends increasingly emphasize sustainability and circularity (Tošović-Stevanović & Ristanović, 2024), the key development challenge within the bioeconomy is not the quantitative expansion of output, but the transition toward higher stages of product finalization and higher value added through the integration of knowledge and technology (Diakosavvas & Frezal, 2019). Numerous studies indicate that the performance of agro-based sectors depends not only on resource endowments, but also on organizational, managerial, and knowledge-intensive factors, as well as on the capacity for functional and structural upgrading (Cvijanović et al., 2015). During the COVID-19 period, these issues became even more closely linked to the broader concept of economic sustainability (Gyarmati, 2024).

The link between the bioeconomy and sustainable development is reflected in the emphasis on efficient resource use, waste reduction, and the integration of biological resources within circular economic processes (Georgescu-Roegen, 1971; Wydra, 2019). From this perspective, agro-bio systems should be viewed not as isolated production units, but as integrated value chains that enable the transition from low-value to high-value products (Wang et al., 2022).

While much of the literature focuses on primary production and the food industry, increasing attention is being paid to knowledge-intensive sectors such as pharmaceuticals and biotechnology, which transform biological resources into products with significantly higher economic value (Wydra, 2019; Diakosavvas & Frezal, 2019). The pharmaceutical sector is characterized by the intensive use of knowledge and technology, high regulatory standards, long development cycles, and a high level of value added embodied in final products (Wydra, 2019; Wang et al., 2022). For this reason, it can be interpreted as a higher segment of the bio-based value chain, in which scientific research, technological innovation, and global market orientation play a central role.

For countries with a strong agricultural base, such as Serbia, the integration of primary production with knowledge- and technology-intensive stages of processing represents a key mechanism for improving competitiveness and long-term growth (Diakosavvas & Frezal, 2019). However, the development of such linkages is constrained by institutional and structural weaknesses, including insufficient attention to sustainability reporting and value-added processing in agriculture (Stojić et al., 2024). At the same time, food industry by-products should be viewed not as waste, but as potential inputs for other production processes within the circular economy framework (Rajković et al., 2020).

Conceptually, this implies not only the modernization of traditional production capacities, but also the strengthening of linkages between agriculture, the food industry, and knowledge-intensive sectors such as pharmaceuticals. Similar evidence on the importance of organizational, managerial, and innovation-related factors for performance has been identified in other agro-based activities, such as beekeeping (Čavlin et al., 2023). In the Serbian context, stronger integration between the agri-food system and the pharmaceutical sector opens opportunities for the development of biopharmaceuticals, nutraceuticals, and herbal medicines, thereby strengthening value chains and competitiveness. At the same time, environmental challenges require pharmaceutical companies to adopt ambitious decarbonization strategies and advanced technological approaches, including green chemistry and AI-based modeling tools (Miralles-Quirós & Miralles-Quirós, 2022; Bratovčić, 2024).

Such a broader view of the bioeconomy as an integrated system supports the idea that research and technological innovation should not be viewed in isolation, but as key drivers of structural transformation toward higher value-added stages of production (Wang et al., 2022). In this sense, positioning the pharmaceutical sector within the agro-bio value chain provides a useful conceptual framework for understanding how biological resources can be utilized in a way that maximizes economic and social value while supporting sustainable development.

Materials and methods

This research is based on a combination of structural, descriptive and comparative analysis of sectoral data, with the aim of assessing the position of the pharmaceutical sector within the agro-food and bio-based value chain in Serbia over the period 2016–2024, which allows the simultaneous consideration of long-term trends and structural changes related to the COVID-19 pandemic.

The main data sources are aggregated financial reports from the Agency for Economic Registers (APR, 2025) and data from the Republic Institute of Statistics (SORS, 2025), based on the Classification of Activities fully aligned with NACE Rev.2. These sources enable consistent and methodologically comparable monitoring of sectoral trends over time.

The empirical analysis focuses on two processing industry sectors representing key segments of the bio-based production system: C10 – Production of food products and C21 – Production of basic pharmaceutical products and pharmaceutical preparations.

Agriculture is considered as a structural and conceptual component of the bioeconomy, but is not included in the direct quantitative analysis.

Due to the limited availability of sufficiently disaggregated national accounts data, the paper applies an accounting approach to the approximation of gross value added based on financial statements. Although such aggregated indicators have well-known limitations, they provide a consistent basis for comparative and structural sectoral analysis, as also noted in the literature (Čavlin, Pešić & Pešić, 2025). Gross value added (GVA) is calculated as the difference between total business income and intermediate consumption, including the costs of materials, energy, production services, intangible costs, and the purchase value of goods sold.

Based on the basic variables — gross value added (GVA), number of employees (EMP), total business income (REV) and export revenues (EXP) — several derived indicators are constructed: GVA per employee (GVA/EMP) as a measure of productivity, exports per employee (EXP/EMP) as an indicator of international competitiveness, and the share of exports in total revenues (EXP/REV) as a measure of sectoral internationalization.

The methodological framework combines several complementary approaches. First, a descriptive and dynamic analysis is applied using index numbers (2016 = 100). Second, a structural and comparative analysis is conducted by comparing average indicator values in two sub-periods (2016–2019 and 2020–2024) to assess the impact of the COVID-19 pandemic. Third, a cross-sectional comparison of sectors is performed for the final year (2024). In addition, long-term growth dynamics is evaluated using the compound annual growth rate (CAGR), while stability and typical performance levels are analyzed using the arithmetic mean, median, and coefficient of variation (CV) for GVA/EMP and EXP/EMP.

This methodological approach allows the position of the pharmaceutical sector to be assessed not only in terms of scale, but also in terms of productivity, growth quality, international orientation, and performance stability within the agro-based and bioeconomic value chain in Serbia.

Results and discussion

The empirical analysis of the food (C10) and pharmaceutical (C21) sectors within Serbia's agro-based value chain is preceded by a brief overview of their structural and institutional characteristics.

Structure of the pharmaceutical sector (C21)

The pharmaceutical sector in Serbia (C21) is relatively small in terms of the number of firms (128 companies in 2024), but highly concentrated in terms of capital, knowledge, and production capacities. Although micro and small enterprises dominate numerically, the sector has a significantly higher share of medium and large companies compared to most other processing industries, indicating the existence of a core group of technologically and organizationally strong firms that generate the dominant share of value added and exports.

The sector is predominantly organized in the form of limited liability and joint-stock companies and shows a pronounced spatial concentration, with almost half of all firms located in Belgrade. This reflects the strong dependence of pharmaceutical production on research infrastructure, highly qualified labor, and developed logistic and regulatory environments. Overall, despite its limited size in terms of the number of firms, the pharmaceutical sector represents a structurally mature, capital-intensive and knowledge-based industry with high technological and regulatory entry barriers.

Structure of the food sector (C10)

In contrast, the food sector (C10) comprises more than 37,000 firms in 2024. Its structure is characterized by extreme fragmentation, with micro and small enterprises accounting for the vast majority of firms, while medium and large companies represent only a marginal share. The sector is predominantly organized through entrepreneurial and small business forms and shows a much more even regional distribution across the country, reflecting its strong link to primary agricultural production and local markets. This organizational structure indicates a development model based primarily on extensive growth, limited capital intensity, and lower levels of technological complexity and product finalization.

These structural differences suggest that the pharmaceutical sector functions as a higher, final and knowledge-intensive segment of the agro-based and bioeconomy value chain, while the food sector remains largely anchored in a more extensive development model based on a large number of small producers and lower stages of product finalization.

Dynamics of key indicators by sectors

Table 1 shows the dynamics of the basic business indicators of the agri-food sector (C10) and the pharmaceutical sector (C21) in the period 2016–2024, using index numbers with the base year 2016 = 100. This approach enables a clear and comparable analysis of the development trends of added value, employment, exports and total business income in both sectors.

The findings indicate that both sectors achieved significant nominal growth in added value in the observed period. In 2024, the index of added value in the food sector amounts to 201.16%, while in the pharmaceutical sector it reaches 190.75%, which means that the added value in both sectors has approximately doubled compared to 2016. Although the food sector records a slightly higher cumulative growth rate of added value, the differences in growth dynamics between the two sectors are not large, which indicates a relatively similar long-term trend of nominal expansion of the volume of activity.

However, much clearer structural differences between sectors are observed when employment trends are observed. The number of employees in the food sector in 2024 is 128.17% index points, which means that employment has increased by about 28% compared to the base year. In contrast, the pharmaceutical sector recorded a significantly more moderate growth in employment, with an index of 103.18% in 2024,

which practically means that the level of employment remained almost unchanged compared to 2016. This growth pattern indicates that the increase in added value in the pharmaceutical sector is predominantly realized through productivity growth and technological intensification, and not through extensive employment which is consistent with the typical development pattern of knowledge and technology-intensive bio-based industries (Wydra, 2019; Diakosavvas & Frezal, 2019).

Table 1. Dynamics of Key Indicators by Sectors (2016 = 100)

Period	VA-C10	VA-C21	EMP-C10	EMP-C21	EXP-C10	EXP-C21	REV-C10	REV-C21
2024	201.16%	190.75%	128.17%	103.18%	182.75%	242.80%	170.17%	173.89%
2023	201.34%	206.11%	127.23%	100.20%	361.90%	226.82%	162.05%	163.49%
2022	172.07%	153.31%	127.38%	93.65%	353.70%	188.99%	163.63%	145.29%
2021	148.47%	159.77%	130.90%	87.95%	141.97%	152.66%	138.28%	124.18%
2020	131.61%	140.05%	130.80%	89.15%	110.35%	156.26%	114.96%	124.20%
2019	114.51%	125.48%	128.40%	91.93%	102.38%	139.61%	110.06%	122.66%
2018	101.20%	110.94%	124.39%	85.95%	99.41%	117.55%	102.23%	105.28%
2017	98.82%	100.35%	124.39%	96.19%	99.22%	116.63%	104.11%	122.48%
2016	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Note: C10 = Manufacture of food products; C21 = Manufacture of basic pharmaceutical products and pharmaceutical preparations, VA = Value Added; EMP = Employment; REV = Total Revenue; EXP = Exports; VA/EMP = Value Added per Employee; EXP/EMP = Exports per Employee; EXP/REV(%) = Export Share in Total Revenue.

Source: Authors' calculations

Differences in export dynamics are especially pronounced. In the food sector, exports in 2024 reach an index of 182.75%, while in the pharmaceutical sector it is as high as 242.80%, pointing to the growing international competitiveness of this activity in the observed period.

The movement of total business income additionally confirms the trend of stable growth in both sectors. In 2024, the total income index is 170.17% in the food sector and 173.89% in the pharmaceutical sector. This data additionally confirms that the growth of this sector is based above all on more intensive use of capital, technology and knowledge.

It is important to highlight the impact of the pandemic period, which is reflected in both sectors through temporary slowdowns or changes in the dynamics of certain indicators, especially in 2020 and 2021. Nevertheless, the overall trends indicate that the pharmaceutical sector showed relatively high resilience, especially in terms of export activity, while the food sector maintained stable growth in terms of production volume and employment.

Structural comparison of the sector before and after the COVID-19 pandemic

Table 2 shows a structural comparison of the food sector (C10) and the pharmaceutical sector (C21) based on the average values of key relative indicators in two sub-periods: 2016–2019 (the period before the pandemic) and 2020–2024 (the period of the pandemic and after it). The analysis is based on the indicators of added value per employee (BVD/EMP), exports per employee (EXP/EMP) and the share of exports in total revenues (EXP/REV), which together enable an overview of the level of productivity, international competitiveness and the degree of internationalization of the observed sectors.

Table 2. Structural Comparison of Sectors: Average Values by Subperiods

Sectors	Period	VA/EMP	EXP/EMP	EXP/REV (%)
Sector C10	2016-2019	1,567	2,064	21.87%
Sector C10	2020-2024	2,380	4,365	33.83%
Sector C21	2016-2019	3,336	4,755	40.82%
Sector C21	2020-2024	5,071	7,548	50.99%

Note: All monetary values are expressed in thousand RSD.

Source: Authors' calculations

The results clearly indicate pronounced and stable structural differences between the two sectors. Already in the period before the pandemic (2016–2019), the pharmaceutical sector achieves a significantly higher level of added value per employee compared to the food sector (3,336 versus 1,567), which means that labor productivity in the pharmaceutical industry was more than twice as high. This difference not only persists, but further deepens in the period 2020-2024, when the VA per employee in the pharmaceutical sector reaches an average value of 5,071, while in the food sector it is 2,380. This confirms that the pharmaceutical sector not only starts from a significantly higher level of added value, but also that in the post-pandemic period it further strengthens its relative structural position.

A similar pattern is observed in exports per employee, as an indicator of international competitiveness. In the period 2016–2019, the pharmaceutical sector achieves more than twice as many exports per employee compared to the food sector (4,755 versus 2,064). In the period 2020–2024, this difference increases further: exports per employee in the pharmaceutical sector grow to 7,548, while in the food sector it reaches 4,365. These data indicate that the pharmaceutical industry not only has a structurally higher level of international market orientation, but that in the period after the pandemic it additionally further strengthened its export position, which is fully consistent with the role of pharmaceuticals as one of the most internationally integrated segments of the bioeconomy (OECD, 2009; Wydra, 2019).

The results related to the share of exports in total revenues are particularly indicative. Already in the period before the pandemic, the pharmaceutical sector achieves a

significantly higher degree of internationalization, with an average export share of 40.82%, compared to only 21.87% in the food sector. In the period 2020–2024, this gap further deepens: the share of exports in total revenues increases to 50.99% in the pharmaceutical sector and to 33.83% in the food sector. This means that more than half of the total revenues of the pharmaceutical industry in the observed period were generated on foreign markets, which is a clear indicator of high international competitiveness and integration into global value chains.

Analysis of the agro-food and pharmaceutical sector in 2024

Table 3 shows the comparative indicators of the agro-food sector (C10) and the pharmaceutical sector (C21) in the final year of the observed period, 2024. This cross-sectional analysis enables an overview of their current structural position within the agri-food and bio-based value chain, through a combination of absolute and relative indicators of business performance.

Table 3. Comparative Indicators of the Agri-Food and Pharmaceutical Sectors in 2024

Sectors	VA	EMP	VA/EMP	EXP	EXP/EMP	REW	EXP/REW(%)
Sector C10	239,861,670	85,316	2,811	295,833,342	3,468	1,214,144,708	24.37%
Sector C21	29,253,206	5,573	5,249	48,886,263	8,772	90,254,157	54.17%

Note: All monetary values are expressed in thousand RSD.

Source: Authors' calculations

Observed in absolute terms, the food sector represents a significantly larger part of the industrial base, with a total added value of 293,861.7 million RSD and 85,316 employees, while the pharmaceutical sector achieves an added value of 29,253.2 million RSD with 5,573 employees. These data confirm that the food industry is quantitatively significantly larger and more important in terms of production and employment. However, structural differences become clearly visible when looking at relative indicators. The added value per employee in the pharmaceutical sector is 5.3 million RSD, while in the food sector it is only 2.8 million RSD. This means that labor productivity in the pharmaceutical industry is almost twice as high as in the food industry, which indicates a significantly higher technological and knowledge-intensive nature of this activity.

Even more pronounced differences are observed in export activity. The total export of the food sector in 2024 amounts to 295,823.3 million RSD, while the pharmaceutical sector achieves exports of 48,886.3 million RSD. Although in absolute terms the export of the food sector is significantly higher, when looking at exports per employee, the picture changes completely: the pharmaceutical sector achieves 8.8 million RSD of exports per employee, while the food sector achieves 3.5 million RSD. In 2024, exports make up 54.71% of the total revenues of the pharmaceutical sector, while in the food sector this share is 24.37%, which is a clear indicator of the deep integration of the pharmaceutical sector into international value chains.

The joint observation of these indicators clearly confirms earlier findings from previous analyses: the food sector has a significantly larger volume and a wider employment base, but the pharmaceutical sector occupies a structurally higher position within the agro-based value chain, with higher added value per employee, greater exportability and a significantly higher degree of internationalization.

This structure indicates that the further development of the bioeconomy in Serbia cannot be based solely on the expansion of primary and secondary processing production, but requires stronger reliance on technology- and knowledge-intensive segments.

Analysis of average Annual Growth Rates (CAGR) in 2016–2024

Table 4 provides a synthetic measure of long-term growth dynamics and enables a clear and direct comparison of the development patterns of the observed sectors, independent of short-term oscillations and cyclical disturbances.

Table 4. Average Annual Growth Rates (CAGR) of Selected Indicators, 2016–2024

Sectors	VA	VA/EMP	EXP
Sector C10	9.13%	5.80%	7.83%
Sector C21	8.41%	7.98%	11.73%

Source: Authors' calculations

The results indicate that both sectors achieved positive and relatively high growth rates of added value in the observed period. The average annual growth rate of VA in the food sector is 9.13%, while in the pharmaceutical sector it is 8.41%.

However, when focusing on the growth of value added per employee, as an indicator of intensive growth and technological progress, the picture clearly shifts in favor of the pharmaceutical sector. The average annual growth rate of VA per employee in the food sector is 5.80%, while in the pharmaceutical sector it is 7.98%.

The average annual growth rate of exports in the food sector is 7.98%, while in the pharmaceutical sector it reaches as much as 11.73%. Such dynamics indicate that the pharmaceutical industry is not only strengthening its production base, but also rapidly increasing its international market presence, thereby further integrating into global value chains.

The combined observation of these indicators indicates the existence of two different but complementary development models. The food sector records a relatively strong growth in the total volume of activities, which is partly based on the growth of employment, while the pharmaceutical sector is developing through a particularly intensive growth in productivity and an even stronger export expansion. These results additionally confirm the thesis that the pharmaceutical sector represents a dynamic and developmentally promising segment of the agro-based industry, whose contribution to structural transformation and the shift towards products with more added value has long-term and strategic importance.

Analysis of stability and sector performance

The results in Table 5 clearly confirm that the pharmaceutical sector achieves a significantly higher typical level of added value per employee compared to the food sector. The arithmetic mean of VA/EMP in the food sector is 2.019 million dinars, while in the pharmaceutical sector it is 4.300 million dinars.

Table 5. Mean, Median and Coefficient of Variation (CV) of Value Added and Exports per Employee (2016–2024)

Sectors	VA/EMP-Mean	VA/EMP-Median	VA/EMP-CV	EXP/EMP-Mean	EXP/EMP-Median	EXP/EMP-CV
Sector C10	2,019	1,802	0.27	3,342	2,413	0.61
Sector C21	4,300	4,460	0.24	6,307	6,470	0.27

Note: All monetary values are expressed in thousand RSD.

Source: Authors' calculations

The average export per employee in the food sector amounts to 3.3 million RSD, while in the pharmaceutical sector it reaches 6.5 million RSD. The median additionally confirms this difference, which once again confirms the significantly higher typical level of export activity per employee in the pharmaceutical industry.

In addition to the level of indicators, the analysis of their stability is particularly important. The coefficient of variation of VA/EMP is 27% in the food sector, while it is 24% in the pharmaceutical sector. We can conclude that the pharmaceutical sector in Serbia not only achieves a significantly higher and structurally advanced level of performance in terms of added value and export activity per employee, but that performance is also characterized by greater stability and less exposure to oscillations over time.

These findings further strengthen previous findings and confirm the thesis that the pharmaceutical sector represents a higher, technologically and knowledge-intensive segment of the agro-based and bio-economic value chain, with an important role in the long-term structural transformation of the Serbian economy. The findings also consistently indicate that the pharmaceutical sector in Serbia occupies a structurally higher and more developmentally advanced position within the agro-based value chain compared to the food industry. Differences in value added per employee, export orientation, growth dynamics, and performance stability are not of a temporary nature, but reflect persistent differences between a knowledge-intensive and a predominantly extensive model of industrial development. The findings confirm that the pharmaceutical industry functions as a higher segment of the bioeconomy and the agro-based value chain, characterized by knowledge- and technology-intensive upgrading, which is fully consistent with the logic of value chain upgrading described in the global value chain literature (Gereffi, Humphrey, & Sturgeon, 2005; Wydra, 2019).

At the same time, the identified structural gap points to a significant but still underutilized potential for stronger integration within the broader agro-based production system, particularly through the development of functional food, supplements, phyto-pharmaceutical and biotechnological products. Although the analysis focuses on Serbia, the results have broader relevance for countries with similar economic structures in Central and Eastern Europe, where a comparable gap between traditional agro-industrial sectors and knowledge-intensive bio-based industries represents a common development pattern.

From a broader perspective, these results support the view that the development of the bioeconomy cannot be based solely on the expansion of primary production and low stages of processing, but requires the systematic strengthening of knowledge-intensive segments and higher positions within value chains, as emphasized in the European bioeconomy policy framework (European Commission, 2018) and the value chain upgrading literature (Gereffi et al., 2005).

Conclusion

The development of the bioeconomy does not depend solely on the volume of primary production and basic processing, but primarily on the ability to move toward knowledge- and technology-intensive stages of value creation. The findings consistently confirm that the pharmaceutical sector in Serbia occupies a structurally higher position within the agro-based value chain. Compared to the food industry, it achieves significantly higher value added per employee, higher exports per employee, a higher degree of internationalization, faster long-term growth of key relative indicators, and greater performance stability over time. These differences are not transient, but reflect the coexistence of two distinct development models: one based mainly on the expansion of production volume and employment, and the other driven by productivity growth, technological intensification, and knowledge. In this sense, the findings provide empirical confirmation that the pharmaceutical industry is not merely another processing branch based on biological resources, but represents a final, knowledge- and technology-intensive segment of the bioeconomy. More broadly, it illustrates how biological resources, scientific knowledge, and industrial organization can be integrated into products with high value added and strong export orientation.

This paper makes three interrelated contributions to the literature. First, from a theoretical perspective, it positions the pharmaceutical sector within the bioeconomy framework from the viewpoint of agro-based value chains and structural transformation. Second, from a methodological perspective, it demonstrates that aggregated sectoral financial statements can be used as an operational approximation for analyzing value added and for the comparative assessment of differences in the level and quality of sectoral growth. Third, from an empirical perspective, it provides quantitative evidence of a pronounced structural gap within Serbia's bioeconomy between traditional agro-industrial sectors and knowledge-intensive bio-based industries.

The study is subject to certain limitations. The analysis is based on aggregated sectoral data and does not include firm-level evidence or international comparisons, which points to promising directions for future research. Further studies could incorporate micro-level data and cross-country comparisons in order to more precisely identify the mechanisms enabling upgrading toward higher stages of the value chain. Although the analysis focuses on Serbia, the findings have broader relevance for countries with similar economic structures, particularly in Central and Eastern Europe, which face comparable challenges in shifting toward more knowledge- and technology-intensive segments of the bioeconomy. In this context, the pharmaceutical sector can be seen not only as a successful individual case, but also as a potential benchmark for a wider structural transformation toward a growth model based on knowledge, innovation, and high value added.

Conflict of interests

The authors declare no conflict of interest.

References

1. Agency for Business Registers of the Republic of Serbia (APR), Retrieved from <https://www.apr.gov.rs> (November 25, 2025).
2. Aničić, D. ., Nestorović, O., Aničić, J. ., & Jovanović, Z. . (2025). Trends and perspectives of agricultural development in Serbia. *Economic of Agriculture*, 72(1), 375–385. <https://doi.org/10.59267/ekoPolj2501375a>
3. Božić, D., & Nikolić, M. (2023). Contribution of food industry to economic development of Republic of Serbia and selected European countries. *BizInfo Blace*, 14(1), 99-110. <https://doi.org/10.5937/bizinfo2301099B>
4. Bratovčić, A. (2024). Dizajn zelene farmaceutske proizvodnje i postizanje ciljeva održivosti, *Časopis za savremena privredna kretanja*, 2(1): 39-48.
5. European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Pharmaceutical Strategy for Europe COM/2020/761 final, Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0761>, (November 27, 2025).
6. European Commission (2018) A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment: updated bioeconomy strategy, Publications Office of the European Union. <https://data.europa.eu/doi/10.2777/792130>.
7. Cvijanović, D., Mihailović, B., Čavlin, M., & Čavlin, G. (2015). Impact of Marketing Consulting on Performances of Agrarian Clusters in Serbia. *Sustainability*, 7(2), 1099-1115. <https://doi.org/10.3390/su7021099>

8. Čavlin, M., Pešić, M., & Pešić, S. (2026). Managing Creditworthiness in the Digital Economy: A Theoretical Framework for a Hybrid and Explainable Model. *IPSI Transactions on Internet Research*, 22(1), 34-43. doi:10.58245/ipsi.tir.2601.05
9. Čavlin, M., Prdić, N., Ignjatijević, S., Vapa Tankosić, J., Lekić, N., & Kostić, S. (2023). Research on the Determination of the Factors Affecting Business Performance in Beekeeping Production. *Agriculture*, 13(3), 686. https://doi.org/10.3390/agriculture13030686
10. Diakosavvas, D. & C. Frezal (2019). Bio-economy and the sustainability of the agriculture and food system: Opportunities and policy challenges. OECD Food, Agriculture and Fisheries Papers, No. 136, OECD Publishing, Paris.
11. Georgescu-Roegen, N. (1971). *The Entropy Law and the Economic Process*. Harvard University Press.
12. Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of international political economy*, 12(1), 78-104.
13. Gyarmati, G. (2024). Transformation of the Three Pillars of Agri-Food Sustainability around the COVID-19 Crisis—A Literature Review. *Sustainability*, 16(13), 5616. https://doi.org/10.3390/su16135616
14. Miralles-Quirós, M. M., & Miralles-Quirós, J. L. (2022). Decarbonization and the Benefits of Tackling Climate Change, *International Journal of Environmental Research and Public Health*, 19(13), 7776. doi:10.3390/ijerph19137776
15. Novaković, D., Novaković, T., Milić, D., Tomaš Simin, M., Nikolić, S., Knežević, M., Radišić, M., Radišić, M., & Pevac, D. (2025). Circular Economy and Resource Efficiency in the Serbian Agri-Food Sector: Evidence from Dynamic Panel Analysis. *Economies*, 13(12), 346. doi:10.3390/economies13120346
16. OECD (2009). The bioeconomy to 2030: designing a policy agenda. Organization for Economic Co-operation and Development (OECD), Paris. OECD.
17. Rajković, M. B., Popović Minić, D., Milinčić, D., & Zdravković, M. (2020). Circular economy in food industry. *Zaštita materijala*, 61(3), 229-250. https://doi.org/10.5937/zasmat2003229R6
18. Rodrik, D. (2004). *Industrial policy for the twenty-first century*. Harvard University, John F. Kennedy School of Government.
19. Statistical Office of the Republic of Serbia (SORS), Classification of Activities, harmonized with NACE Rev.2, Retrieved from <https://www.stat.gov.rs> (November 25, 2025).
20. Stojić, M., Pejović, B., & Bižić, V. (2024). Correlation between solvency of serbian agricultural sector and investments in environmental responsibilities. *Economic of Agriculture*, 71(2), 381–395. doi.org/10.59267/ekoPolj2402381S
21. Tadić, J., Jevtić, J., & Jančev, N. (2019). Modeling of critical profitability factors: empirical research from food industry in Serbia. *Economic of Agriculture*, 66(2), 411–422. https://doi.org/10.5937/ekoPolj1902411T

22. The White House (2012). National Bioeconomy Blueprint. *Industrial Biotechnology*, 8(3), 97-102. doi:10.1089/ind.2012.1524
23. Tošović-Stevanović, A., & Ristanović, V. M. (2024). Farm economy in Serbia – distribution channels of sustainable products. *Economic of Agriculture*, 71(4), 1225–1235. <https://doi.org/10.59267/ekoPolj24041225T> p.1225)
24. Vapa Tankosić, J. & Mirkov, M. (2025). Foreign Trade Exchange of Agricultural and Food Products of the Republic of Serbia with the European Union and CEFTA. *J Agron Technol Eng Manag* 2025, 8(2), 1506-1517. doi: 10.55817/SKRW9756
25. Vasić, S., Ristić, K. & Vasić Garić, M. (2025). Cirkularna ekonomija kao pristup održivosti i njen uticaj na životnu sredinu, *Ekonomija: teorija i praksa*, 18(3), 71-86. doi:10.5937/etp2503071V.
26. Wang, T., Yu, Z., Ahmad, R., Riaz, S., Khan, K. U., Chaudhry, M. A., & Zhang, T. (2022). Transition of bioeconomy as a key concept for agriculture and agribusiness development. *Frontiers in Sustainable Food Systems*, 6, 998594
27. Wydra, S. (2019). Value chains for industrial biotechnology in the bioeconomy. *Sustainability*, 11(8), 2435.

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2. Hjalager, A. M., & Richards, G. (Eds.). (2003). *Tourism and gastronomy*. Routledge, London.
3. Mićović, A. (2017). Tourism Development and Evolution of Tourism Related Rules, *2nd International Scientific Conference – Thematic Proceedings II*, Faculty of Hotel Management and Tourism, Vrnjačka Banja, 181-202. Retrieved from http://www.hit-vb.kg.ac.rs/conference/images/thematic_proceedings/2017_II.pdf
4. Stošić, L., & Stošić, I. (2013). Diffusion of innovation in modern school. *International Journal Of Cognitive Research In Science, Engineering And Education (IJCRSEE)*, 1(1), 12-24.

5. Domanović, V., Vujičić, M., & Ristić, L. (2018), Profitability of food industry companies in the Republic of Serbia, *Economic of Agriculture*, 65(1), 11-32. doi:10.5937/ekoPolj1801011D
6. The Food and Agriculture Organization of the United Nations (FAO), Retrieved from <http://www.fao.org> (July 31, 2018)

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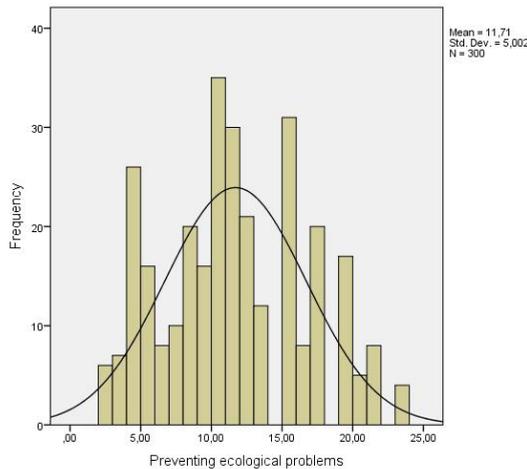
Table 1. The distribution cost of packaged goods from Subotica to retail-store objects

Indicators	Period			Total
	Month 1	Month 2	Month 3	
Distance crossed (km)	12.926	11.295	13.208	37.429
Fuel consumption (litre)	3.231	2.823	3.302	9.356
Value of fuel consumption (RSD)	242.378	211.790	247.653	701.821
Total time spend on touring (hour)	314	266	417	997
Value of total time spend on touring (RSD)	47.048	39.890	62.570	149.508
Number of tours	98	77	102	277
Toll value (RSD)	0	0	0	0
Number of pallets transported (piece)	1.179	976	1358	3.513
Total weight transported (kg)	602.600	429.225	711.116	1.742.941
Vehicle maintenance costs (RSD)	203.858	164.970	224.806	593.634
Lease costs (RSD)	480.938	454.214	565.784	1.500.936
Total sum (RSD)	974.222	870.864	1.100.813	2.945.899

Source: Petrović, 2012

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Figure 1. Agriculture, value added (% of GDP)



Source: Authors' calculations

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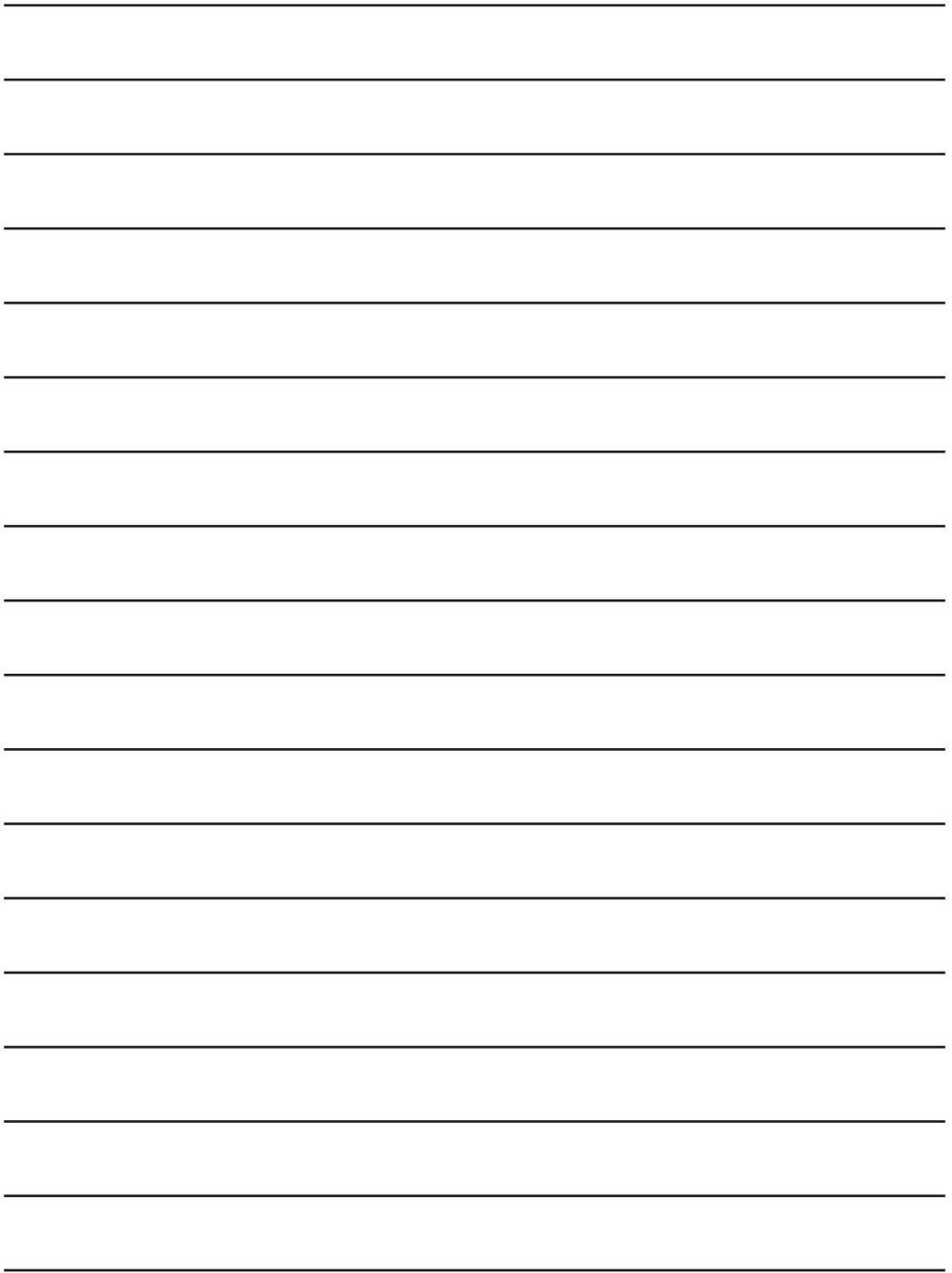
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