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Increasing or Decreasing Scale? The Pros and Cons of Farm Size for Financial Sustainability

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Abstract

The article focuses on the question of optimal farm size in the context of contemporary agricultural challenges such as rapid population growth, climate change, and limited natural resources. The analysis shows that farm economic size can have a significant impact on financial performance indicators including productivity, profitability, liquidity, solvency, and sustainability. The article provides a detailed overview of the pros and cons of different farm economic sizes and their impact on financial sustainability, drawing on academic literature, available data, and statistical methods. The results indicate that larger farms have lower factor productivity but higher solvency. Smaller farms on the other hand have higher profitability and productivity. Medium-sized farms are characterized by high liquidity and financial autonomy.

Keywords

Economic size, farms, financial sustainability .

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Introduction

In the contemporary context of increasing demands on agriculture and ensuring food security, the task of achieving efficient and sustainable production arises. This task necessitates comprehensive debates and research. In light of these challenges, the question of the optimal scale for farms emerges, attracting attention and prompting profound reflections on the interconnection between farm size and financial sustainability.

Modern agricultural challenges – such as rapid population growth, climate change, and limited natural resources – require new approaches to food production. In this new context, farm size emerges as a key factor influencing both the efficiency of production processes and the sustainability of agricultural systems. Striving for an optimal farm size represents a delicate balance between economic benefits and environmental protection, while the social aspect of agriculture must not be neglected either.

In academic literature and in the practice of agricultural entrepreneurs, a clear duality in approaches to farm size stands out. Some strive for large-scale expansion by investing in new technologies and methods to increase productivity and dominate the market. Others focus on sustainability and responsible resource-efficient production, preferring smaller scales and emphasizing measures like diversification, organic farming, or biodiversity restoration. These diverse approaches necessitate discussions regarding the impact of farm size on business efficiency, income, competitiveness, and sustainability.

In this context, the purpose of this article is to provide a thorough and analytical overview of the pros and cons of different economic sizes of farms, focusing on their financial sustainability. Through analysis of academic literature, available data, and various statistical methods, the article establishes the basis for more detailed research on the impact of farm size on several key factors, including productivity, profitability, liquidity, solvency, and sustainability of agricultural activities.

By conducting this analysis, the article seeks to contribute to resolving this important issue by providing a new perspective and additional dimensions to the debate. The expected outcome of the study is to create a foundation for a detailed comparison between different approaches to farm size and their impact on financial sustainability.

Such a comparison can serve as a valuable tool for informed decision-making by agricultural entrepreneurs, investors, policymakers, and all stakeholders whose activities are related to the development of agriculture.

Farm size can be a key factor when it comes to financial sustainability. However, there is no consensus in the literature on whether larger farms are more financially sustainable or vice versa.

The concept of economies of scale is related to the idea that increasing production will lead to decreasing costs of producing a unit of output (Teece, 1980). Multiple studies (Duffy, 2009; Kim, 2012; Roest, 2018; Bojnec and Fertő, 2021) have indicated that larger farms can achieve economies of scale, meaning lower average costs per unit of output. Błażejczyk-Majka et al. (2012) examined the influence of farm size in EU countries and concluded that the highest efficiency is achieved by the largest farms, though this is more pronounced in economically more developed countries.

Large farmers are more likely to adopt innovative methods, invest more resources and efforts in acquiring agricultural knowledge, and focus more on production methods rather than processing technologies (Mignouna, 2011; Hu, 2022). According to Bielik and Rajčániová (2004), farm size has a significant influence on the efficiency of land use as a key production factor.

Ren et al. (2019) found that increasing farm size has a positive impact on farmers' net profits, as well as on economic, technical and labor efficiency. At the same time, increasing farm size was associated with a statistically significant decrease in the use of fertilizers and pesticides per hectare, demonstrating clear environmental benefits. The net profit margin of farms increases with economic size, but it is unclear how long this increase continues (Celik and Emre, 2014).

Large farms have greater resources and capacity to introduce new technologies like automation, remote monitoring, precision agriculture, using drones for crop monitoring, and other such innovations. These can improve productivity, reduce costs, and increase revenues (Čechura et al., 2022).

Some studies (Henderson, 2014; Helfand et al., 2015; Sheng et al., 2019; Muyanga and Jayne, 2019) find a negative relationship between farm size and productivity in developing country agriculture, which they mainly attribute to imperfections in labor markets. Assunção and Ghatak (2003) relate the inverse farm size-productivity relationship to differences in farmers' abilities.

Rada and Fuglie (2019) examined the relationship between farm size and productivity across several countries (poor and rich) and found that in economically lagging countries, smaller farms have a productivity advantage. However, with economic and market growth this advantage diminishes, shifting to constant and subsequently increasing returns to size.

Bojnec and Latruffe (2013) found that small farms are less technically efficient but more allocatively efficient and profitable. They state that medium-sized farms accumulate all the disadvantages in terms of productivity: they are too small to be economically efficient but too large to be profitable. According to Galluzzo (2022), farm economic size does not constrain technical efficiency. In fact, small farms are technically more efficient than large farms in terms of economic size. This suggests a more efficient resource allocation in small farms.

Larger farms may be more vulnerable in crises because they have larger volumes of fixed costs. A study found that small farms cope better in economic downturn phases (Czyzewski and Majchrzak, 2017).

Small farms are often more flexible and can respond quickly to changes in the market environment (Akimowicz et al., 2013; Brenes-Muñoz et al., 2016). Bakucs et al. (2013) examined the relationship between farm size and growth in France, Hungary and Slovenia, providing evidence that smaller farms grew faster than larger ones over the studied period (2001-2008) in all three countries.

Farms of relatively modest size may achieve much of the potential cost savings related to size. Hall and Le Veen, (1978), examining different sources of efficiency, argue that factors other than labor-saving technology can make important contributions to economic efficiency. Small farms have advantages over medium-sized ones regarding access to land, natural resources, human resources, raw materials, and equipment. However, many competitiveness indicators for small farms are below industry standards (Bachev, 2023).

Small farms cannot afford significant investments. They can compensate through improvements in scale and technical efficiencies. This may mean optimizing the use of proper tillage techniques, better water management, or improved pest and disease control. Using these techniques can help small farmers offset the lack of new technologies or large scale.

Small farms protect the rural environment from the socio-economic marginalization of rural areas and reduce rural depopulation (Galluzzo, 2016). Small farms developing their own agribusiness also develop their rural areas and territorial communities, partially solving the unemployment problem (Manolova end Penov, 2014; Gorikhovskyi, 2017). Their long-term viability may be critical for the global competitiveness of European agriculture (Kryszak et al., 2021).

Small farms sometimes find it difficult to access large markets or price premiums and may encounter problems trying to obtain credits (Buckwell and Davidova, 1993; Kusek et al., 2017). Some researchers (Collier and Dercon, 2014; Adamopoulos and Restuccia, 2014; Otsuka et al., 2016) suggest that the presence of numerous smallholdings may hamper agricultural growth and competitiveness in the long run.

The main research questions that this study focuses on are:

1. To what extent does the economic size of agricultural holdings correlate with key financial indicators such as profitability, productivity, liquidity and solvency?
2. How does the financial efficiency of agricultural holdings vary depending on their economic size? In which economic size classes do holdings have the highest or lowest profitability, liquidity and solvency?
3. What is the relationship between the scale of the agricultural holding and the risk of financial instability? How does the scale of the holding affect its resilience to external economic and financial shocks?

The aim of this study is to identify whether and how the economic size of agricultural holdings correlates with their financial sustainability, stability and ability to cope with financial challenges. Based on the established correlations and dependencies, the optimal farm sizes for achieving maximum financial efficiency and sustainability will be determined.

Materials and methods

A literature review is conducted, focusing on publications from highly-regarded, peer-reviewed journals and extracted from academic databases such as Scopus and Web of Science, to provide comprehensive information on the research topic. Key insights from the literature facilitate understanding of the discussed issue.

The study utilises annual financial and production data at the individual farm level from the Agricultural Accountancy Data Network (AADN) of the Ministry of Agriculture and Food of Bulgaria for the period 2014-2020. The AADN data are selected due to their representativeness for the sector, granularity at individual farm level, and availability of data for a series of years. The annual data allow tracing the dynamics in financial indicators for different farm categories. Six categories of economic size of holdings are analysed: below 8 thousand euros, 8-25 thousand euros, 25-50 thousand euros, 50-100 thousand euros, 100-500 thousand euros and above 500 thousand euros. The economic size is measured in euros and represents the total standard output. The annual representative samples of the AADN vary from 2,229 to 2,272 number of agricultural holdings for the individual years.

The study analyses the relationship between the economic size of holdings and their financial indicators through three methodologies: correlation analysis, multinomial logistic regression and decision tree modelling. The combination of linear, categorical and non-linear modelling provides in-depth and multifaceted insights into the research question. The consistent application of multiple methods also validates and cross-verifies the findings from different statistical perspectives.

The financial indicators examined in this study are key metrics that help assess the financial health of the farm:

1. Current Ratio: This ratio measures the farm's ability to cover its short-term liabilities with available assets. It is important for ensuring solvency in case of unexpected expenses or difficulties;
2. Financial Autonomy Ratio (Equity Ratio): This indicator shows how much of the farm's assets are financed through equity. A higher ratio indicates less reliance on external debt and greater stability;
3. Debt Ratio (Leverage): This ratio measures the share of debt in the farm's total financing structure. Higher leverage can increase financial risk due to larger liabilities to creditors.
4. Profitability Ratio (Return on Assets): This metric reflects the farm's ability to generate profits relative to invested capital. Higher profitability indicates more efficient use of resources;

5. Factor Productivity Ratio: This ratio compares the farm's output to the sum of labour and capital costs. A higher ratio means better utilisation of resources;
6. Solvency Ratio: This ratio assesses the farm's ability to meet its current obligations (e.g. payments to suppliers) with its current assets. A higher ratio indicates financial stability.

The correlation analysis determined the linear relationship between farm size and different financial indicators using the Pearson coefficient. Analysis of variance (ANOVA) is applied to study differences in financial indicators according to farm size.

The multinomial logistic regression investigates the relationship between financial indicators and the economic size of holdings, categorised into six groups. The regression model identifies statistically significant differences between financial indicators and farm size categories, providing logarithmic (or log-odds) coefficients for interpretation.

The decision tree modelling analyses whether financial indicators can predict farm size, regardless of time characteristics. Using the Classification and Regression Trees (CRT) method, we are able to build a tree-based structure reflecting the interactions between financial indicators and their influence on agricultural producers. Each node in the tree is a decision based on a given indicator, while the leaves represent the producer's category. The use of cross-validation enhances the reliability of the model, ensuring it is not overfitted and provides good generalisation. After applying CRT, key indicators that most effectively predict farm size can be identified. The visual representation of the tree allows observing the hierarchy of interactions and the significance of each variable.

Results and discussion

Correlation analysis and ANOVA of financial ratios by farm size

A correlation analysis is conducted to assess the relationship between farm size and key financial indicators. The financial indicators considered are current ratio, financial ratio, debt ratio, return on assets, factor productivity ratio, and solvency ratio. Farm size is categorised into 6 groups based on annual revenue. Pearson correlation coefficients are computed between farm size and each financial indicator over a 7-year period from 2014-2020 (Table 1).

The correlation analysis reveals weak to moderate correlations between farm size and financial ratios. The strongest correlation is a moderate negative correlation between farm size and factor productivity ratio ($r = -0.42$, $p < 0.05$), indicating that larger farms tend to have lower productivity coefficients. Smaller negative correlations are observed between farm size and return on assets ($r = -0.28$, $p < 0.05$) and debt ratio ($r = -0.21$, $p < 0.05$). No statistically significant correlations are found between the economic size of the agricultural holding and current liquidity, financial autonomy or solvency.

An analysis of variance (ANOVA) is also conducted to compare financial indicators across farm size categories. ANOVA finds significant differences between size categories for factor productivity ratio ($F = 9.62$, $p < 0.001$), return on assets ($F = 4.17$, $p < 0.01$) and debt ratio ($F = 3.24$, $p < 0.05$). Post-hoc Tukey tests reveal that agricultural holdings with an economic size over 500 thousand euros have significantly lower productivity coefficients than all other size categories. As for return on assets, medium-sized farms (25-100 thousand euros) have lower profitability than smaller farms. The results show that financial performance on some metrics varies depending on farm size.

Financial indicator	Correlation with farm size	ANOVA results	Significant difference between groups
Current ratio	r = -0.13, p = 0.24	F = 1.28, p = 0.27	No
Financial autonomy ratio	r = -0.19, p = 0.12	F = 2.05, p = 0.07	No
Debt ratio	r = -0.21, p < 0.05	F = 3.24, p < 0.05	Yes
Profitability ratio	r = -0.28, p < 0.05	F = 4.17, p < 0.01	Yes
Factor productivity ratio	r = -0.42, p < 0.01	F = 9.62, p < 0.001	Yes
Solvency ratio	r = -0.16, p = 0.18	F = 1.47, p = 0.20	No

Source: Own calculations based on Agricultural Accounting Information System data

Table 1: Correlation and ANOVA results for relationship between financial indicators and farm size.

Multinomial logistic regression to assess relationship between financial ratios and farm economic size

Multinomial logistic regression is applied to analyse the relationship between financial ratios and farm economic size over the period 2014-2020. The dependent variable, representing farm economic size, has 6 categories: up to 8 thousand euros; 8 to 25 thousand euros; 25 to 50 thousand euros; 50 to 100 thousand euros; 100 to 500 thousand euros; and over 500 thousand euros. The independent variables include the ratios for current liquidity, financial autonomy, debt, profitability, factor productivity, and solvency. The category of the smallest agricultural producers – up to 8 thousand euros – is chosen as the reference.

The regression results (Table 2) can be interpreted as follows:

The Intercept for agricultural holdings with an economic size of 50-100 thousand euros is 1.52. Applying the exponential function (e^x) gives us exp (1.52) ≈ 4.57. This is the odds ratio between holdings of size 50-100 thousand euros and those up to 8 thousand euros with other variables fixed or controlled. In other words, with other variables held constant, holdings in the "50-100 thousand euros" category have 4.57 times higher odds of being in that category compared to the base category of "up to 8 thousand euros".

The debt ratio coefficient for agricultural holdings of size 50-100 thousand euros is 0.27. Applying the exponential function gives us exp (0.27) ≈ 1.31. This means that for every one unit increase in the debt ratio, the odds of a holding belonging to the "50-100 thousand euros" category are 1.31 times greater compared to the base category, with all other variables held constant. This suggests larger holdings are more likely to have higher debt.

The return on assets coefficient for agricultural holdings of size 50-100 thousand euros is -0.91. The applied exponential function gives exp (-0.91) ≈ 0.40. This indicates that for every one unit increase in profitability, the odds of a holding belonging to the "50-100 thousand euros" category are 0.40 times (or 60% lower) relative to the base category, with other variables held constant. This may imply larger holdings can have lower profitability compared to smaller ones.

The multinomial regression approach provides insight into the variations in the financial profile of agricultural enterprises of different sizes (Table 3).

Farm size category	Intercept	Current ratio	Financial autonomy ratio	Debt ratio	Profitability ratio	Factor productivity ratio	Solvency ratio
up 8 thousand euros	0	0	0	0	0	0	0
8-25 thousand euros	0.34	-0.04	-0.01	-0.03	0.02	0.12	0.34
25-50 thousand euros	0.74	-0.02	0.01	0.11	-0.06	-0.19	0.74
50-100 thousand euros	1.52	-0.16	-0.07	0.27	-0.32	-0.02	1.52
100-500 thousand euros	2.08	-0.20	-0.11	0.39	-0.73	-0.20	2.08
over 500 thousand euros	2.73	-0.23	-0.13	0.43	-0.91	-0.23	2.73

Source: Own calculations based on Agricultural Accounting Information System data

Table 2: Multinomial logistic regression coefficients for predicting farm size category based on financial indicators.

Farm Size Category	Key Financial Ratios	Interpretation
up 8 thousand euros (reference)	-	-
8-25 thousand euros	Lower Factor Productivity Ratio: Higher Solvency Ratio	Smaller farms have a slightly lower productivity ratio and a higher solvency ratio.
25-50 thousand euros	Higher Debt Ratio; Higher Profitability Ratio; Lower Factor Productivity Ratio; Lower Solvency Ratio	Mid-sized farms have a slightly higher debt ratio, a higher profitability ratio, a slightly lower productivity ratio, and a slightly lower solvency ratio.
50-100 thousand euros	Higher Debt Ratio; Higher Profitability Ratio; Lower Factor Productivity Ratio; Lower Equity Ratio	Larger farms have a higher debt ratio, a higher profitability ratio, a lower productivity ratio, and a lower equity ratio.
100-500 thousand euros	Higher Debt Ratio; Higher Profitability Ratio; Lower Factor Productivity Ratio; Lower Equity Ratio	The largest farms have a higher debt ratio, a higher profitability ratio, a lower productivity ratio, and a lower equity ratio.
over 500 thousand euros	Higher Debt Ratio: Higher Profitability Ratio; Lower Factor Productivity Ratio; Lower Equity Ratio; Lower Solvency Ratio	The very largest farms have the highest debt ratio, the highest profitability ratio, the lowest productivity ratio, the lowest equity ratio, and the lowest solvency ratio.

Source: Own calculations based on Agricultural Accounting Information System data

Table 3. Key financial characteristics by farm size category.

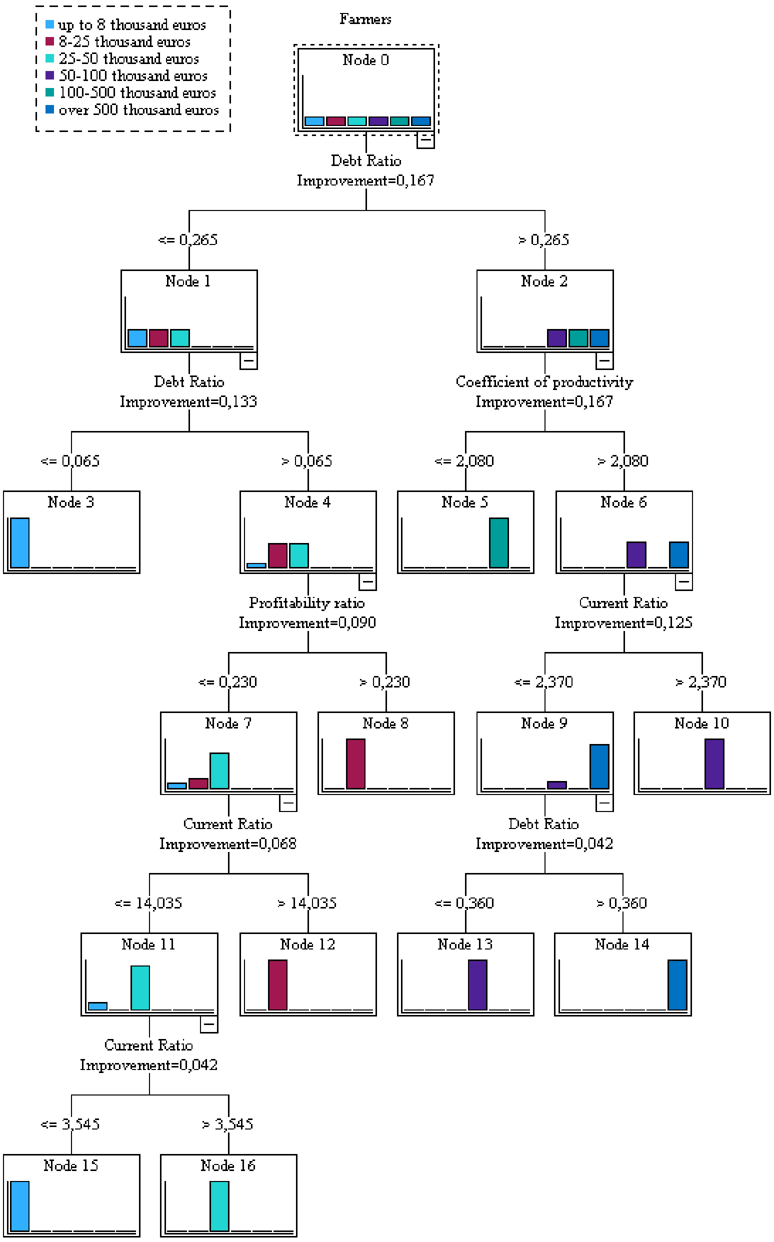
Decision tree modeling to link farm economic size and financial ratios

This study utilises decision tree modelling to categorise agricultural producers based solely on financial ratios, without relying on time characteristics like year. The goal is to understand how financial health predicts farm size.

The dataset contains 6 categories of agricultural producers divided by economic size, and 7 financial ratios related to liquidity, leverage, profitability, productivity, and solvency. Non-financial characteristics like year are excluded to avoid capturing spurious time trends.

The decision tree classifier recursively splits the data by selecting optimal splitting points using Gini impurity to maximise homogeneity in each node (Figure 1).

Specifically, the tree first splits the sample based on the debt-to-assets ratio, indicating leverage is a key differentiator between small and large holdings. Agricultural holdings with an economic size up to 50 thousand euros are distinguished



Source: Own calculations based on Agricultural Accounting Information System data

Figure 1. Decision tree model for linking farm economic size and financial ratios.

by lower leverage than those with economic size over 50 thousand euros. The smallest holdings up to 8 thousand euros economic size have the lowest leverage compared to all other groups, meaning they operate mostly with equity. Agricultural holdings of 8 to 25 thousand euros economic size are distinguished by higher profitability than those over 25 thousand euros economic size, meaning they utilise their resources more efficiently to generate profits. This group of holdings also has the highest liquidity among holdings up to 50 thousand euros economic size, showing they have more short-term assets to meet short-term obligations. Agricultural holdings up to 8 thousand euros economic size have the lowest liquidity.

Among agricultural holdings over 100 thousand euros economic size, those of 100 to 500 thousand euros economic size have the lowest factor productivity. Holdings of 50 to 100 thousand euros economic size have the highest liquidity, while the largest over 500 thousand euros have the lowest liquidity, indicating financial instability risk.

Agricultural holdings of 100 to 500 thousand euros economic size have lower liquidity and lower profitability compared to smaller agricultural holdings.

The largest holdings, over 500 thousand euros economic size, exhibit lower liquidity and profitability but higher solvency. This suggests larger capital reserves and assets but weaker returns.

In summary, this study shows that farm size can be predicted from just a few key financial ratios, without relying on time characteristics. The intuitive decision tree model provides interpretable classification rules that highlight the importance of financial health. The analysis also reveals specific financial traits that distinguish small, medium and large agricultural operations.

A limitation of the study is sample size. Further validation on larger datasets is needed to assess real-world predictive accuracy.

In light of the conducted literature review and in the context of the current study, our findings are confirmed by the existing scientific literature, which adds further validity to our observations.

The observation of the existence of an optimal farm size in terms of efficiency coincides with the conclusions of Rao and Chotigeat (1981), Lamb (2003) and Deininger and Byerlee (2011), who also identify a threshold of diminishing returns when increasing scale. These authors emphasise that after reaching a certain size, further expansion of the holding can lead to reduced marginal productivity.

The finding of differences in indicators depending on farm size is consistent with the results from the studies of Rada and Fuglie (2019) and Kryszak (2021), which highlight the advantages of small farms, especially in less developed economies, particularly in the context of their adaptability and resilience.

The observation of the higher profitability of small holdings due to more efficient use of limited resources is in line with the conclusions of Bojnec and Latruffe (2013) and Koteva (2019), who also note the benefits of small farms in this regard.

The hypothesis of the balance between economies of scale and flexibility for medium-sized farms corresponds with the observations made by Filho and Vian (2016), Jayne et al. (2019) and Galluzzo (2022), who find that medium-sized farms can achieve faster growth thanks to this balance.

Based on these matches, our study further supports existing theories and observations in the field of agricultural economics, while providing a unique perspective on Bulgarian conditions.

Conclusion

The analysis highlights the presence of a positive correlation between the economic size of holdings and their financial results. However, this relationship is not linear and there is an optimal size above which efficiency starts to decrease due to increasing organisational complexity. Factors such as access to financing, technologies and market power also have an influence.

Agricultural holdings of different economic sizes demonstrate statistically significant differences in some of their financial metrics. This underscores the fact that size can play a pivotal role in certain aspects of financial management and performance.

Larger holdings tend to have lower factor productivity, which may be due to the complex interaction of several factors, including increasing organisational complexity, limited applicable capacity of technologies, and diminishing economies of scale. However, they continue to be the most solvent compared to other farm categories. Larger holdings have easier access to bank and other financing sources due to the availability of more assets as collateral. This allows them to invest in upgrading and growth. On the other hand, these holdings also have a greater dependence on debt financing, which may expose them to greater risk in case of financial shocks.

Smaller economic size agricultural holdings have higher profitability compared to medium-sized ones. This may be due to more efficient use of resources and lower operating costs. They can maximise the benefits from their limited resources through intensive and innovative practices, while maintaining close control over the production process. Smaller holdings often demonstrate greater flexibility and ability to adapt quickly to changing market conditions or climate changes, which can increase their efficiency and allow them to take advantage of market niches. Although larger holdings may have greater access to capital for investing in technologies, smaller holdings can also use innovative technologies to increase efficiency, especially those suited to small scales and with low operating costs. The personal commitment of owners and their participation in the day-to-day running of small holdings can lead to more careful management, high motivation and efficient decision-making, further enhancing efficiency.

Medium economic size holdings demonstrate high liquidity and financial independence thanks to the optimal balance between achieving economies of scale and maintaining flexible management. This balance allows them to effectively implement techniques to increase productivity without leading to excessive increase in organisational complexity. Moreover, the average size of their holdings provides better access to external financing compared to smaller ones due to the availability of more assets as collateral. Additional investments enable them accelerated growth and technological upgrade. Another advantage is the possibility to integrate activities such as transport, logistics and processing. This increases the added value nd profitability of medium-sized holdings. Due to the larger volume of output, these holdings also have stronger negotiating positions for purchase prices with traders and processors. This also leads to revenue optimisation.

While economic size strongly influences agricultural holdings' financial metrics, other factors like management skills, geographic location, technologies, and crops grown also play a decisive role in holdings' financial stability.

What is the optimal economic size for an agricultural holding? There is no unambiguous answer to this question. The optimal farm size balances land, labour, and capital costs against market opportunities and income potential. Optimal size can vary significantly depending on crop, location, management skills, and owner strategies. This makes the question of the "optimal" size very case-specific.

In light of the findings, further research into additional factors influencing agricultural holdings' financial sustainability is warranted. This will aid in understanding the dynamics of these relationships and developing effective strategies to optimise resources and enhance holdings' financial stability.

The current study leads to specific policy recommendations for supporting the sustainability and economic growth of agricultural holdings. The results show that the optimal size of holdings depends on various factors like type of crops grown, available technologies and capacity of farmers. Hence, policies should not focus solely on promoting large holdings, but rather provide flexible support to farmers to develop a sustainable business model according to their needs. Access to finance should be facilitated through specialised credit lines for agricultural producers with suitable interest rates and collateral requirements. This will reduce the risk of over-indebtedness in the industry. Targeted training and advisory services need to be provided to farmers around proper financial planning and management for sustainable production activity. Improving the financial skills of agricultural producers is key to the growth of their holdings. The digitalisation of agriculture should be encouraged through policies introducing tax reliefs and subsidies for adopting modern technological solutions. This will allow agricultural holdings to enhance their efficiency and balance the challenges of increasing scale.

The implementation of such targeted policies in agriculture will help achieve long-term growth of the agrarian sector, based on the principles of economic efficiency and sustainability.

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