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The Impact of the Input-Output Price Ratio on the Profitability of Hungarian Agricultural Enterprises Between 2007 and 2021

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ABSTRACT

This research focuses on the link between the input-output price ratio and agricultural profitability. Analyzing agricultural profitability is a key issue for the development of the sector, with one of its most important components being the evolution of the agricultural price index. This research presents an analysis of the agricultural price ratio in the recent period, with a focus on the correlations between production direction and profits. The study analyses Hungarian agricultural enterprises on the basis of the agricultural price indices of the Hungarian Central Statistical Office (HCSO) and uses data from the agricultural price index and the agricultural database of the Test Farm Information System operated by the Agricultural Economics Research Institute. The analysis works with statistically validated data from 2007 to 2021. Based on our results, changes in input-output prices are a good predictor of the profitability rate of farmers in the current and future years. This provides an opportunity to optimally allocate agricultural subsidies and to strengthen the loss-compensation effect.
Keywords: prices, agricultural profitability, subsidy
JEL codes: Z29

INTRODUCTION

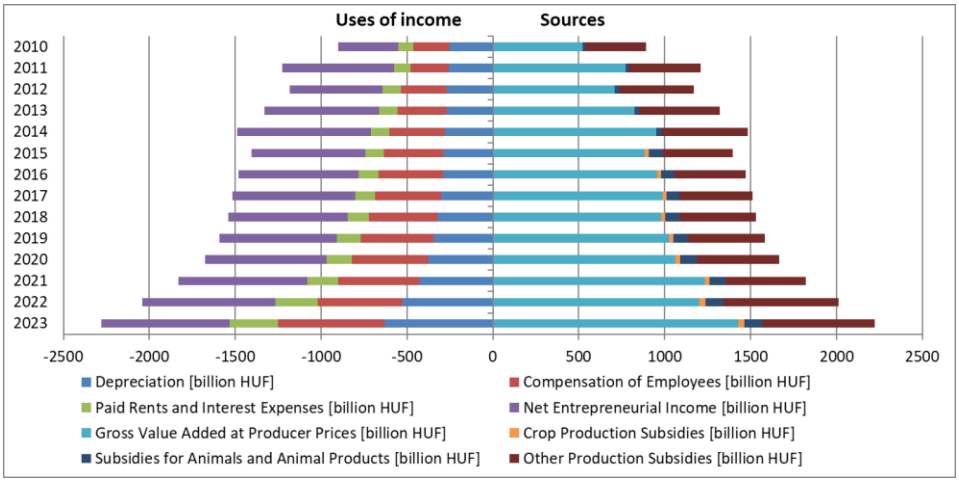
The profitability of agriculture is influenced by a multitude of factors. Empirical evidence highlights that climate change, fluctuations in oil prices, the liberalization of trade and of international financial markets, the conversion of food commodities into biofuels, and the escalation of global risks amplify food price volatility, thereby impacting farmers' profitability (*Wheeler & Braun*, 2013; *Zmami & Ben-Salha*, 2023; *Chen et al.*, 2020; *Frimpong et al.*, 2021; *Szerb et al.*, 2022). Additionally, geopolitical risks significantly affect both prices and profitability (*Hudecová et al.*, 2023; *Perekhozhuk & Glauben*, 2017).

Following Hungary's accession to the European Union, the share of product-based subsidies steadily declined, whereas the proportion of non-product-based subsidies progressively increased. Subsidies are directly linked to changes in entrepreneurial income, with their share in agricultural entrepreneurs' income

showing a marked increase. However, fluctuations in income are also significantly driven by production variability, largely attributed to weather conditions.

In terms of income composition, gross value added does not cover depreciation, employee compensation, rental payments, and interest expenses. Net entrepreneurial income is derived almost exclusively from subsidies (*Figure 1*), leading to the conclusion that, without subsidies, agriculture would be unsustainable.

Figure 1: Sources and uses of income 2010-2020 (billion HUF)



Source: Based on *HCSO* (2020, 2023) data

The development of agricultural digitization, the rise of precision farming, the asymmetry between producers and buyers, and the extent of market concentration also play critical roles in shaping agricultural price dynamics (*Milics et al.*, 2021). Due to sticky prices, price variations in this sector demand particular attention.

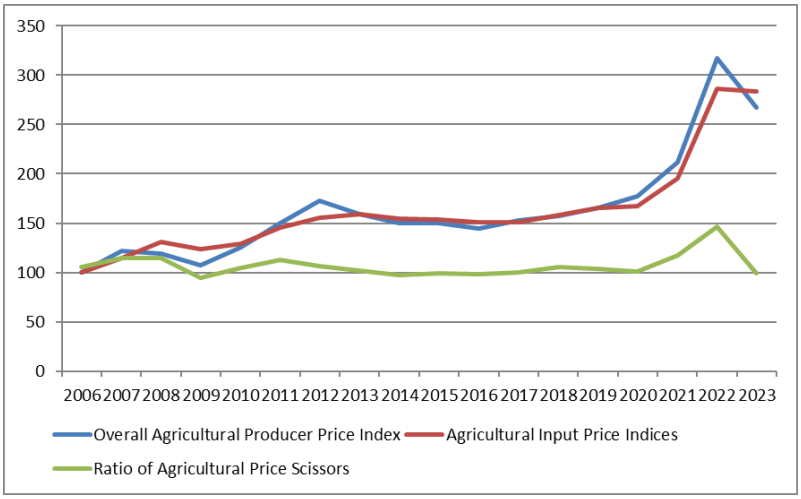
On the supply side, increasing emphasis is placed on understanding and managing the impact of input prices – especially energy, feed, and agricultural raw material costs. These commodities are crucial for profitability, as shown in our results. It is also important to note that fluctuations in international oil prices and exchange rates influence both input and output prices (*Gardebroek et al.*, 2016; *Sensoy et al.*, 2015; *Chen et al.*, 2014; *Koirala et al.*, 2015; *Rafiq & Bloch*, 2016; *Zhang et al.*, 2015; *Pourroy et al.*, 2016), thereby indirectly affecting agricultural profitability through pricing mechanisms.

An additional reason for closely monitoring agricultural raw material prices closely is their pivotal role in the production process. Consequently, any increase in their costs may contribute to inflationary pressure (*Esposti & Listorti*, 2013; *Bakucs et al.*, 2014). Most agricultural raw materials exhibit low price elasticity of demand, meaning that even small changes in demand can lead to significant price fluctuations (*Moses et al.*, 2019). Price volatility represents a substantial risk within the agricultural sector, as profit margins in many production areas remain close to break-even, leaving little room for error (*Bareith & Csonka*, 2022).

This study aims to explore how input costs and output prices influence agricultural profitability, focusing on changes in product prices and agricultural inputs. The agricultural terms of trade (or price ratio) are defined as the index of agricultural producer prices divided by the price index of inputs used in agriculture.

The output price index of agricultural products reflects price fluctuations paid to producers for goods intended for resale or processing**,** as well as for those sold directly to households. However, it does not include price changes of breeding animals traded between farmers. These indices are calculated using the Laspeyres formula, with weights based on the value ratio of sales outside the agricultural sector. The domestic trajectory of the agricultural price index is shown in *Figure 2*.

Figure 2: Agricultural Prices in Hungary, 2007–2023 (Percentage, 2006 = 100)



Source: *HCSO*, 2024

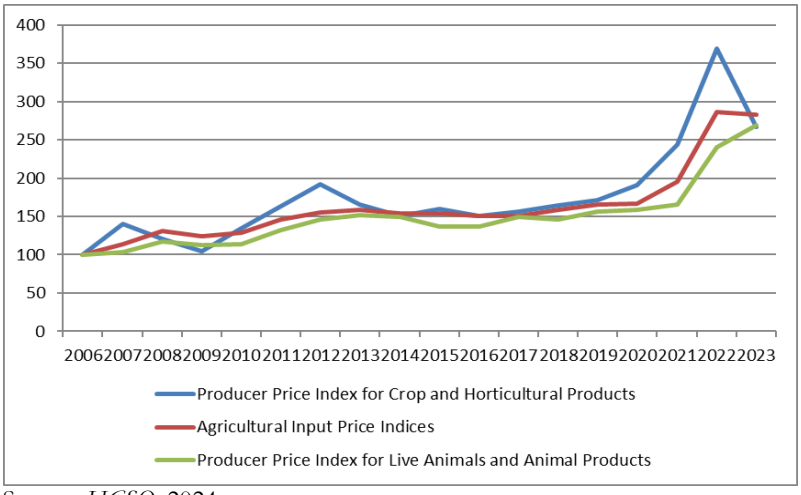
Figure 2 may be somewhat misleading, as it suggests a fixed agricultural price ratio (terms of trade) in 2006. In reality, the terms of trade in agriculture have remained persistently open over an extended period, with only occasional counter-trends before 2006, as input prices (costs) tended to grow faster than output (sales) prices. Nevertheless, the analyzed period – excluding 2008 and 2009 – was generally favorable for Hungarian producers, as no further deterioration in the price ratio occurred.

Subsequently, the output price index of agricultural products is disaggregated (*Figure 3*). Aggregate analysis obscures important differences between crop production and livestock farming. Therefore, it is necessary to examine input-output price ratio trends across production sectors separately.

The agricultural producer price index is divided into two components: the „Crop and Horticultural Producer Price Index" – covering cereals, industrial crops, vegetables, and fruits-– and the "Producer Price Index for Livestock and Animal Products." *Figure 3* clearly illustrates the dynamic and favorable trend in crop and

horticultural product prices. Over the examined period, the growth rate of industrial product prices used in agricultural production was slower than the growth in crop sales prices.

Figure 3: Development of Agricultural Prices by Production Sector in Hungary, 2007–2023 (Percentage, 2006 = 100)



Source: *HCSO*, 2024

Conversely, producer prices for livestock and animal products increased more modestly compared to the rise in agricultural input prices. This creates a mixed scenario in which certain Hungarian farmers, particularly in livestock, are disadvantaged by the input-output price ratio, while crop producers may benefit from its favorable evolution. Consequently, it is essential to assess these divergent impacts across sectors more thoroughly.

MATERIALS AND METHODS

The methodological framework of this study was designed to explore the relationship between agricultural profitability and the input-output price ratio across crop and livestock sectors. The chosen time frame (2007–2021) ensures the use of statistically validated data, minimizing the distortions caused by provisional figures or short-term anomalies.

To capture sector-specific dynamics, agricultural profitability was proxied using Return on Equity (ROE) derived from the Test Farm Information System (FADN/AKI), while price dynamics were assessed using disaggregated agricultural price indices published by the Hungarian Central Statistical Office (HCSO). The input-output price ratio was operationalized by dividing the output price index (for crops or animal products) by the corresponding agricultural input price index. This ratio reflects the terms of trade faced by producers and is a widely accepted indicator in agricultural economics.

Regression analysis was employed to quantify the strength and direction of the relationship between annual changes in the input-output price ratio and sectoral profitability. A linear regression model was selected for its interpretability and robustness in identifying general trends over time. In the case of crop production, profitability was lagged by one year to reflect the delayed impact of pricing on financial outcomes due to storage, delayed sales, and seasonality. For livestock sectors, same-year profitability was modeled, capturing the relatively immediate responsiveness of these enterprises.

The regression outputs indicate varying degrees of explanatory power across sectors:

Crop production showed the strongest correlation, with an R^2 of 0.6752, indicating that nearly 68% of the variability in profitability can be explained by changes in the price ratio ($p < 0.001$).

Pig farming revealed a moderate relationship ($R^2 = 0.5144$), also statistically significant ($p < 0.01$).

Dairy farming exhibited a weaker but still meaningful correlation ($R^2 = 0.3349$), significant at the 5% level ($p \approx 0.024$).

These models are relevant because they highlight the predictive utility of input-output price ratios for anticipating sectoral performance. However, they do not claim causality and must be interpreted within the context of broader market and policy variables. The regression coefficients suggest practical implications: for example, a one-unit improvement in the crop price ratio corresponds to a measurable increase in ROE the following year.

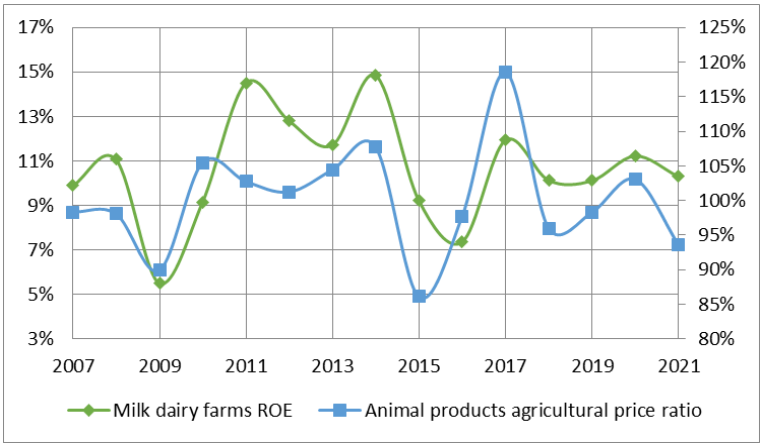
While the models simplify the complexity of agricultural systems, they serve as valuable tools for both policymakers and producers by enabling early detection of profitability trends and better-informed subsidy allocation strategies.

RESULTS AND DISCUSSION

One sector where a high correlation was observed between the sectoral price index for animal products (milk) and profitability is the dairy cow sector (*Figure 4*). Between 2010 and 2014, milk prices experienced consistent growth due to rising global demand. However, in 2015, milk prices dropped by 20%, while the agricultural input price indices remained relatively stable (*HCSO*, 2020). As a result, the return on equity for producers fell from 15% to 7–9% during 2015 and the subsequent year.

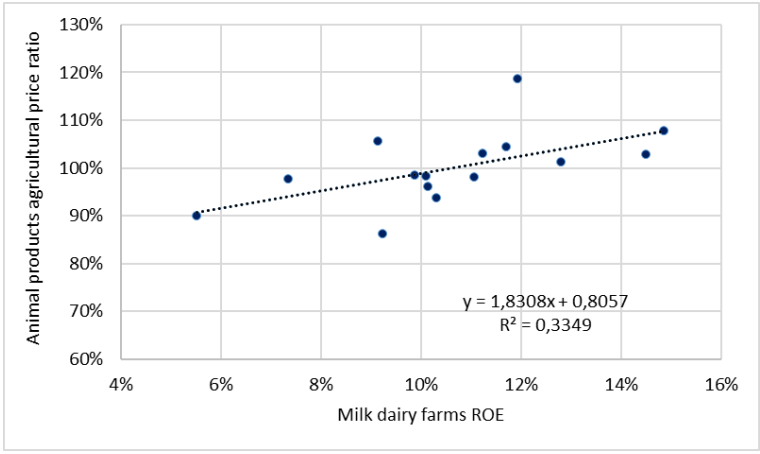
Figure 5 graphically represents the vertical axis for input-output price ratios and the horizontal axis for profitability, with the data points corresponding to individual years. In this context, the emphasis lies not on time series trends but on the relationship between the two variables. A linear relationship between profitability and input-output price ratios can be observed. Cases of positive correlation exhibit an upward linear trendline. Specifically, in the dairy sector, a moderate positive relationship exists between annual changes in the agricultural input-output price ratio and profitability within a given year. This effect is visually represented in the linear regression line and its formula in *Figure 5* (regression table in *Annex 1*).

Figure 4: Return on Equity of dairy cow sector (ROE, left axis in %) and trend in the agricultural price index on animal products (right axis in %, base=previous year) of domestic dairy farms in Hungary 2007-2021



Source: Based on data from *HCSO*(2024) and *AKI*(2024)

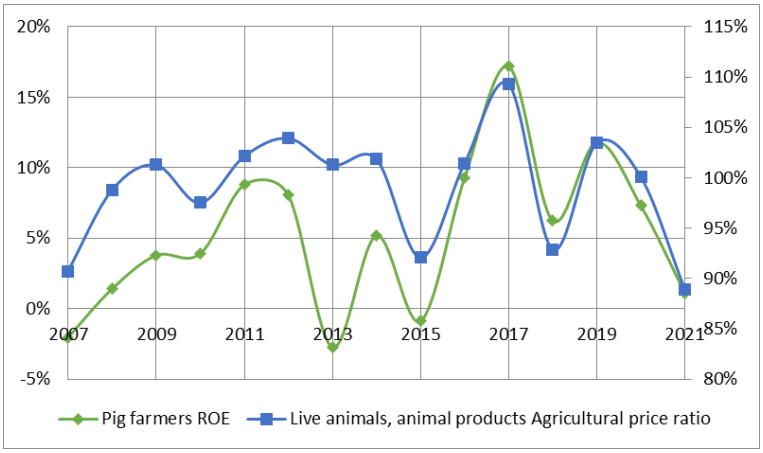
Figure 5: Regression: Return on Equity (ROE, left axis, %) of dairy cow sector, and the Animal products agricultural price ratio (right axis, %, base = previous year), 2007–2021.



Source: Based on data from *HCSO*(2024) and *AKI*(2024)

The profitability of pork enterprises is also positively related to the agricultural price shows a moderately strong positive relationship**.** For example, in the pig line of production, the producer price of domestically produced slaughter pigs was six and a half percent lower in 2015 than in 2014. At the same time, the average profitability of enterprises in this production direction fell from 4% to below 0% in 2015.

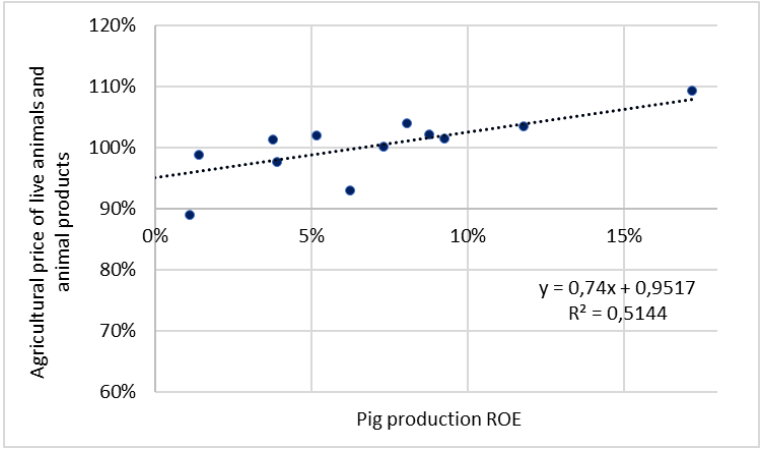
Figure 6: Return on Equity of pig production (ROE, left axis in %) and trend in the Live animals agricultural price ratio (right axis in %, base=previous year) in Hungary 2007- 2021



Source: Based on data from *HCSO*(2024) and *AKI*(2024)

This effect can be seen from the linear regression line in *Figure 7* and its formula in *Annex 2*.

Figure 7: Regression: Return on Equity (ROE, left axis, %) of pig production sector, and the Animal products agricultural price ratio (right axis, %, base = previous year), 2007–2021



Source: Based on data from *HCSO*(2024) and *AKI*(2024)

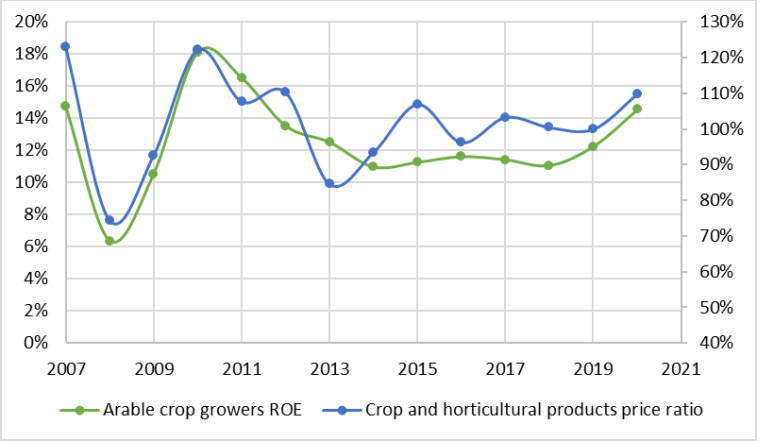
(See exact interpretation on coefficients of the linear formula, significance level of the model and confidence interval in *Annex 2*) For livestock farmers, a stronger positive correlation was found between annual changes in the agricultural input-output price ratio and profitability within a given year. This correlation indicates that

improvements in price ratios are closely tied to profitability. Conversely, when input costs rise more rapidly than output prices, this is strongly associated with a decline in profitability.

For crop farms, the relationship appears with a time lag compared to livestock farms due to factors like drying periods, storage, and futures price agreements. Therefore, sectoral price indices were compared with profitability in the following year.

For instance, in field crop production, a strong positive correlation exists between changes in the agricultural input-output price ratio and the profitability in the subsequent year.

Figure 8: Return on Equity of Crop Production farms (ROE, left axis in %) and trend in the Agricultural Crop and Horticultural Products price ratio (right axis in %, base=previous year) in Hungary 2007- 2021



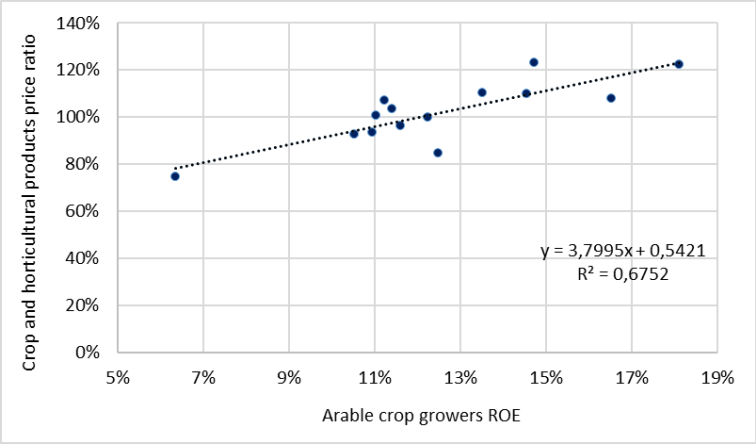
Source: Based on data from *HCSO*(2024) and *AKI*(2024)

Figures 8 reveal that declining price ratios in 2008 and 2013 negatively impacted profitability in subsequent years. Changes in input-output prices effectively forecast farmers' profitability rates in the current and following years.

Figures 9 illustrate the strong positive relationship between the input-output price ratio for crop and horticultural products and the return on equity (ROE) of crop farms in the following year. The regression analysis in *Annex 3* confirms this relationship with a high explanatory power ($R^2 = 0.6752$) and strong statistical significance ($p < 0.001$). This indicates that nearly 68% of the variability in profitability can be explained by changes in the price ratio, underlining its predictive value for crop sector performance. The study demonstrates that the input-output price ratio is a significant determinant of profitability in Hungarian agriculture. The analysis revealed that while crop producers generally benefited from favorable price trends, livestock farmers were more vulnerable to adverse input-output price dynamics. The findings show a strong correlation between profitability and changes in agricultural price ratios, particularly in crop farming with a one-year delay, and

more immediately in livestock sectors such as dairy and pig farming. These findings underline the need for sector-specific support mechanisms that consider the differing sensitivities to price changes. Furthermore, the continued reliance on subsidies highlights the structural fragility of the agricultural sector. In light of global challenges such as climate change and geopolitical instability, the incorporation of price ratio forecasts into agricultural policy and subsidy planning is not only advisable but essential for long-term sustainability and resilience.

Figure 9: Return on Equity (ROE, horizontal axis, %) of Crop Production farms and Agricultural Crop and Horticultural Products price ratio (vertical axis, %, base = previous year), by Year.



Source: Based on data from *HCSO*(2024) and *AKI*(2024)

The Hungarian findings align with broader international research that highlights the critical role of price transmission and input-output price dynamics in shaping agricultural profitability. Several European-level studies, such as those by *Bakucs et al.* (2014), have examined how market structures and policy environments influence the degree and speed of price transmission across the agro-food chain. In line with our results, these studies suggest that producers in less integrated or less competitive markets – such as Hungary and several neighboring Central and Eastern European (CEE) countries – often face weaker bargaining positions, particularly in livestock sectors, where price transmission is more asymmetric and delayed. Moreover, *Esposti and Listorti* (2013) emphasize that during periods of market volatility, price signals become distorted, leading to greater uncertainty and reduced profitability, a trend observed in our livestock sector analysis as well.

Compared to Western European economies with more diversified farm structures and risk mitigation tools, CEE countries are generally more vulnerable to unfavorable price movements due to their higher reliance on subsidies and input cost sensitivity. By empirically confirming a strong correlation between price ratios and profitability, especially in crop production with delayed effects, our study contributes to a growing

body of evidence underscoring the importance of responsive policy frameworks – such as early warning systems and flexible subsidy schemes – across the EU.

CONCLUSIONS

The variation in correlation strength and timing across agricultural sectors can be attributed to both biological production constraints and structural market characteristics. Livestock producers typically respond more rapidly to changes in input-output price ratios due to shorter production cycles, especially in pig and poultry farming. Moreover, the perishable nature of animal products and higher working capital intensity prompt quicker economic responses. Market structure also plays a role: contract farming, vertically integrated supply chains, and cooperative arrangements can either buffer or amplify producers' exposure to price fluctuations. These mechanisms are more prevalent in the livestock sector, enabling more direct and rapid transmission of price signals.

In contrast, crop producers often experience a lagged profitability effect due to seasonal production cycles, storage capacity, and the use of futures contracts which decouple current market prices from immediate financial outcomes. This delayed response, reflected in our one-year shift analysis, supports the idea that price ratio changes are still predictive but unfold over a longer horizon in arable farming.

While our findings demonstrate statistically significant relationships, it is important to acknowledge external confounding variables that may influence profitability independently of price dynamics. Weather anomalies, particularly droughts and floods, significantly impact yields and input efficiency. Geopolitical events – such as regional conflicts or trade restrictions – can disrupt supply chains and cause sharp commodity price volatility. Additionally, currency fluctuations affect both input costs (often denominated in euros or USD) and export competitiveness. These factors, while beyond the scope of the current model, represent important areas for future research and underline the need for multifactorial risk assessment in agricultural economic forecasting. While the study provides valuable insights into the relationship between input-output price ratios and agricultural profitability, it is not without limitations. First, the analysis is based on aggregated national data and does not account for farm-level heterogeneity or regional differences in production conditions, cost structures, and market access. Second, external shocks such as climate anomalies or policy changes are not directly modeled, despite their potential to distort price and profitability relationships.

Despite these limitations, the research makes a significant contribution to the current body of knowledge by quantifying the predictive relationship between agricultural price ratios and profitability in a Central European context. It highlights the sector-specific effects of price dynamics and offers a data-driven foundation for designing more responsive and targeted agricultural support policies. By emphasizing the delayed effect in crop production and the immediate response in livestock sectors, the study provides practical insights for policymakers aiming to improve income stability in agriculture.

The lessons of our publication suggest that the agrarian input-output price ratio should be understood from a broader perspective. The findings of this study indicate that the agricultural input-output price ratio significantly influences sector profitability. While aggregate agricultural price ratios for the entire sector showed positive trends over the past decade for crop farmers, the livestock sectors experienced substantial negative impacts due to agricultural price trends.

It is crucial to note that, without government support, the profitability of the agricultural sector remains modest compared to other economic sectors. The continuous rise in costs poses a significant challenge to Hungarian agriculture, further exacerbated by climate change and global conflicts.

Given the strong correlation identified between agricultural prices and the profitability of the agricultural economy, it is recommended that predictive changes in input-output prices be utilized when designing support systems for the sector**,** based on Hungarian agricultural data.

Annex 1

Regression: Return on Equity of dairy cow sector, and the Animal products agricultural price ratio, 2007–2021

Regression Statistics	
Multiple R	0,5787
R Square	0,3349
Adjusted R Square	0,2837
Standard Error	0,0653
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,0279	0,0279	6,5461	0,0238
Residual	13	0,0555	0,0043		
Total	14	0,0834			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0,8057	0,0781	10,3163	0,0000	0,6370	0,9744	0,6370	0,9744
Milk dairy farms ROE	1,8308	0,7156	2,5585	0,0238	0,2849	3,3767	0,2849	3,3767

Annex 2

Regression: Return on Equity of pig production and Live animals agricultural price ratio, 2007–2021

Regression Statistics	
Multiple R	0,7172
R Square	0,5144
Adjusted R Square	0,4770
Standard Error	0,0407
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,0228	0,0228	13,769	0,0026
Residual	13	0,0216	0,0017		
Total	14	0,0444			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0,9517	0,0148	64,2846	0,0000	0,9197	0,9837	0,9197	0,9837
Pig farmers ROE	0,7400	0,1994	3,7108	0,0026	0,3092	1,1708	0,3092	1,1708

Annex 3

Regression: Return on Equity of Crop Production farms and Agricultural Crop and horticultural Products price ratio (base = previous year), 2007–2021

Regression Statistics	
Multiple R	0,8217
R Square	0,6752
Adjusted R Square	0,6481
Standard Error	0,0171
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,0073	0,0073	24,944	0,0003
Residual	12	0,0035	0,0003		
Total	13	0,0108			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0,0556	0,0365	-1,5239	0,1534	-0,1352	0,0239	-0,1352	0,0239
Crop and horticultural products price ratio	0,1777	0,0356	4,9944	0,0003	0,1002	0,2552	0,1002	0,2552

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