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Chapter: Contemporary Challenges and Innovations in Sustainability Assessment and Environmental Management

Food security, competitiveness erosion, and the illusion of sustainability: insights from Romania's pig sector

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Annotation. The pig sector is confronting numerous challenges under the European Union's (EU) stricter socio-economic and environmental sustainability requirements, which complicate the management of African Swine Fever (ASF) and its market effects. Farmers face increasing difficulty in remaining both environmentally compliant and economically efficient. In this context, some EU countries face declining pig meat production capacity and growing reliance on pig meat imports to satisfy domestic demand. Among EU member states, Romania is among the most affected, as reflected by the size of its pig meat trade deficit, which represents the country's largest deficit among agri-food products. The objective of this research was to provide market insights capable of serving as a foundation for policy measures designed to improve the performance of the Romanian pig sector. This paper proposes an integrative descriptive framework to jointly examine food security, competitiveness, and environmental impacts in the Romanian pig sector over the 2011–2022 period. Data were drawn from the Romanian National Institute of Statistics, the International Trade Centre, and FAOSTAT. The results indicate that Romania's dependence on pig meat imports is associated with weaker domestic production potential in the context of ASF management, with implications for the sector's structural sustainability. Food security risks therefore emerge, in addition to the food safety concerns arising from the intensification of ASF. By contrast, Romania's domestic pig-livestock

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emissions remain low within the EU, but this apparent sustainability gain largely reflects production contraction and import dependence.

Keywords: pig meat sector; food security; trade balance deficit; import dependency; environmental externalisation; Romania.

JEL classification: Q17, Q18, Q56.

Introduction

Concerns for the present and future of global food security have started to re-emerge over the past decades in tandem with the growth of the world population. The concept of food security has evolved in recent decades and has gradually expanded. It initially focused on food availability and food production (United Nations, 1987; Chaves *et al*., 2013), then expanded explicitly to include food accessibility (physical, economic, and social), its use (Berry *et al*., 2015), and finally to cover the stability of these dimensions (Curtis, Halford, 2014).

Within this evolving framework, the livestock sector, and the pig meat industry in particular, has emerged as a critical nexus where food security, economic sustainability, and environmental policy converge. The sector's dual role as a significant contributor to nutritional security and as a major source of agricultural greenhouse gas emissions positions it at the centre of contemporary debates about sustainable food systems (Papatsiros *et al*., 2026). In the European Union, these tensions have become especially pronounced as member states navigate the simultaneous pressures of ensuring food availability, managing disease outbreaks, and meeting climate neutrality targets, while remaining competitive.

The European pig sector: evolving policy context and sustainability pressures

The pig meat industry across the European Union faces significant challenges as the sector moves to meet the targets of the European Green Deal, with the objective of carbon neutrality to be achieved by 2050. The sector is required to implement new measures for the reduction of methane (CH_4) and nitrous oxide (N_2O) emissions (European Commission, 2019). These environmental exigencies are compounded by shifts in production capacity and growing reliance on imports to satisfy domestic demand in several member states, alongside exposure to external market disruptions (the 2020 COVID-19 pandemic, trade corridor shifts following the Russia–Ukraine war, and energy price volatility).

The spread of African Swine Fever (ASF) across Eastern European member states has added a further layer of complexity to these challenges. The disease has disrupted production capacity, reduced livestock numbers, and heightened biosecurity requirements for commercial farms. In response, the European Union has enacted supranational targeted regulations to address the intricate issues related to ASF alongside broader environmental challenges (EFSA *et al*., 2021; 2023). The simultaneous pressures of disease management, emissions reduction, and ensuring stable pig meat supplies have created a multi-dimensional policy challenge that varies significantly in intensity across member states.

The Romanian pig sector: import dependence, disease pressure, and food security risks

Among EU member states, Romania faces particularly acute challenges in the pig meat sector. It represents the major component of the country's food trade deficit, a situation accentuated by the influence of the ASF outbreaks (Popescu, 2020). The high incidence of ASF is strategically significant,

considering the alignment with the broader environmental and food safety goals (Faichuk *et al*., 2022). Although research has been performed on the economic impacts of ASF and ecological regulations, very few link the effect comprehensively to market outcomes and concerns about sustainability (Olsen *et al*., 2023).

Romania's structural challenges in the pig meat sector have intensified over recent years, marked by a sustained contraction in domestic pig livestock and a corresponding shift toward import reliance to meet domestic consumption needs (Dinu *et al*., 2025). This trajectory raises questions about the long-term viability of domestic pig meat production capacity and about the apparent environmental improvements associated with reduced livestock numbers. Understanding these dynamics is essential for informing policy interventions that can balance food security, economic resilience, and environmental objectives in a sector facing multiple simultaneous pressures, with ASF acting as a compounding shock that amplifies existing vulnerabilities. This paper contributes to this literature segment by delivering an analysis that puts together economic, environmental, and, ultimately, policy perspectives. The study examines the Romanian pig meat sector over the 2011–2022 period, applying an integrative descriptive framework to 16 indicators spanning trade dynamics, market performance, and environmental footprint.

The paper is structured as follows. The Literature Review examines existing research on pig meat trade policies, import dynamics in the EU context, and the economic and environmental impacts of ASF. The Data and Methodology section describes the 2011–2022 dataset drawn from INTRACEN, TEMPO, and FAOSTAT, and outlines the integrative descriptive framework used to analyse interdependencies among food security, competitiveness, and environmental indicators. The Results section presents the findings from correlation, distributional, and stability analyses. The Discussion section examines the structural barriers facing SMEs in accessing EU markets, the implications of livestock contraction for rural employment, and other specific elements. The Conclusions synthesise the main findings, discuss policy implications, and identify directions for future research.

1. Literature Review

The pig meat sector is a vital sector in the global agricultural economies, especially in the European Union, where the sector is regulated by stringent policies and frameworks for its environment and economic importance. The EU remains one of the largest producers and consumers of pig meat, although there is a large trade deficit in some of its members, for example, Romania, that have high levels of import. The import levels are affecting the local market and, perhaps more importantly, the global markets are increasingly shaped by, and in turn favour, the major pig meat exporters, for example, Brazil and the United States (Bojnec, Fertő, 2019; Ladoşi, Păpuc and Ladoşi, 2023; Xhoxhi, Szücs, 2024). Equally, research by Boboc *et al*. (2021) also discovers the fact that the global market dynamics also affect the EU countries. These conclusions are furthered by Bellini (2021) and Kim *et al*. (2024), who noted that the EU countries are vulnerable to the global market dynamics that influence local pricing and the world market competition. Additionally, market dynamics are not only influenced by the quantity of trades and national capacity of EU countries to maintain performant levels of livestock farming but also by the biosecurity aspects that pose threats to the entire agricultural sector, such as the ASF (Dhollander *et al*., 2025). The economic impact of ASF has been severe, especially in Eastern Europe, thus, destabilising the economic equilibrium of the pig livestock farming.

The European Food Safety Authority demonstrated that ASF spreads very fast and destroys pig populations. The high rates have implications on local economic stability amongst the pig farmers and

major food security implications for the country (Rogoll *et al*., 2023). The literature also reveals that biosecurity and disease management practices are an essential part of mitigating the spread of ASF, with more strict surveillance and control measures required to protect the sector (Alvarez-Rodriguez *et al*., 2024). One important trade-off that characterises Romania's pig meat market is high dependency on imports for this type of products, governed by its need to maintain product availability in stores for customers and ensure a high level food security for national consumption. Thus, while importing pig meat is crucial for maintaining domestic market equilibrium, this dependency also poses actual challenges to achieving self-sufficiency and an economically-sustainable pig meat market. In the context of meeting the European Green Deal's targets for reducing methane (CH_4) and nitrous oxide (N_2O) emissions, conversely, EU adopted strategic policies that support a gradual process of eliminating industries that do not meet environmental or economic requirements, while concurrently strengthening sectors that match with sustainability aims and modern economic standards (Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')). This is critical as agriculture is one of the major sectors that emit high levels of methane and nitrous oxide, as found out by research by Raimondi *et al*. (2025). The EU introduced to the member states a directive on the environmental footprint, which has led to the adaptation of the pig farming strategies, which are found to have a major conflict by research by Tretola *et al*. (2024) and Rauw *et al*. (2020). Also, scholars such as Plavšić (2023) suggest that pig farms must be a major entry in food security frameworks as efficiency in production is crucial as the environmental footprint of this particular zootechnical activity fades when compared to other sectors of the economy. The main stated literature finding is improved efficiency in production technologies and scaling (Sinke *et al*., 2023), which is especially important for Romania that still suffers food insecurity due to the sector's inefficiencies, the only way to stabilise the sector is through massive investment and technological development (Popescu *et al*., 2023).

According to Rieger *et al*. (2023), pig meat production is a major source of income in the rural areas of Europe, and any changes in production should consider the sector. They argue that increasing pig meat production will indeed increase the living standards and reduce rural poverty. Precision livestock farming has also been proposed as a viable technological investment, through which feed, water, and other inputs can be targeted and allocated more efficiently at the individual animal level, thereby improving production performance without undermining sustainability objectives. Romania, for example, has long suffered food insecurity due to the lack of efficient investment, as argued by Baltag and Osoianu (2023). Consequently, research by Dinu *et al*. (2024) emphasises spatial diffusion and contagion effects of environmental practices and policies that could be harnessed to understand the environmental impacts in the Romanian pig meat sector, especially in view of the EU regulations and sustainability targets. The methods and results of their study established a solid framework for measuring the environmental impact of economic activity and are hence quite apt for quantifying the sustainability and market dynamics of the pig meat sector in Romania. Such linkage, hence, implies very strong effects of economic activities on the environmental health front and a strong comparative perspective of the effectiveness of policies across different sectors and regions.

Innovations in farming practices are needed to support the sector. Rao *et al*. (2023) note that there is also a need for maintaining health and enhancement of the growth performance of pigs in supply chains. Finally, the most important highlight from the literature is that there is a need to ensure that the policies

addressed are coherent and holistic of the various issues that might face the pig meat sector in addressing the food insecurity challenge. Borghino *et al*. (2024) further adds to this argument by suggesting that there is a need to ensure that the food insecurity problem in the EU can be solved from policy dimensions by making major reforms that will create sustainable markets for the local farmers.

2. Research Methods

The list of socio-economic and environmental indicators included in this study was designed in line with the research objective. For all the indicators mentioned in *Table 1*, data collection covers the 2011-2022 period, which was considered sufficient enough to obtain relevant research findings through the identification of trends and patterns at the level of the Romanian pig meat sector. Upon preprocessing, data were harmonised across all three databases utilised in this study, namely the International Trade Center – INTRACEN (2024) for aspects related to foreign trade; TEMPO / the National Institute of Statistics Romania (2024) for aspects concerning the domestic pig meat market; and FAOSTAT (2024) for aspects regarding the environmental impact of the pig livestock.

Table 1. The selection of indicators included in the research framework

Code	Indicator	Unit of measurement	Data source
I_1	Import of live pigs	billion USD	INTRACEN, Trade Center
I_2	Import of pig meat	billion USD	INTRACEN, Trade Center
I_3	Export of live pigs	billion USD	INTRACEN, Trade Center
I_4	Export of pig meat	billion USD	INTRACEN, Trade Center
I_5	Deficit of the trade balance with live pigs	billion USD	INTRACEN, Trade Center
I_6	Deficit of the trade balance with pig meat	billion USD	INTRACEN, Trade Center
I_7	Pig livestock (number)	million pigs	TEMPO, Indicator code AGR201A
I_8	Average live pig weight	tonnes per pig	TEMPO, AGR202A÷AGR201A
I_9	Average purchase prices for live pigs	RON per live kg	TEMPO, Indicator code PPA102C
I_{10}	Average nominal unit expenditure on pig meat	RON per kg	TEMPO, BUF114J÷BUF110J
I_{11}	Average pig meat nominal consumption monthly	kg per month per person	TEMPO, Indicator code BUF110J
I_{12}	Average nominal expenditure for pig meat monthly	RON per month per person	TEMPO, Indicator code BUF114J
I_{13}	Average monthly nominal net earnings	RON per month per person	TEMPO, Indicator code FOM106E
I_{14}	Inflation rate	percentage	TEMPO
I_{15}	Romania's share of EU-27 pig livestock CH_4 emissions	percentage	FAOSTAT
I_{16}	Romania's share of EU-27 pig livestock N_2O emissions	percentage	FAOSTAT

Note: Indicator codes (I_1–I_{16}) are nominal identifiers for reference purposes. No weighting scheme is applied in the analysis.

Source: authors' own selection of indicators.

The analytical framework adopted in this paper is descriptive-correlational and exploratory in nature, not causal-econometric. This methodological choice is grounded on two considerations. First, the empirical scope is restricted to a single country observed across a 12-year window, which yields a sample size that is insufficient for robust econometric estimation of structural relationships. Second, the research aim is

to characterise interdependencies and temporal patterns across the food security–competitiveness–environment nexus, and such characterisation is a necessary diagnostic step that precedes and informs formal causal analysis. The framework is therefore positioned as integrative, with its contribution lying in the joint examination of trade, market-performance, and environmental indicators within a single analytical lens.

From a methodological standpoint, the empirical analysis was divided into three segments, each addressing various aspects of the Romanian pig meat market dynamics. This division facilitated a more in-depth approach to the statistical data, starting from descriptive statistics analysis to more complex stability and variability measurements concerning the food security dimension, market and environmental performance.

The first segment of the analysis consisted of a correlation analysis, in which the correlation matrix served as the foundational tool for investigating the interconnections among the selected indicators. Correlation coefficients and their associated p-values were computed at the level of the Romanian pig meat market, with statistical significance tested at the 0.05 and 0.01 thresholds. By designing the research framework in this manner, it was ensured that the findings would be rooted in significant associations.

The second segment was devoted to a distributional analysis of each indicator. Descriptive statistics were computed, including the mean, median, maximum, minimum, and standard deviation, alongside measures defining the shape of the distribution such as skewness and kurtosis. To complement these measures, normality was assessed through the Jarque–Bera statistic and its corresponding p-value, which allowed the distributional adherence to normality to be evaluated. Each indicator listed in Table 1 was thereby thoroughly examined in terms of its distributional characteristics.

The third segment focused on stability and variability analysis, through which food security implications were examined in relation to pig meat market dynamics and environmental exigencies. Volatility was calculated as the standard deviation of the year-over-year percentage change, providing a quantifiable measure of relative fluctuations and thereby enabling the assessment of the temporal stability of pig meat market conditions. In addition, performance- and growth-related metrics were incorporated into the analysis, namely the average growth rate, the compound annual growth rate (CAGR), and a focused 3-year CAGR, which together captured both short-term and long-term growth trends. The end-to-start ratio was also calculated, allowing the magnitude and direction of change between the beginning (2011) and end (2022) of the studied period to be quantified.

Together, the three analytical segments build on one another: the correlation matrix establishes the structure of associations among indicators, the distributional analysis characterises their statistical properties, and the stability and variability analysis adds a temporal dimension to the findings. The integrative descriptive framework thereby provides a coherent diagnostic basis for examining the Romanian pig meat sector across its socio-economic and environmental dimensions, with implications for food security and for the formulation of evidence-based policy.

3. Results

The correlation matrix was constructed in *Table 2* with the objective of quantifying both the relationship strength and the direction between the indicators included in this paper, thus laying the ground for further exploration into the analysis at the level of series distributions, as well as at the level of stability,

variability, and performance-related aspects. This initial procedure ensured a better understanding of the dynamics between the complex factors influencing the Romanian pig meat market's performance, the environmental impact attributed to the Romanian pig livestock, and other food security factors. In the long term, Romania's reliance on pig meat imports is associated with weaker domestic production and export capabilities, with implications for the sustainability of the Romanian pig meat sector and for the sector's resilience against global market fluctuations, posing food security risks. The correlation between I_2 (import of pig meat) and I_6 (deficit of the trade balance with pig meat) is positive, outstandingly strong (0.997), and statistically significant, indicating that pig meat imports are closely linked to the deficit in trade balance for pig meat. The negative powerful correlation (–0.969) between I_2 and I_7 (Romania's pig livestock) suggested that decreases in domestic livestock numbers are associated with increased imports of pig meat. This pattern may reflect various factors, including the African Swine Fever present in Romania's pig farms and competitive pricing from imported pig meat with implications for the profitability and viability of domestic pig farming. A reduction in livestock numbers raises concerns about the long-term domestic production capabilities, with implications for Romania's level of food security. The positive correlation between pig meat imports (I_2) and the average nominal unit expenditure indicator for pig meat (I_{10}) suggests that import dependence increased alongside consumer-level unit expenditure. This points to a co-movement between pig meat import reliance and rising unit expenditure during the analysed period.

The relationship between the number of pig livestock (I_7) and the unit expenditure indicator for pig meat (I_{10}) reflects the supply-demand dynamics within the domestic market. A decrease in livestock numbers is associated with higher pig meat expenditure due to reduced domestic pig supply. Conversely, if the reduction in pig livestock was due to decreased profitability driven by low pig meat prices (influenced by high import levels), then this market reaction further exemplifies the vicious circle previously described. The dynamics between I_2 (import of pig meat), I_6 (deficit of the trade balance with pig meat), and I_{11} (pig meat nominal consumption monthly) reflected critical aspects of Romanian market performance. The high correlation between I_2 and I_6 (0.997, statistically significant) showed that the country spends more on importing pig meat than it gathers from exporting it. Results prove Romania's reliance on foreign pig markets for meeting domestic consumption needs. On the other hand, the strong positive correlation between I_2 and I_{11} (0.912, statistically significant) suggested that imports are a key factor in satisfying the domestic demand for pig meat, which has an average growth rate of 4.49% during the 2011-2022 period. While this ensures that Romanian consumers' needs and food security are met due to imports, it also highlights vulnerability. Considering that the domestic market is heavily dependent on imports to meet consumption demands (as indicated by the correlation between I_{11} and I_2), any disruptions in the global pig meat supply chain or any significant changes in trade policies will have immediate, negative and significant impacts on the availability and price of pig meat in Romania. Thus, while importing pig meat is crucial for maintaining domestic market equilibrium, this dependency also poses actual challenges to achieving self-sufficiency and an economically-sustainable pig meat market.

Table 2. The correlation matrix

	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}	I_{16}
I_1	1.000															
I_2	0.221	1.000														
I_3	–0.140	–0.615*	1.000													
I_4	–0.005	–0.679*	0.712*	1.000												
I_5	0.999**	0.240	–0.171	–0.027	1.000											
I_6	0.205	0.997**	–0.645*	–0.735**	0.224	1.000										
I_7	–0.243	–0.969**	0.553	0.601*	–0.259	–0.960**	1.000									
I_8	0.130	0.819**	–0.410	–0.345	0.142	0.794**	–0.909**	1.000								
I_9	0.370	0.722**	–0.332	–0.454	0.378	0.716**	–0.623*	0.355	1.000							
I_{10}	0.317	0.924**	–0.522	–0.724**	0.332	0.931**	–0.901**	0.663*	0.793**	1.000						
I_{11}	0.144	0.912**	–0.462	–0.517	0.158	0.899**	–0.970**	0.895**	0.574	0.868**	1.000					
I_{12}	0.225	0.947**	–0.522	–0.686*	0.240	0.948**	–0.946**	0.750**	0.739**	0.984**	0.938**	1.000				
I_{13}	0.208	0.974**	–0.553	–0.668*	0.224	0.972**	–0.988**	0.850**	0.678*	0.945**	0.970**	0.980**	1.000			
I_{14}	–0.047	0.651*	–0.505	–0.649*	–0.030	0.671*	–0.494	0.203	0.647*	0.651*	0.411	0.615*	0.544	1.000		
I_{15}	–0.330	–0.966**	0.576	0.604*	–0.347	–0.963**	0.991**	–0.913**	–0.430	–0.885**	–0.936**	–0.942**	–0.983**	–0.252	1.000	
I_{16}	–0.323	–0.967**	0.591	0.620*	–0.340	–0.966**	0.988**	–0.907**	–0.427	–0.884**	–0.929**	–0.939**	–0.980**	–0.269	–0.999**	1.00

Note: * $p < 0.05$; ** $p < 0.01$. I_1 – Import of live pigs (billion USD); I_2 – Import of pig meat (billion USD); I_3 – Export of live pigs (billion USD); I_4 – Export of pig meat (billion USD); I_5 – Deficit of the trade balance with live pigs (billion USD); I_6 – Deficit of the trade balance with pig meat (billion USD); I_7 – Pig livestock (million pigs); I_8 – Average live pig weight (tonnes per pig); I_9 – Average purchase prices for live pigs (RON per live kg); I_{10} – Average nominal unit expenditure on pig meat (RON per kg); I_{11} – Average monthly nominal pig meat consumption (kg per month per person); I_{12} – Average monthly nominal expenditure on pig meat (RON per month per person); I_{13} – Average monthly nominal net earnings (RON per month per person); I_{14} – Inflation rate; I_{15} – Romania's share of EU-27 pig livestock CH_4 emissions; I_{16} – Romania's share of EU-27 pig livestock N_2O emissions.

Source: Own computation on the basis of data extracted from INTRACEN, TEMPO, and FAOSTAT databases.

Romania's ability to export pig livestock and pig meat (I_3 and I_4) is inherently affected by the domestic pig livestock (I_7), with statistical significance in the case of the moderate (0.60) correlation between I_4 and I_7. Ensuring livestock is essential to increase food security levels, as noticed based on the correlation matrix results, which also emphasise the importance of domestic agricultural policies and practices. The I_6 (Romania's trade balance deficit with pig meat) interactions with domestic production indicators like pig livestock numbers (I_7: –0.960) and average purchase prices (I_9: 0.716 and I_{10}: 0.931) are meaningful from a theoretical standpoint, as well as they are statistically significant. Findings show that high trade balance deficits reflect inadequate pig production strategies. Once again, it is underscored that enhancing domestic production efficiency could reduce Romania's import dependency, thereby improving the trade balance results and market performance.

The strong correlation (0.899) between I_6 and I_{11} (pig meat consumption in Romania) is statistically significant and puts the spotlight on the demand side. Results show that Romania's increased pig meat demand has exacerbated trade deficits, since it has been primarily met through imports. Economic indicators (I_{12}: average monthly nominal expenditure for pig meat; I_{13}: average monthly nominal net earnings; and I_{14}: inflation rate) indirectly influence trade deficit trends (I_6), in the same direction, through their impact on domestic demand. Studying these relationships helps in formulating synergistic strategies that do not only target the trade balance results directly, but also, they address underlying

economic conditions contributing to Romania's pig meat deficit. Moreover, other economic indicators within the dataset, specifically I_9 (average live-pig prices), I_{10} (the average unit expenditure indicator for pig meat), I_{11} (average pig meat consumption), I_{12} (average pig meat expenditure), I_{13} (Average monthly nominal net earnings), and I_{14} (Inflation rate); they exhibit positive, strong, and significant correlations among themselves, indicating that as the prices for live pigs and pig meat unit expenditure increase, so does the nominal expenditure for these products. Additionally, the I_{11} – I_{13} strong correlation (0.970, statistically significant) put the relationship between the pig meat consumption and consumer earnings into the spotlight, demonstrating that increased income levels facilitate increased pig meat consumption levels. The inflation rate (I_{14}) is moderately correlated with I_9 (0.647) and I_{10} (0.651), statistically significant, and suggest that inflation contributed, to some extent, to the increase in pig livestock and pig meat expenditure.

The assessment of the environmental impact of the Romanian pig livestock, an essential research element of this paper, was carried out by analysing Romania's share of EU-27 pig livestock CH_4 emissions (I_{15}) and N_2O emissions (I_{16}). Both shares are strongly and positively correlated with the pig livestock (I_7 correlation coefficients: 0.991 with I_{15} and 0.988 with I_{16}), statistically significant relationships. Data proved that as the number of pig livestock in Romania decreased, the country's share of EU-27 CH_4 and N_2O emissions generated by the pig livestock decreased as well. Conversely, strong, but negative correlations were found between I_{15}, I_{16}, and indicators related to Romania's pig meat imports (I_2, correlation coefficients: –0.966 with I_{15} and –0.967 with I_{16}) and pig meat trade balance deficits (I_6, correlation coefficients: –0.963 with I_{15} and –0.966 with I_{16}), all statistically significant. Findings suggest when a reduction in domestic pig production occurs, then Romania relies more on pig meat imports and generates larger trade balance deficits in this regard, which leads to lower CH_4 and N_2O emissions.

Since decreasing pig livestock numbers reduces the emissions generated by pig farming, it might appear as an attractive measure to increase environmental performance in this sector. Yet, this approach is neither economically nor environmentally sustainable in the broader context of competitiveness. Transferring pig production to other countries does not solve the issue of pig livestock emissions, but it relocates these emissions to other countries that are highly competitive from an economic perspective, but with huge environmental impacts. For example, Spain scored the greatest pig meat trade balance surplus (5.6 billion USD) in 2022 among all the EU member states, but this country also accounted for the greatest share of EU's pig livestock CH_4 emissions (28.32%) and N_2O emissions (23.73%).

In this context, Romania's pig livestock constant decrease is associated with lower domestic CH_4 and N_2O emissions. However, combined with the deepening trade deficit in pig meat, broader implications should be taken into account. These market dynamics contribute to the outsourcing of environmental impacts to other countries, that, while economically competitive, they inherit great environmental footprints. By importing pig meat from countries with higher levels of CH_4 and N_2O emissions, Romania indirectly contributes to the global environmental footprint of the pig meat sector. Hence, although Romania's CH_4 and N_2O national emissions are below the EU average, its environmental impact becomes 'transferred' to other countries. Romania's loss of domestic capabilities, increased pig meat import dependency, and poor resilience in the face of price volatility and supply chain disruptions build upon the argument that the country is not in a favourable market position. On the contrary, Romania is economically unsustainable based on its current market performance. Additionally, from another dimension of sustainability, that of the environment, Romania performs slightly better than other EU countries, since it does not generate impressive CH_4 and N_2O emissions. Unfortunately, through its

imports, Romania reallocates emissions to other countries specialised in pig meat trade. To achieve sustainability at all its dimensions, efforts must focus on reducing emissions globally through cooperative international efforts and innovative, sustainable agricultural practices.

Transitioning to the second segment of the paper on descriptive statistics, distributional and normality measures, the aim was to contribute to the understanding of the data's underlying behaviour. The statistics from *Table 3* provide a robust foundation for targeted strategic policy interventions in Romania. Thus, new layers of complexity were added to the research framework concerning the analysis of the performance of the pig market and its environmental impact.

Table 3. Descriptive statistics, distributional, and normality measures

Indicator	Mean	Standard deviation	Median	Maximum	Minimum	Skewness	Kurtosis	Jarque-Bera Stat	Jarque-Bera *p*-value
I_1	0.106	0.019	0.110	0.139	0.067	–0.421	2.801	0.374	0.830
I_2	0.522	0.188	0.461	0.869	0.328	0.450	1.782	1.147	0.564
I_3	0.000	0.000	0.000	0.002	0.000	1.251	3.417	3.217	0.200
I_4	0.029	0.021	0.036	0.062	0.002	–0.032	1.510	1.112	0.573
I_5	0.106	0.019	0.109	0.138	0.067	–0.433	2.727	0.412	0.814
I_6	0.491	0.204	0.413	0.866	0.289	0.499	1.775	1.248	0.536
I_7	4.446	0.718	4.556	5.363	3.328	–0.159	1.491	1.189	0.552
I_8	0.122	0.014	0.128	0.140	0.104	–0.244	1.343	1.492	0.474
I_9	5.988	0.635	6.050	7.360	5.210	0.632	2.914	0.801	0.670
I_{10}	13.086	2.830	11.850	18.639	10.021	0.847	2.310	1.673	0.433
I_{11}	1.208	0.188	1.226	1.514	0.939	0.020	1.848	0.664	0.717
I_{12}	16.229	5.978	13.985	28.220	9.410	0.800	2.395	1.464	0.481
I_{13}	2,377.67	817.98	2,192.00	3,801.00	1,444.00	0.410	1.760	1.105	0.576
I_{14}	3.608	3.915	3.550	13.800	–1.500	1.324	5.015	5.534	0.063
I_{15}	1.930	0.302	2.051	2.255	1.508	–0.352	1.410	1.385	0.500
I_{16}	3.623	0.538	3.856	4.201	2.881	–0.373	1.403	1.423	0.490

Source: own computation on the basis of data extracted from INTRACEN, TEMPO, and FAOSTAT databases.

Romania's import of live swine (I_1) was 0.106 billion USD on average and this series showed a concentration above the mean, as evidenced by the leftward skewness (–0.421), suggesting period of reduced import activity, referring to the beginning of the period (2011). The greater pig meat imports average of 0.522 billion USD revealed Romania's strong dependence on global markets to meet domestic demand and the positive I_2 skewness (0.450) underscored the occasional import spikes observed at the end of the analysed period, likely resulted from increased demand and lack of domestic pig meat offer. High variability was also noticed in terms of Romania's live pig exports (I_3), as demonstrated by a standard deviation 1.06 times greater than the mean. However, this is not adding to the competitiveness of the Romanian pig meat market, since the export volumes are much smaller compared to the pig livestock imports. Accounting for, on average, 0.03 billion USD, Romania's export of pig meat (I_4) exhibits a relatively low negative skewness (–0.032), but later stability indicators show high relative variability over time. On the other hand, considering the average trade balance deficit in pig meat of Romania (I_6) of 0.491 billion USD per year, the maximum (0.866 billion USD in 2022), and the positive skewness (0.499); all these market performance metrics raise potential food security concerns based on significant deficit volume increases.

Regarding Romania's pig livestock, the mean of almost 4.5 million heads (I_7), as well as the slight negative skewness (–0.159), indicate a trend of decreasing pig populations over the 2011-2022 period. This livestock decrease reflects the major challenge caused by the African Swine Fever disease which has intensified in Eastern Europe and it has negatively impacted the pig supply chain, hence leading Romania to increased reliance on pig imports to meet domestic consumer demand. As a result, Romania's trade balance results are negatively impacted as well, with food security implications. I_8, the average weight of pigs in Romania, showed minimal variability, which suggested efficient livestock management practices nationally. The average prices for live pigs (I_9) and the average nominal unit expenditure on pig meat (I_{10}) were series that were characterised by positive skewness (0.632 and 0.847), with mean values indicating gradual price increases. These trends partially reflect rising inflationary pressures, increased market demand or increased production costs.

The descriptive statistics corresponding to the average pig meat nominal consumption in Romania (I_{11}) indicated a mean of 1.208 kg of pig meat per month, with a skewness near zero (0.020), hence suggesting a distribution that is close to symmetric around the mean. However, the annual data points from 2011 to 2022 show a clear upward consumption trend, from 0.939 kg in 2011 to 1.514 kg per month per person in 2022. The average nominal expenditure for pig meat showcased a mean of 16.22 RON per person per month, with a standard deviation of 5.97 RON, reflecting substantial variability in how much consumers are spending on pig meat over the years in Romania. Skewness (0.800) indicated a distribution with a longer right tail, suggesting periods of significantly higher pig meat expenditure, especially after the year 2020, driven by price increases and higher meat consumption volumes. Thus, by connecting these findings with those specific to I_{13} (nominal monthly net earnings), it can be noticed that periods of higher expenditure on pig meat aligned with periods when incomes were sufficient to support increased spending, when the value placed on pig meat consumption overcame economic constraints. The strong and positive correlation between I_{12} and I_{13} implies a significant link between consumer income levels and their spending patterns on pig meat. Consumer earnings variations are closely mirrored by changes in how much they spend on pig meat. Also, the observed I_{12} (0.800) and I_{13} (0.410) skewness values signalled that there were longer tails towards the higher end of the distributions, meaning that while the bulk of the data (median and mode included) is located towards the lower end of the scale, the mean is pulled towards the right by outliers, specific to the years 2020, 2021 and 2022. Therefore, the presence of outliers and the longer tails towards the right underscore the pig market growth in Romania and the opportunities for entrepreneurial activity in this sector

Inflation's (I_{14}) impact on earnings (I_{13}) and pig meat expenditure (I_{12}) suggest adaptive consumer responses. The positive skewness (1.324) and high kurtosis (5.015) of the inflation rate indicated the occurrence of years with significantly high inflation rates, with direct negative impact on the purchasing power of the average consumer in Romania. The moderate positive correlation between the inflation and the average monthly nominal net earnings suggested that, generally, inflation and consumer earnings tend to increase simultaneously. However, increases might not always be proportional, and, in some cases, they could lead to gaps in terms of the real purchasing power, with significant impact on consumer behaviour. This situation highlights the intricate relationship between the Romanian pig meat market dynamics and the national economic policy, underscoring the need for coordinated strategic actions in pricing, wage adjustments, and inflation management to ensure the stability and security of the Romanian pig meat sector.

Focusing on the environmental impact, Romania's share of EU-27 pig livestock CH_4 emissions (I_{15}) reached a mean of 1.93%, with a standard deviation of 0.3%. The skewness value of –0.352 revealed that most data points were concentrated above the mean, yet with occasional lower outliers. N_2O emissions gathered larger shares than CH_4, with a mean of 3.62%, yet below the EU-27 average, which underscore some degree of environmental performance. Based on the kurtosis values, both I_{15} and I_{16} scored values lower than the benchmark of 3, which means that the distributions lacked heavy tails, suggesting that extreme values were less frequent in both CH_4 and N_2O pig livestock emission data sets. The Jarque-Bera test results indicate a steady environmental impact from the Romanian pig livestock.

Building upon the Romanian pig meat market performance and environmental insights gathered from the descriptive statistics analysis, distributional, and normality metrics; the final segment of the paper shifted the attention towards the stability and variability measures in *Table 4*. Thus, this research approach ensures reaching comprehensive results and key insights, which are highly necessary for appropriately designing synergistic strategies aimed at improving the performance, resilience, and sustainable growth prospects of the Romanian pig meat market. End-to-start ratios are displayed in *Figure 1*.

Table 4. Stability, variability and performance statistics

Indicator	Coefficient of variation (CV)	Average growth rate	Geometric mean	Compound annual growth rate (CAGR)	3-Year CAGR	Volatility	Absolute value registered in the year 2011	Absolute value registered in the year 2022
I_1	18.03%	5.91%	3.69%	3.69%	–6.08%	23.23%	0.067	0.100
I_2	36.22%	9.28%	8.34%	8.34%	8.66%	15.30%	0.360	0.870
I_3	103.12%	28.55%	–8.84%	–8.84%	2.64%	111.42%	0.000	0.001
I_4	74.03%	3.94%	–13.22%	–13.22%	–8.02%	67.07%	0.014	0.003
I_5	18.22%	6.00%	3.73%	3.73%	–6.09%	23.46%	0.067	0.100
I_6	41.55%	9.93%	8.70%	8.70%	8.74%	17.48%	0.346	0.867
I_7	16.15%	–4.20%	–4.24%	–4.24%	–4.19%	3.10%	5.364	3.329
I_8	11.51%	2.28%	2.19%	2.19%	–0.26%	4.57%	0.104	0.132
I_9	10.60%	3.83%	3.19%	3.19%	3.08%	12.08%	5.210	7.360
I_{10}	21.63%	6.02%	5.80%	5.80%	4.02%	7.06%	10.021	18.639
I_{11}	15.55%	4.49%	4.44%	4.44%	3.84%	3.38%	0.939	1.514
I_{12}	36.84%	10.63%	10.50%	10.50%	8.02%	5.59%	9.410	28.220
I_{13}	34.40%	9.25%	9.20%	9.20%	5.72%	3.42%	1,444	3,801
I_{14}	108.50%	16.91%	19.67%	8.20%	74.44%	137.74%	5.8	13.8
I_{15}	15.66%	–3.76%	–3.87%	–3.53%	–1.77%	4.71%	2.24	1.51*
I_{16}	14.85%	–3.45%	–3.56%	–3.24%	–1.53%	4.74%	4.14	2.88*

Source: own computation on the basis of data extracted from INTRACEN, TEMPO, and FAOSTAT databases *Values corresponding to the year 2021, the latest available at the moment of carrying out this research.

The moderate coefficient of variation (CV) of Romania's live pig imports (I_1: 18.03%) paired with the positive average growth rate (5.91%) and a CAGR of 3.69% indicated a steady increase in the import volumes over the study period. This growth was also reflected in the end-to-start ratio of 1.490. Thus, this trend underscores economic concerns about the sustainability of the Romanian pig meat sector. The series of pig meat imports (I_2) showcased high variability, with CV of 36.22% and an impressive CAGR of 8.34%, pointing towards a significant upward trend in importing pig meat. The end-to-start ratio of 2.414

indicated more than a doubling in the value of Romanian pig meat imports, therefore denoting a very strong dependency on foreign markets to satisfy domestic consumption needs. The positive 3-year CAGR (8.66%) further emphasised the strong dependency on imports, as well as the vulnerabilities to price fluctuations and the urgent need for strategies to enhance domestic production efficiency and competitiveness. Furthermore, price pressures could negatively affect profitability and, ultimately, the viability of Romania's farming operations, as noticed in the declining swine livestock numbers (I_7), thus perpetuating the vicious cycle of increased imports and reduced swine domestic production.

The extreme volatility and the declining export trend in terms of Romania's pig livestock exporting were revealed by the high CV (103.12%), alongside the negative CAGR (–8.84%). The slight positive 3-Year CAGR (2.64%) hinted at recent efforts to recover Romania's export capabilities with pigs, yet the overarching trend suggests a critical area for policy intervention and strategic planning to improve export performance. Transitioning to I_4, data indicated a troubling trend in Romania's pig meat exports, marked by a high CV (74.03%) and a significantly negative CAGR (–13.22%), greater than in the case of I_3. The low end-to-start ratio (0.210) illustrated an abrupt decline in pig meat exports, suggesting untapped market opportunities. This decline in pig exports is symptomatic of broader issues within the Romanian pig meat sector, including competitive disadvantages and other issues negatively affecting the sector, such as the African Swine Fever.

I_5 closely mirrored the trend observed in the case of I_1, with a slightly higher CV (18.22%), indicating a similar level of variability in Romania's trade balance deficits for pig livestock. The average growth rate (6.00%) and the CAGR (3.73%) suggested that the deficit has been expanding in parallel with the increase in pig livestock imports. In addition, the end-to-start ratio of 1.496 reflected worsening trade balance results. Furthermore, Romania's trade balance deficit with pig meat reveals an even worse picture, with a CV of 41.55%, hence very strong variability. The substantial annual growth rate and CAGR of nearly 10% and 8.7%, respectively, indicated a rapidly widening pig meat deficit, corroborated by the massive end-to-start ratio of 2.504. From 0.346 billion USD in 2011, Romania's pig trade balance deficit reached a new peak in the year 2022: 0.866 billion USD. This end-to-start ratio confirmed that the deficit more than doubled, pointing to a significant increase in Romania's pig meat imports (I_2), not matched by its exports. On top of that, the high volatility (17.48%) reflected the challenges of pig meat domestic market, which is far from being competitive and sustainable.

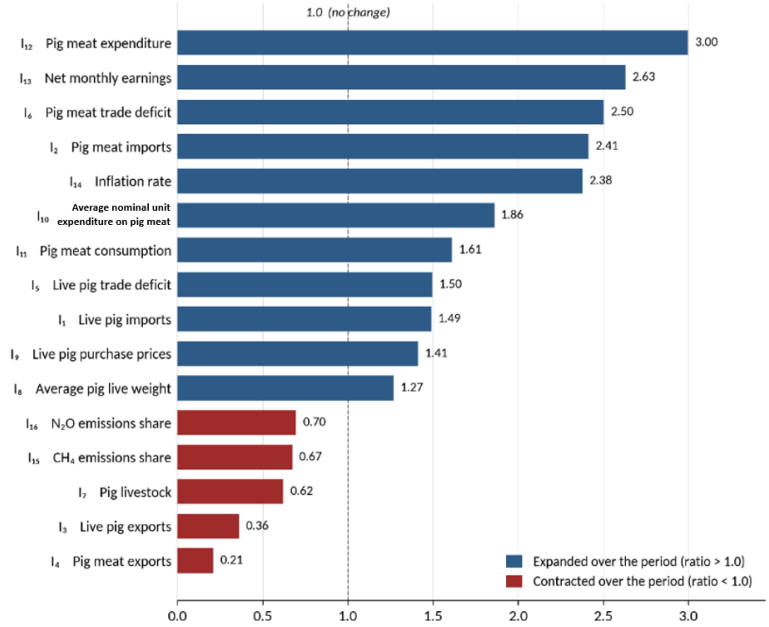
The expanding deficits in trade balance for both pig livestock (I_5) and pig meat (I_6) are consistent with ongoing production challenges in Romania. Deficits widen simultaneously with the significant pig livestock (I_7) reduction from 5.3 million heads in 2011 to 3.3 million heads in 2022, indicating a substantial decrease in domestic production capabilities, with an end-to-start ratio of 0.621. This trend is concerning for Romania's food security, given the I_7 CV (16.15%) and negative CAGR, which point to underlying production challenges associated with constrained growth and the contraction of the pig livestock.

The average weight of pigs in Romania (I_8) was included in this research framework as a metric for animal health, management practices, and market performance. The CV (11.51%) showed a relatively stable environment for pig growth, with a consistent increase in average pig weights, as demonstrated by a CAGR of 2.19%. Moving from 0.104 tonnes per head, on average, in 2011, to 0.132 tonnes per head in 2022, and with an end-to-start ratio of 1.269, these statistics indicate Romania's improvement in pig weight, reflecting performance in dimension of the market.

The price factor was considered in the empirical analysis through the inclusion of I_9 into the framework – the average pig livestock price series, which was subject to 3.19% increase based on CAGR. Although the CV reached 10.60% in the case of I_9, the unit expenditure for pig meat in Romania (I_{10}) exhibited an even higher variability than pig livestock prices, based on the 21.63% CV, hence showing the signs of more pronounced fluctuations, potentially linked to factors such as feed price (cost) increases. I_{10}'s corresponding annual growth rate (6.02%) and the CAGR (5.80%) also revealed the same pattern. The higher rate of increase for pig meat expenditure is especially notable when considering the end-to-start ratio of 1.860 (compared to 1.413 for I_9, live pigs), indicating a significant elevation in prices over the same period. The observed trends in price and expenditure dynamics are reflective of the global market conditions, as well as indicative of the broader economic and operational challenges confronting the Romanian pig industry. By correlating these pricing trends with other indicators such as the trade balance deficits (I_5 and I_6) and the pig livestock dynamics (I_7), comprehensive insights into the broader economic context were obtained. The progressive price increases underscore the urgent need for strategic measures to sustainably and efficiently empower domestic production capabilities, as well as to reduce Romania's import dependency.

Approaching the Romanian pig market dynamics through the lens of meat consumption (I_{11}), expenditure (I_{12}), average monthly net earnings per capita (I_{13}), and the inflation rate (I_{14}), a complex interplay of demand, spending, earnings, and price levels was unveiled. The nominal consumption of pig meat was observed to increase (CAGR: 4.44), escalating from 0.939 kg per capita monthly to 1.514 kg, with an end-to-start ratio of 1.612. This steady rise in consumption signifies a consistent demand for pig meat among Romanian consumers, which remained robust despite the market prices shifts or inflationary outcomes. The expenditure for pig meat was subject to a more pronounced surge (CAGR: 10.50%), with the expenditure escalating from 9.41 to 28.22 RON per capita per month, as denoted by an end-to-start ratio of 2.999, almost double if compared to the pig meat consumption end-to-start ratio. This expenditure growth, against a 36.84% CV, coincides with rising costs associated with the purchase of pig meat, which may pose a risk to Romania's food security. In parallel, the average monthly nominal net earnings were also subject to considerable increases, with a CAGR of 9.20%, growing from 1,444 RON per person per month in 2011 to 3,801 RON per person per month in 2022. The end-to-start ratio reached 2.632, a high level that characterises an enhancement in economic conditions through wage growth that equip consumers to accommodate the constantly increasing pig meat consumer expenditure.

However, the inflation rate (I_{14}), underscores economic challenges, with the rate climbing from 5.8% to 13.8% as seen in the end-to-start ratio of 2.379. Such pronounced increases in inflation have broad implications, impacting Romanian consumers' purchasing power. These findings are correlated with earlier research insights. The consistent growth in pig meat consumption and expenditure, coupled with the substantial increase in average monthly earnings in Romania, is consistent with an adaptive consumer base that has accommodated rising pig meat expenditure. Nonetheless, the inflationary pressures pose a formidable challenge, threatening to erode the purchasing power gains and imply risks to the sustainable development of the pig meat sector in Romania. Hence, research results point to the need for strategic interventions to revitalise the pig meat sector, which also calls for the efficient management of inflation.



Source: authors' own computation on the basis of data extracted from INTRACEN, TEMPO, and FAOSTAT databases.

Figure 1. **The Illusion of Sustainability through the Lens of the End-to-Start Ratios: Expansion of Import Dependence Alongside Contraction of Domestic Production and its Associated Environmental Footprint**

Figure 1 summarises the direction and magnitude of change for all indicators between 2011 and 2022, expressed as end-to-start ratios. Two distinct clusters emerge: indicators relating to imports, costs, consumption, and trade balance deficits expanded substantially over the period, while indicators relating to domestic production capacity and to its associated environmental footprint contracted in parallel.

Shifting the focus to environmental impacts, Romania's share of EU-27 pig livestock CH_4 emissions (I_{15}) CV of 15.66% is closely aligned with that of N_2O emissions (I_{16}), 14.85%. Despite the similar and moderate variability indicated by the CV values, the end-to-start ratios (0.673 for I_{15} and 0.696 for I_{16}) revealed a substantial decrease in pig livestock emissions in Romania. These findings are consistent with a general trend towards CH_4 and N_2O emissions reduction that likely reflects the decline in pig livestock numbers rather than deliberate sustainability efforts. To further support these results, the negative CAGR of −3.53% for I_{15} and −3.24% for I_{16} mark the substantial decreasing trend in gas emissions. The geometric means of −3.87% for I_{15} and −3.56% for I_{16} reinforce this trend.

4. Discussion

The findings on Romania's declining pig meat export capacity and rising import dependence point to significant structural barriers facing domestic producers, particularly small and medium-sized enterprises (SMEs). Congruent with the literature (Gracia *et al.*, 2011; Galnaitytė *et al.*, 2023), producers face compounded challenges in accessing EU and international markets: compliance costs for EU food safety and traceability standards, limited economies of scale in processing and cold-chain logistics, and difficulty securing the volume contracts required by large retail buyers. The contraction of domestic slaughter capacity alongside the persistence of ASF has further constrained SMEs' ability to maintain stable production and export flows. Addressing these barriers requires targeted support for producer

organization formation, co-investment in shared processing infrastructure, and technical assistance for certification and market access. Such measures can enable SMEs to transition from subsistence-oriented or informal production toward integration into formal EU value chains.

The sustained contraction of pig livestock has direct implications for rural employment and for the sectoral contribution to economic growth in agricultural regions (Vera-Toscano *et al*., 2026). Beyond on-farm production, the pig sector provides livelihoods through upstream industries (feed production, veterinary services, farm equipment) and downstream activities (slaughter, processing, distribution). The decline in herd numbers in Romania has coincided with labour outflows from rural areas and with the aging of the farming population (Ursu *et al*., 2023), creating a feedback loop in which reduced production discourages new entrants and investment in workforce development. Revitalizing the sector requires attention to labour market dynamics. In this regard, training programs for modern farm management are recommended (Manolache *et al*., 2024), incentives for generational renewal, and improved working conditions that can retain skilled labour in the sector.

The apparent environmental improvements observed in this study occurred as a consequence of production contraction, while deliberate technological or managerial interventions aimed at emissions intensity reduction were not observed. This distinction is critical for both Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) evaluations of the sector's sustainability trajectory. True environmental progress would involve reducing emissions per unit of output through technology adoption. In this respect, to achieve sustainability, improved manure management systems, precision feeding, biogas capture are recommended (Ramanauske *et al*., 2023; Štreimikienė, 2023). Similarly, production scaling and competitiveness gains depend on investments in technologies that improve feed conversion efficiency, disease surveillance, and data-driven farm management. Policy frameworks that incentivize emissions-intensity improvements without penalizing production per se are needed to align environmental objectives with food security and economic viability goals.

In line with the vision of Teodorescu *et al*. (2023), technologies that facilitate production scaling, including modular housing systems, automated feeding and climate control, genetic selection programs for disease resistance, and digital traceability platforms are critical for enabling Romanian producers to reverse the export decline observed in this study. The transition from small-scale, low-productivity operations to commercially viable farms capable of meeting retail volume and quality standards depends on access to these scaling technologies, yet investment constraints and limited technical extension services have slowed adoption in Romania's pig sector (Popescu *et al*., 2025). Reversing this trajectory demands deliberate integration of technology adoption incentives within the National Strategic Plan 2023–2027 and other national financing instruments, with co-financing rates calibrated to reduce upfront investment risk for producers while maintaining fiscal sustainability, even marginal increases in support rates can accelerate adoption when farmers actively invest in learning and implementing new management practices.

Conclusions and Recommendations

This article provides an exploration of Romania's pig meat sector and an analysis of market dynamics and environmental concerns viewed through the lens of the food security issue. The delicate balance between the country's limitations in domestic production and its reliance on imports primarily presents challenges to national economic and food security. The analysis of the Romanian pig meat market indicates critical dependencies and vulnerabilities defining the existing economic and environmental

Romanian reality. The high statistically significant relationship that exists between imports of pig meat and trade balance deficits (0.997) is consistent with Romania's strong reliance on imports to meet the growing domestic consumption need, which has increased by 4.49% on average between 2011 and 2022. This dependence suggests that any disruption in the global supply chain or shift in trade policies could have meaningful implications for the availability and pricing of pig meat in the country. Thus, underlining that securing food supplies in pig meat sector via imports, y*et al*so highlighting that Romania remains highly exposed to international market forces.

Pig meat imports are critical for Romania to secure and keep products on stores' shelves and maintain stability in the domestic markets. However, it goes against achieving an economically sustainable and self-sufficient pig meat market. Although Romanian consumers enjoy low prices through imports, the general sustainability and resilience of the country's pig meat sector are at risk. The reduced number of livestock further complicates the market situation, given the underlying supply-demand dynamics of higher prices. Further discussing the environmental implications that were highlighted in the results section of the paper, it could seem that the reduction of pig livestock numbers will benefit environmental performance due to less emission of CH_4 and N_2O attributed to the pig livestock farming sector. When, in fact, this dynamic raises concerns regarding both economic and environmental sustainability. Viewed through a sectoral-nexus lens, the environmental implications of declining pig livestock numbers in Romania extend to the logistic supply chain, which is increasingly relied upon to maintain product availability at the levels required for national food security.

The findings of this study point to a number of specific policy directions for the Romanian pig meat sector, each of which is anchored in particular empirical patterns identified in the analysis. First, the substantial contraction of the domestic pig livestock observed over the study period (I_7: end-to-start ratio of 0.62; reduction from 5.36 to 3.33 million heads between 2011 and 2022) calls for the strengthening and conditioning of post-outbreak recovery instruments. The existing African Swine Fever compensation scheme administered by the Romanian Ministry of Agriculture and Rural Development, in coordination with the National Sanitary Veterinary and Food Safety Authority, could be expanded by conditioning financial compensation on the adoption of certified biosecurity standards. Such conditionality mechanisms can be linked to improved biosecurity compliance and support maintaining commercial herd structures during African Swine Fever outbreaks. However, the strength and direction of this relationship depend on enforcement capacity and farm-level heterogeneity. Second, the magnitude of the pig meat trade balance deficit (I_6: end-to-start ratio of 2.50; absolute value of 0.87 billion USD in 2022) supports the need to prioritise financing for the pig sector within Romania's National Strategic Plan 2023–2027. Investment measures targeting medium-sized commercial farms could be supported with enhanced co-financing rates above the standard level, in recognition of the strategic role of these farms in stabilising the domestic productive base. Third, the close association between pig livestock numbers and pig livestock greenhouse gas emissions (I_7–I_{15} correlation: 0.991) indicates that the observed reduction in CH_4 and N_2O emissions is consistent with the contraction of the productive base rather than with deliberate environmental progress. This finding spotlights the importance of adapting national climate policy reporting frameworks to distinguish between efficiency-driven and contraction-driven emission reductions, thereby avoiding the misattribution of artefactual declines to deliberate policy action.

Several limitations should be acknowledged. First, the analytical design is descriptive-correlational, and therefore does not permit causal inference. Second, the single-country focus, although justified by

Romania's distinctive position as one of the most import-dependent pig-meat markets in the EU-27, constrains the direct generalisability of the findings to other national contexts. Building on this diagnostic foundation, future research could extend the analysis through econometric techniques applied to longer harmonised time series and to broader EU-wide samples, once such data become available.

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MAISTO SAUGUMAS, KONKURENCINGUMO EROZIJA IR TVARUMO ILIUZIJA: ĮŽVALGOS IŠ RUMUNIJOS KIAULININKYSTĖS SEKTORIAUS

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Santrauka. Kiaulininkystės sektorius susiduria su daugybe iššūkių dėl naujų Europos Sąjungos (ES) reikalavimų, susijusių su socialiniu, ekonominiu ir aplinkos tvarumu. Šie reikalavimai apsunkina afrikinio kiaulių maro (AKM) ir jo poveikio rinkai valdymą. Didėjant pastangoms mažinti su šia problema susijusią riziką, ūkininkams kyla vis daugiau iššūkių siekiant suderinti aplinkosaugos reikalavimų laikymąsi su ekonominiu veiklos efektyvumu. ES šalys susiduria su mažėjančiais kiaulienos gamybos pajėgumais ir didėjančia priklausomybe nuo kiaulienos importo, kadangi siekia patenkinti vidaus paklausą. Tarp visų ES valstybių narių Rumunija yra antra labiausiai nuo kiaulienos prekybos deficito nukentėjusi šalis – 2024 m. šis deficitas viršijo 1 mlrd. EUR ir buvo didžiausias tarp visų šalies žemės ūkio ir maisto produktų prekybos deficitų. Šio tyrimo tikslas – pateikti rinkos įžvalgas, kurios galėtų tapti pagrindu politikos priemonėms, skirtoms Rumunijos kiaulininkystės sektoriaus veiklos gerinimui. Todėl straipsnyje siūloma integruota aprašomoji sistema, skirta bendrai nagrinėti aprūpinimą maistu, konkurencingumą ir poveikį aplinkai Rumunijos kiaulininkystės sektoriuje 2011–2022 m. laikotarpiu. Duomenys gauti iš Rumunijos nacionalinio statistikos instituto, Tarptautinės prekybos centro ir FAOSTAT. Rezultatai atskleidė, kad Rumunijos priklausomybė nuo kiaulienos importo yra susijusi su silpnesniu vidaus gamybos potencialu naujame AKM valdymo kontekste, kuris atitinkamai veikia struktūrinį sektoriaus tvarumą. Todėl, be maisto saugos problemų, susijusių su AKM plitimu, didėja ir rizika maisto saugumui. Vis dėlto, nepaisant šių struktūrinių iššūkių, Rumunijos kiaulininkystės sektoriaus poveikis aplinkai ES mastu išlieka nedidelis.

Reikšminiai žodžiai: kiaulienos sektorius; maisto saugumas; prekybos balanso deficitas; priklausomybė nuo importo; aplinkosaugos eksternalizacijos; Rumunija.