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# Determinants of Labor Productivity and Economic Sustainability in Romanian Family Farms Across Different Economic Size Classes: Literature Review and Sectoral Analysis

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**Abstract**

Romanian agriculture is characterized by fragmented land structures, limited capitalization, and high labour dependence, conditions that may constrain the economic performance of family farms. This study integrates two complementary components: (i) a systematic literature review conducted within the PRISMA 2020 framework, synthesizing evidence from 34 empirical studies concerning Romanian and Central and Eastern European family farms; and (ii) an original sectoral analysis based on publicly available Eurostat data for 2016–2025, including national trends and NUTS-2 regional comparisons. The reviewed evidence indicates that market integration, production specialization, technological adoption, investment capacity, and human capital are frequently associated with stronger labour-productivity outcomes, whereas land fragmentation and surplus labour are more frequently associated with weaker performance, particularly among smaller farms. The Eurostat analysis identifies an overall upward, although fluctuating, trajectory in nominal agricultural output and gross value added per AWU. The polynomial models provide a descriptive fit to these temporal patterns but do not identify their causal determinants. Overall, the findings support a size-differentiated interpretation of labour-productivity patterns and underline the relevance of targeted policies addressing the different structural conditions of Romanian family farms.

**Keywords:** labor productivity; family farms; market integration; land fragmentation; agricultural sustainability

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Academic Editors: Cristina Raluca Gh. Popescu, Di Zeng, Xinjian Chen and Yun Shen

Received: 25 May 2026
Revised: 30 July 2026
Accepted: 17 August 2026
Published: 26 August 2026

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## 1. Introduction

### *1.1. Research Necessity and Research Gap*

Small-scale family farming represents the numerically dominant form of agricultural organization in Romania and plays a significant socio-economic role in rural development [1–4]. The sector is characterized by extreme structural fragmentation: 98.4% of farms cultivate less than 10 hectares, while only 0.2% exceeds 100 hectares [5]. This fragmented structure constrains economies of scale, mechanization, investment capacity, and market integration, sustaining a substantial productivity gap relative to the European Union (EU) average [6]. Although Romania ranks seventh in the EU in agricultural output value (EUR 23.4 billion in 2025), a considerable gap in structural efficiency persists relative to its productive potential [7].

Labor productivity, defined as the value of agricultural output generated per unit of labor input, is a central indicator of farm viability, competitiveness, and long-term economic sustainability. Although Romania recorded a substantial increase in labor productivity per AWU between 2016 and 2025 (from approximately EUR 11.74 to 13.16 million per 1000 AWU in the Output indicator), this growth originated from an exceptionally low baseline: 18.5% of Romania's total employment remains in agriculture, compared to an EU average of 4.0% [8,9]. Despite productivity gains, persistent labor surplus continues to suppress labor efficiency, underscoring the need to identify and understand the economic determinants of labor productivity across different farm size classes [10].

The literature has examined a range of determinants—structural, financial, production, technological, market, and human capital factors—but three substantive gaps remain:

Gap 1—Methodological fragmentation. Most existing studies analyze determinants individually (e.g., subsidies or education or mechanization), without integrating them within a unified analytical framework that captures their interdependence across farm size classes [11,12].

Gap 2—Lack of size-differentiated empirical evidence. Comparative studies that disaggregate determinant effects by economic size class (semi-subsistence, small commercial, medium, large) remain scarce, although evidence suggests strongly heterogeneous responses [13,14].

Gap 3—Limited integration of post-2020 dynamics and sustainability dimensions. Few studies examine simultaneously the latest CAP 2023–2027 reform period, the European Green Deal sustainability requirements, and the differentiated structural transformation of Romanian family farms [15,16], while semi-subsistence farms (under 5 hectares) face structural and policy-related constraints that limit their economic performance [17]. Medium-sized farms (20–100 hectares) tend to achieve a more balanced relationship between labor efficiency and sustainability, whereas large farms (over 100 hectares) benefit from economies of scale but may encounter diminishing marginal returns to labor, highlighting the importance of liquidity management and organizational capacity [1,6,18].

Recent studies have further demonstrated that eco-efficiency and human capital efficiency tend to increase with farm size, while labor overuse suppresses productivity in small-scale operations, and higher educational attainment enhances managerial capacity and market integration outcomes [18,19]. Collectively, these findings emphasize the need for size-differentiated analytical approaches, given that single-factor interventions—such as land consolidation or subsidy allocation—are insufficient to raise labor productivity without complementary improvements in production specialization, market access, and human capital development [20–22]. Despite a growing body of research on these issues, the determinants of labor productivity are rarely examined within a unified analytical framework that accounts for cross-size interactions [23]. Evidence suggests that financial determinants—particularly CAP subsidies and liquidity stability—disproportionately strengthen the economic resilience of medium and large family farms relative to smaller holdings, a pattern consistent with the size-dependent role of subsidies and investment capacity discussed in Section 2.2 [24,25]. These patterns collectively motivate the need for the integrated, size-differentiated framework developed in the present study.

### *1.2. Aim of the Study*

The general aim of this research is to synthesize the economic determinants of labor productivity in Romanian family farms across different economic size classes, integrating structural, financial, production, market, and human capital dimensions within a unified analytical framework. By combining a systematic literature review with an original sectoral

analysis, this research aims to provide evidence-based support for designing targeted agricultural policies that improve labor efficiency, market integration, and the resilience of Romanian family farms in the context of the ongoing transition from subsistence to market-oriented agriculture.

### *1.3. Research Questions*

In line with the two complementary components of this study, the research questions are formulated separately for the systematic literature review and for the sectoral analysis.

Systematic Literature Review (SLR):

- RQ1: What economic determinants (structural, financial, production, market, and human capital) have been identified in the empirical literature as being associated with labour productivity in Romanian and Central and Eastern European family farms?
- RQ2: How do the reported associations between these factors and labour productivity vary across different farm-size classes?

Sectoral Analysis (SA):

- RQ3: What has been the trajectory of agricultural labor productivity (Output/AWU and GVA/AWU) in Romania over the period 2016–2025, and to what temporal patterns and short-term fluctuations are observed in these indicators?
- RQ4: What regional (NUTS-2) disparities exist in labor productivity, and what do they suggest about the structural disparities characterizing Romanian agriculture?

### *1.4. Structure of the Paper*

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework, research gaps, conceptual model, and hypotheses. Section 3 describes the two methodological components: the systematic literature review and the Eurostat-based sectoral analysis. Section 4 presents the results of the literature synthesis and sectoral analysis, followed by the assessment of the research hypotheses, discussion of the main mechanisms, policy considerations, and study limitations. Section 5 presents the conclusions and policy implications.

## 2. Theoretical Framework

Labor productivity and agricultural sustainability research in the agricultural sector has gained momentum in recent years, with the subject being driven by important structural change and sustainability issues in European agricultural systems [26]. A multidimensional approach is followed in this research, with structural, financial, technical, and human capital factors being taken into consideration. An important feature of this review is the incorporation of important longitudinal data (2016–2024) and newly developed theoretical paradigms for the period 2024–2026, with the aim of interpreting structural change in the context of the current European Green Deal and CAP 2023–2027 priorities.

### *2.1. Structural and Production Determinants*

Farm size is one of the structural factors highlighted by the majority of the literature as the main driver of labor productivity. Studies comparing data for Central and Eastern European (CEE) countries highlighted the fact that larger farms achieve superior labor productivity compared to smaller farms, thanks to economies of scale and high mechanization levels [21–23]. Nevertheless, recent evidence indicates the existence of non-linear relationships between structural factors and labor productivity. While small farms still experience structural constraints, medium-sized commercial farms achieve the best structural balance between efficiency and sustainability [27].

In the context of the Romanian agricultural sector, the high level of land fragmentation is one of the defining structural constraints. Indeed, the majority of Romanian farms operate on less than 10 hectares. Recent evidence published after 2022 indicates the negative effects of high fragmentation on production costs, mechanization levels, and labor efficiency, with negative effects on the efficiency of labor allocation in the context of semi-subsistence farms [28]. Commercial orientation is also important, with farms showing high commercialization and specialization levels achieving superior labor productivity [29,30].

Three important structural types can be identified on the basis of recent literature, which is the focus of this research:

- Semi-subsistence farms (<5 ha): These farms experience important structural constraints and high labor redundancy;
- Small commercial farms (5–20 ha): This group benefits most from specialization, intensification, and increased accessibility to markets, showing the highest potential for profitability growth [31,32];
- Medium and large farms achieve the most stable balance between technical efficiency and economic sustainability, applying capital-intensive methods.

### *2.2. Financial and Technical Determinants*

Financial factors, such as subsidies, liquidity, and capital structure, appear to be a key driver of labor productivity. The studies based on Eurostat and FADN/RICA database data indicate that subsidies contribute to income stability, although their impact varies across different size classes: small farms mainly depend on subsidies to maintain cash flow, whereas medium and large farms apply them to support strategic investment [33]. The longitudinal approach, covering the 2004–2025 periods, is particularly interesting in this context, as it reflects the total effect of these financial flows in Romania's transition after EU accession, creating a baseline prior to the global market volatility registered in the mid-2020s. Liquidity constraints appear to be a significant problem for small family farms in Romania, affecting their ability to invest in labor-saving technologies and making them more vulnerable to external shocks [34].

The impact of technical factors, such as digitalization and eco-efficiency, becomes increasingly critical under the European Green Deal [35,36]. Recent findings suggest that investing in mechanization, precision, and digital technologies has a strong positive impact on labor efficiency, with the most pronounced effects recorded on medium and large farms [37,38]. This paper benchmarks the evolution of technical factors in Romania over the 2016–2020 periods to 2024–2026 efficiency requirements, thus identifying the adaptation path of Romanian farms to modern efficiency norms.

Eco efficient farms can enjoy high labor productivity with optimal costs and long-term sustainability, although the costs of adaptation can be high for smaller farms [37,39].

Another important issue discussed in the relevant literature is the "technology treadmill," which argues that although technology can increase labor productivity, it can also reduce the long-term price margins for farmers. As a consequence, the benefits shift to consumers rather than farmers. This issue is discussed both in the context of the entire European Union and Romania [40].

### *2.3. Human Capital and Macroeconomic Determinants*

Human capital is one of the important factors for labor productivity. Studies in Romania and CEE show that farms with high human capital efficiency can enjoy high economic performance because the managers can efficiently innovate and effectively operate in complex markets [31,33]. Excessive family labor, which is common in semi-subsistence farms,

can reduce productivity if the labor input is above the economically optimal level, resulting in hidden under-employment [34].

Macroeconomic factors can affect farms through price ratios, inflation, interest rates, and labor markets [41,42]. An increase in input prices and fluctuations in output/input price ratios can affect small farms to a greater extent because they lack the financial means to deal with these pressures [43]. By focusing on the period 2004–2020, it is possible to identify the structural pressures facing farms in a stable environment. This is important because it provides a reference point to evaluate the policy frame-works for the 2025–2026 periods. Factors such as institutional pressures, including the CAP reform and the Green Deal, can affect farms differently depending on their size, technology, and labor force [5,12].

### *2.4. Research Gap and Hypotheses*

The literature analysis revealed that labor productivity in agriculture depends on a multidimensional set of determinants that vary in their influence across structural, financial, technical, and human capital dimensions [14,44]. The influence of structural determinants—such as farm size, land fragmentation, and specialization—on labor productivity is evident in most studies [44]. Financial determinants, such as subsidies, liquidity, and capital structure, are found to have a stabilizing effect on labor productivity, although this effect is size-dependent [45]. Technical determinants, such as mechanization, digitalization, and eco-efficiency, are significant in modern agricultural contexts in line with the European Green Deal [46]. Human capital determinants, including education, management capacity, and labor force composition, are consistently identified as critical drivers of labor productivity in agricultural contexts [47,48].

### *2.5. Research Gap, Conceptual Model, and Hypotheses*

The theoretical synthesis presented in Sections 2.1–2.4 reveals that labor productivity in family farming is shaped by a multidimensional interaction of structural, financial, technological, market, and human capital determinants, rather than by farm size alone. However, this synthesis also exposes three substantive gaps that motivate the conceptual model of the present study.

Gap 1—Methodological fragmentation. As shown in Section 2.4, most existing studies analyze determinants individually—structural factors in isolation from financial or human capital factors—without integrating them within a unified analytical framework capable of capturing their interdependence across farm size classes [49].

Gap 2—Lack of size-differentiated empirical evidence. The non-linear pattern identified in Section 2.1 (small commercial farms achieving the strongest structural balance, in contrast to both semi-subsistence and very large holdings) is documented only fragmentarily; comparative studies that systematically disaggregate determinant effects by economic size class remain scarce [14], despite evidence of markedly heterogeneous effects across semi-subsistence, small commercial, and larger farms. This gap is compounded by the reliance on aggregate data in most Romanian studies, which masks significant heterogeneity in determinant effects across size classes [49].

Gap 3—Limited integration of post-2020 dynamics and sustainability requirements. Few studies examine simultaneously the CAP 2023–2027 reform period, the European Green Deal sustainability priorities, and the differentiated structural transformation of Romanian family farms documented in Sections 2.2 and 2.3. In particular, the transformation of small commercial farms—considered of strategic importance for rural development [50]—remains underexplored with respect to the simultaneous role of specialization, liquidity, and farmer education in shaping sustainable labor productivity.

Building on these gaps and on the determinant-specific evidence synthesized above, the following conceptual model links farm economic size to labor productivity through four interdependent channels—structural, financial, technological/human capital, and production/market—and translates into four testable hypotheses (Figure 1).

**H1.** *The influence of farm size on labor productivity is non-linear: small commercial farms (5–20 ha) are more responsive to economic determinants than semi-subsistence farms, consistent with the structural balance identified in Section 2.1 [15,16].*

**H2.** *Financial determinants such as CAP subsidies and liquidity stability exert a greater influence on the economic resilience of medium and large family farms than on smaller ones, in line with the differentiated role of subsidies and investment capacity discussed in Section 2.2 [24,25].*

**H3.** *Technological endowment in terms of human capital (education) is a universal determinant of labor productivity, irrespective of the farm's economic size class, reflecting the cross-cutting relevance of human capital efficiency established in Section 2.3 [18,20].*

**H4.** *Production volume, market integration, and farm characteristics have size-dependent effects on labor productivity—most significant for small commercial farms, structurally limited for semi-subsistence farms, and showing decreasing marginal returns for larger farms, consistent with the technology-treadmill and specialization evidence discussed in Sections 2.2 and 2.3 [13,16].*

Figure 1 synthesizes this conceptual model, illustrating how the four determinant categories reviewed in Sections 2.1–2.4 relate to the four hypotheses assessed in Section 4.7.

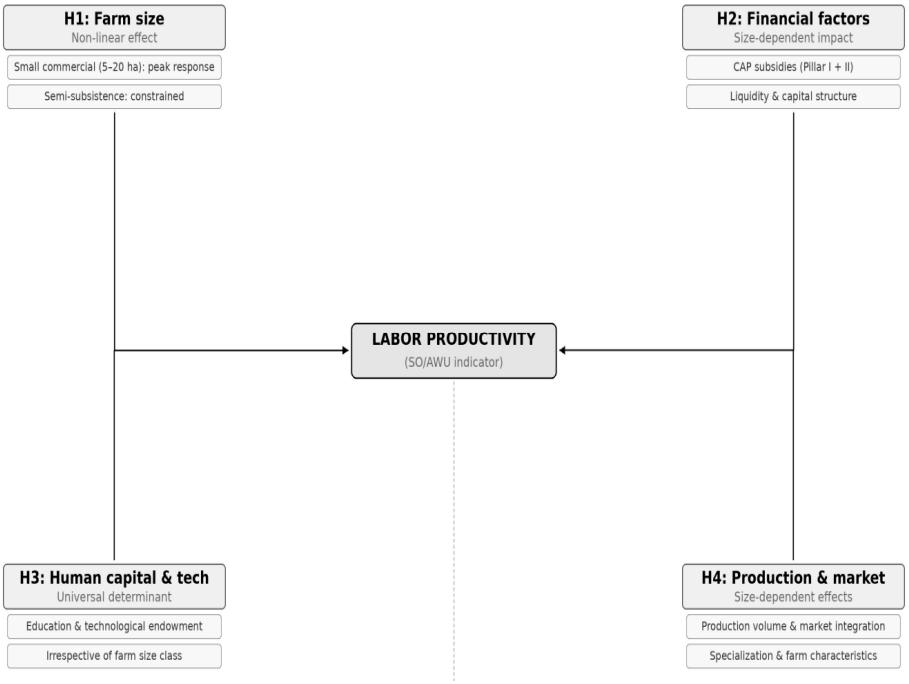



**Figure 1.** Conceptual model linking theoretical determinants to research hypotheses H1–H4 (authors' own elaboration).

### *2.6. Contribution of the Study*

Against the above background, the current study aims to make a significant contribution to the relevant literature by exploring the role of economic size differentiation regarding the economic determinants of labor productivity and economic sustain-ability of Romanian family farms. The simultaneous analysis of economic size differentiation and the complex

interaction of economic, financial, technical, and human capital variables is considered to provide a better understanding of the complex mechanisms of economic performance in a highly fragmented agricultural sector. The study connects the evidence identified in the reviewed literature with the patterns observed in the authors' Eurostat-based sectoral analysis for 2016–2025, while maintaining a clear methodological distinction between these two components.

## 3. Materials and Methods

The primary dependent variable of this study is labour productivity, operationalized in the sectoral analysis (Section 3.2) through Standard Output per Annual Work Unit (SO/AWU) and Gross Value Added per Annual Work Unit (GVA/AWU). SO/AWU measures the value of agricultural production generated per unit of labour, while GVA/AWU captures labour-based value creation and is used as a complementary indicator of economic performance. Economic sustainability, market integration, technological adoption, and farm resilience are treated throughout this study as explanatory or contextual variables discussed within the systematic literature review (Section 3.1), not as interchangeable measures of labour productivity.

The study integrates two clearly differentiated methodological components. The first is a systematic literature review conducted and reported in accordance with the PRISMA 2020 framework. It synthesizes empirical evidence concerning the structural, financial, technological, production, market, and human-capital factors associated with labour productivity in Romanian family farms and comparable agricultural systems in Central and Eastern Europe. The second component is an original sectoral analysis based exclusively on publicly available Eurostat datasets. This analysis examines the temporal evolution of Romanian agricultural labour productivity and regional disparities during 2016–2025 using harmonized statistical indicators and calculations performed by the authors.

The findings obtained from the two components are reported separately and subsequently interpreted jointly. This integrated approach connects the patterns identified in the sectoral data with the broader empirical evidence synthesized from the literature [49]. It does not imply that the aggregate sectoral associations represent farm-level causal effects.

### *3.1. Systematic Literature Review*

#### 3.1.1. Search Strategy and Data Sources

The systematic literature review followed the identification, screening, eligibility-assessment, and inclusion stages recommended by the PRISMA 2020 framework. The literature search was conducted using the Elicit semantic-search platform, which retrieves publications indexed in Semantic Scholar and OpenAlex. Elicit was selected because its semantic-retrieval functionality can identify conceptually relevant empirical studies beyond exact keyword matching.

The search strategy combined the following six concepts:

1. labour productivity;
2. family farms;
3. Romania;
4. Central and Eastern Europe;
5. economic determinants;
6. agricultural sustainability.

Because Elicit uses semantic retrieval rather than conventional Boolean syntax, these concepts were entered as a structured keyword query: "labour productivity; family farms; Romania; Central and Eastern Europe; economic determinants; agricultural sustainability".

The final search was conducted on 15 April 2026. The eligibility assessment was restricted to peer-reviewed empirical studies published in English between 2004 and 2025. Elicit was the sole source used for record identification in the PRISMA procedure. Scopus and Web of Science were not used as independent identification sources, and no records from these databases were added during the PRISMA identification stage. The Elicit search retrieved 500 potentially relevant records.

#### 3.1.2. Eligibility Criteria

Studies were included when they simultaneously met the following four criteria:

They examined family farms located in Romania or in comparable Central and Eastern European agricultural systems.

They investigated labour productivity or closely related indicators of labour-based economic performance.

They analysed at least one structural, financial, technological, production, market, or human-capital factor associated with labour productivity.

They employed an empirical quantitative or mixed empirical research design that provided extractable evidence.

Studies were excluded when they:

- focused exclusively on non-family commercial agricultural enterprises;
- examined non-agricultural activities;
- presented only conceptual or theoretical discussions without empirical evidence;
- did not report sufficient methodological information for extracting and comparing their findings.

The four formal eligibility criteria were operationalized through six screening dimensions. The geographical criterion was assessed through the "Romanian or comparable CEE agricultural system" dimension. The outcome criterion was assessed through the "labour-related economic outcomes" dimension. The determinant criterion corresponded to the "economic determinants analysis" dimension, while the methodological criterion corresponded to the "empirical study design" dimension. Two additional dimensions—"family farm focus" and "agricultural activity focus"—were used to ensure that studies concerning non-family enterprises or non-agricultural activities were excluded. Therefore, the six screening dimensions represent a detailed operationalization of the four formal eligibility criteria rather than a separate set of selection rules.

#### 3.1.3. Study Selection and Screening Procedure

The selection procedure followed four sequential stages: identification, title and abstract screening, full-text eligibility assessment, and final inclusion.

During the identification stage, 500 potentially relevant records were retrieved through Elicit from publications indexed in Semantic Scholar and OpenAlex. Because Elicit consolidates identical bibliographic records retrieved from these sources, no duplicate records required manual removal.

Title and abstract screening and full-text eligibility assessment were conducted independently by three authors (G.U., B.A.U., and B.M.C.). Disagreements were discussed by the three reviewers and resolved through consensus. A formal inter-rater agreement statistic, such as Cohen's or Fleiss' kappa, was not calculated; this is acknowledged as a methodological limitation in Section 4.11.

During title and abstract screening, 412 records were excluded because they did not meet the predefined geographical, thematic, family-farm, or agricultural-activity requirements. The remaining 88 publications underwent full-text eligibility assessment.

Following the full-text assessment, 54 studies were excluded because they:

- examined agricultural systems that were not sufficiently comparable with Romanian family farming;
- did not employ an eligible empirical methodology;
- did not focus on family farms;
- did not provide sufficient methodological information or extractable results.

Consequently, 34 distinct empirical studies met all eligibility criteria and were retained for the systematic evidence synthesis. The complete study selection procedure is illustrated in the PRISMA 2020 flow diagram (Figure 2).

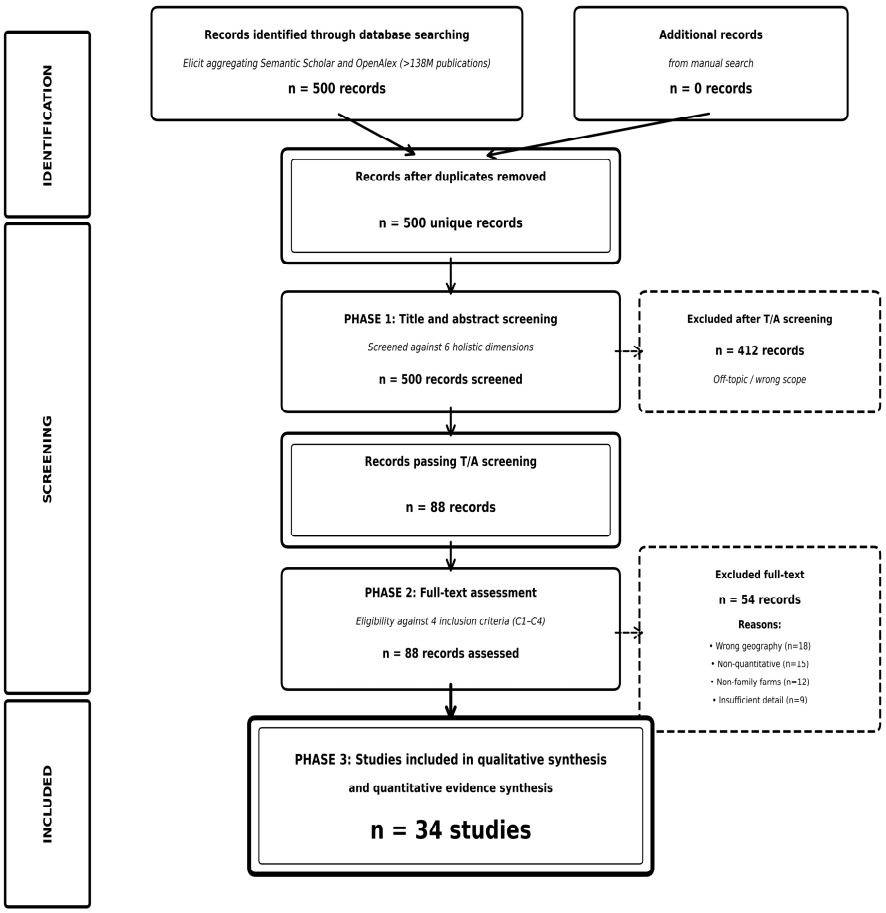



**Figure 2.** PRISMA 2020 flow diagram illustrating the identification, screening, eligibility assessment, and inclusion of studies examining the economic determinants of labour productivity in Romanian family farms across different economic size classes. Source: Authors' own elaboration.

The study selection process was conducted and reported in accordance with the PRISMA 2020 Statement (Figure 2), ensuring a transparent, systematic, and reproducible approach to identifying, screening, assessing eligibility, and including relevant empirical evidence. The initial search performed using the Elicit semantic search engine, which aggregates publications from Semantic Scholar and OpenAlex, identified 500 records ($n$ = 500). No additional records were retrieved through manual searches, and no duplicate records were identified. During the first screening phase, all 500 records were assessed against six predefined eligibility dimensions: Romanian Family Farm Population, Labour Economic Outcomes, Economic Determinants Analysis, Empirical Study Design, Family Farm Focus, and Agricultural Activity Focus. Following title and abstract screening, 412 records were excluded because they did not match the geographical scope or thematic focus of the review. The remaining 88 studies underwent full-text assessment based on four predefined inclusion criteria. Of these, 54 studies were excluded due to inappropriate geographical

coverage, lack of quantitative methodology, absence of a family farm focus, or insufficient methodological detail. Consequently, a final sample of 34 studies met all eligibility criteria and was retained for qualitative review and quantitative evidence synthesis.

#### 3.1.4. Data Extraction

The data extraction phase focused on key determinants of labor productivity, which include farm structure, financial determinants, production determinants, market integration, and human capital determinants, such as labor efficiency, education level, and age of farmers. The researchers were able to synthesize this information to assess their findings on how these determinants affect labor productivity in different farm size categories in Romania.

The data extraction protocol comprised seven areas of investigation:

Farm characteristics: Confirmation of farm type (family farm, etc.), location in Romania (region/area if specified), economic size measures (hectares, standard output, turnover, etc.), and size category classification used by authors, and number of farms.

Economic determinants: Input prices (material costs, feed, equipment, fuel, etc.), management determinants (motivation, job satisfaction, and digitalization), market determinants (prices, market integration, and supply chain), production determinants (scale, intensity, and technology), labor productivity, and other economic determinants.

Labor productivity definition: Definition or formula used units of measurement (per hour, per person, per farm), gross or net, time period, and other adjustments.

Economic size classification: Classification criteria used (hectares, standard out-put, etc.), number and definition of size categories, distribution of farms in size category, and any EU and national standards used in size classification.

Nature of the relationships between the determinant and productivity: statistical significance, size, direction of the relationships (positive/negative), correlation coefficient/regression coefficient, relative importance of the determinants, existence of thresholds.

Size-related effects: existence of differential effects depending on farm size, interaction between determinants and farm size, greater/less importance of the determinants depending on farm size, existence of economies/diseconomies of scale on labor productivity, existence of recommendations/interpretations depending on farm size.

Study Methodology: type of study design used, data collection methods, time period covered, sample size, statistical methods used for data analysis, data sources used.

#### 3.1.5. Quantitative Evidence Synthesis

The extracted quantitative results were synthesized through descriptive aggregation of statistical parameters. The quantitative results on the relationships between the economic determinants and labor productivity were aggregated on the following parameters for each determinant: the direction of the relationships with labor productivity (positive, negative, and non-significant); statistical significance; correlation coefficient; regression coefficient; proportion of variance explained.

The size-related effects were aggregated according to farm class: semi-subsistence (<2–5 ha); small commercial farm (5–20 ha); medium-to-large farm (>20 ha). The consistency of the results was examined; the patterns of heterogeneity were also examined with regard to the measurement methods used, time period, and geo-graphic scope.

#### 3.1.6. Profile of the Evidence Base

The systematic review identified 34 studies examining the relationships between economic determinants and labor productivity/income in Romanian agriculture. The main characteristics of the included studies are presented in Table A1 (Appendix A).

In terms of methodological approach, the included studies relied on two primary data collection strategies. The first category comprised primary survey-based studies, which collected original farm-level data through structured questionnaires administered to samples of 834–900 farms across CEE countries [9,10,51–53]. A second cate-gory drew on international statistical databases to assess long-run structural changes in the Romanian agricultural sector [54]. The most widely used data source was the Farm Accountancy Data Network (FADN/RICA) database [55–62], which provides harmonized, comparable farm-level economic data for assessing agricultural systems, across Europe [63,64].

The temporal framework distinguishes between the periods examined in the reviewed literature and the period covered by the authors' sectoral analysis. The included studies provide evidence relating to the main phases of Romanian agricultural development: the pre-EU accession period (2004–2006), the post-accession structural adjustment period (2007–2013), the implementation of the 2014–2020 CAP programming framework, and the transition to the 2021–2025 policy cycle [65,66]. In contrast, the original Eurostat-based sectoral analysis consistently covers the period 2016–2025. Regarding geographical scope, 10 studies focus specifically on Romania, 8 adopt a Central and Eastern European comparative perspective, and 7 examine the European Union as a whole, while the remaining studies address other national or comparative settings. This geographical diversity enables both an in-depth assessment of Romanian agriculture and broader interregional benchmarking [67].

### *3.2. Sectoral Analysis Based on Eurostat Data*

This component is entirely distinct from the systematic literature review described in Section 3.1: it consists of original calculations performed by the authors on publicly available Eurostat datasets, and is reported separately from the literature-synthesis findings throughout Section 4.

#### 3.2.1. Data Sources

The sectoral analysis uses Eurostat datasets aact_eaa01 (agricultural output, gross value added, subsidies, investment), aact_ali01 (labor input—Annual Work Units), ef_kvftaa (farm size, standard output), and apro_cpsh1 (land area). These are publicly accessible online via the Eurostat Data Browser and require no data access request.

#### 3.2.2. Variable Definitions

Labor productivity in the sectoral analysis is measured as Standard Output per Annual Work Unit (SO/AWU), where Standard Output (SO, million EUR) reflects the monetary value of agricultural production and Annual Work Unit (AWU, thousand units) measures labor input. Where gross value added data are used instead of output, the indicator is reported as GVA/AWU. Both indicators are computed as the ratio of the relevant national or NUTS-2 aggregate to labor input, enabling comparison of labor efficiency across regions and over time.

The Labor Productivity Index (LPI) is an author-constructed descriptive synthesis scale ranging from 0 to 100 and is not an official Eurostat or FADN indicator. Higher scores indicate a stronger relative labour-productivity profile. The intervals assigned to the farm-size categories synthesize sectoral indicators and findings from the reviewed literature and should be interpreted as indicative ranges, not as confidence intervals or inferential statistical estimates.

#### 3.2.3. Quantitative Methods

The following methods were applied to the Eurostat series for the 2016–2025 periods:

(1) Fixed-base dynamics index (IFB): IFB = (Xn/X1) × 100, where X1 is the 2016 value (the first year of the analyzed sectoral series) and Xn is the value in the final year of the series.
(2) Average annual growth ($\Delta^-$): $\Delta^- = (Xn - X1)/n$, where n is the number of years between 2016 and 2025.
(3) Descriptive statistics: arithmetic mean, standard deviation, and coefficient of variation, to characterize central tendency and dispersion.
(4) Graphical analysis of temporal dynamics: polynomial regression with the coefficient of determination ($R^2$), used to capture non-linear trends over 2016–2025.

## 4. Results

### *4.1. Structural Characteristics of Agricultural Holdings*

The structural configuration of agricultural holdings differs significantly across Central and Eastern European countries, with Romania exhibiting a pronounced fragmentation pattern. Table 1 presents a comparative overview of the number of farms, average farm size, and the distribution of small farms (<10 ha UAA), highlighting substantial cross-country heterogeneity.

**Table 1.** Structural characteristics of agricultural holdings and distribution of small farms (<10 ha UAA) in selected CEE countries.

| Specification | Poland | Lithuania | Romania | Serbia | Moldova |
|---|---|---|---|---|---|
| 1. Total number of farms (thousands) | 1306.7 | 169.9 | 2862.9 | 569.3 | 369.7 |
| 2. Farms smaller than 10 ha of UAA | 990 (76%) | 108 (64%) | 2700 (94%) | 501 (88%) | 239 (65%) |
| 3. Average farm size (ha of UAA) | 11.4 | 17.4 | 4.5 | 6.1 | 6.8 |
| 4. Total utilized agricultural area (thousand ha) | 14,841 | 2964 | 12,824 | 3487 | 2497 |
| 5. Agricultural land in farms < 10 ha UAA (thousand ha) | 3562 | 385 | 3975 | 2057 | 275 |
| 6. % of total UAA | 24% | 13% | 31% | 59% | 11% |

Sources: Authors' own compilation and calculations based on official Farm Structure Survey and Agricultural Census statistics from Eurostat (Poland, Lithuania and Romania), the Statistical Office of the Republic of Serbia, and the National Bureau of Statistics of the Republic of Moldova. Country data refer to the latest available official reference year for each national statistical system.

As shown in Table 1, Romania records the highest share of small farms, with approximately 94% of holdings operating on less than 10 ha of utilized agricultural area (UAA), compared to 76% in Poland and 64% in Lithuania [68]. Despite their numerical dominance, these farms account for only 31% of total UAA, confirming a high degree of land fragmentation. These findings are consistent with previous studies documenting the structural duality of Romanian agriculture and its implications for efficiency and productivity.

### *4.2. Farm Size and Labor Productivity: Non-Linear Effects*

The descriptive segmentation presented in Table 2 suggests a non-linear pattern between farm size and the selected labour-productivity characteristics. Small commercial farms (5–20 ha) display the highest indicative LPI values, but these descriptive ranges should not be interpreted as statistically tested differences among farm-size categories. The divergence between LPI and GVA/AWU is not necessarily contradictory because the two indicators represent different dimensions of farm performance. GVA/AWU expresses the monetary value added generated per annual work unit, while LPI provides a broader descriptive synthesis of productivity-related characteristics. Small commercial farms may

combine market participation, effective family-labor utilization, responsiveness to input costs, and technological adoption more evenly. Conversely, larger farms may achieve higher GVA/AWU through greater capitalization and more advanced technologies without recording the highest indicative LPI values. Accordingly, Table 2 provides a comparative structural profile supporting the examination of H1, rather than evidence of a causal farm-size effect or a statistically validated productivity optimum.

**Table 2.** Descriptive segmentation of Romanian agricultural holdings by UAA size class and selected productivity-related characteristics.

| Farm Category | Size (ha) | Share RO (%) | UAA Share (%) | Market Integr. | Labor Productivity Index (LPI) (0–100) | Input Cost Resp. | Tech Adopt | GVA/AWU (EUR) |
|---|---|---|---|---|---|---|---|---|
| 1. Subsistence | <1 | 52.3% | 4.1% | None | 8–12 | Negligible | Absent | <2000 |
| 2. Semisubsist. | 1–5 | 35.4% | 13.6% | Marginal | 18–28 | Low | Minimal | 2000–4500 |
| 3. Small comm. (H1) | 5–20 | 7.8% | 18.9% | Full | 62–78 | Very high | Active | 8500–14,000 |
| 4. Medium comm. | 20–100 | 3.1% | 22.4% | Full | 54–68 | High | Strong | 12,000–22,000 |
| 5. Large comm. | 100–500 | 0.8% | 19.1% | Full | 38–50 | Moderate | Advanced | 18,000–35,000 |
| 6. Very large | >500 | 0.2% | 21.9% | Full | 22–35 | Moderate | Precision | 25,000–60,000 |

Notes: UAA = Utilized Agricultural Area; AWU = Annual Work Unit; GVA = Gross Value Added. Farm shares may not sum to 100% due to rounding. LPI values represent author-constructed descriptive synthesis ranges on a 0–100 scale; they are not official Eurostat/FADN indicators, confidence intervals, or inferential estimates. Source: Authors' compilation based on Eurostat farm-structure statistics, the Romanian National Institute of Statistics, the CAP Strategic Plan for Romania 2023–2027, and the studies included in the systematic literature review. GVA/AWU ranges represent descriptive synthesis values and should not be interpreted as official Eurostat estimates for each UAA class.

The descriptive non-linear pattern presented in Table 2 is consistent with Hypothesis H1 and suggests that small commercial farms (5–20 ha) display the highest indicative Labor Productivity Index range (62–78) among the farm-size categories considered. This interpretation is consistent with previous evidence concerning farm-size efficiency thresholds in Central and Eastern European agriculture [9,10,51–53,69,70] and with FADN-based studies documenting the structural duality of Romanian agricultural holdings [55,59,71]. The reviewed evidence also suggests that small commercial farms are particularly responsive to changes in output prices, input costs, and access to credit, market integration, and technological adoption. Nevertheless, because Table 2 combines sectoral statistics with evidence synthesized from previous studies, the reported values should be interpreted as descriptive patterns rather than as causal effects or results of an inferential statistical test.

### *4.3. Measurement of Labour Productivity*

Labor productivity was not uniformly defined and measured across the reviewed studies, which poses a problem in comparing results directly [72]. Table 3 presents a summary of the different approaches used.

In line with this literature, the present study adopts the standard output per Annual Work Unit (SO/AWU) as a consistent and comparable empirical measure of agricultural labor productivity at the regional level. The results for Romania, disaggregated at NUTS2 level, are presented in Table 4.

The analysis reveals significant regional disparities in agricultural labor productivity in Romania. Values range from approximately 6667 EUR/AWU in the North-East region, characterized by a predominantly subsistence-oriented agricultural structure, to over

16,471 EUR/AWU in the Bucharest-Ilfov region, where commercial farming and higher levels of capitalization prevail.

Figure 3 illustrates the evolution of Agricultural Output Value per 1000 AWU in Romania from 2016 to 2025, showing both year-to-year fluctuations and the pronounced long-term upward trend in labor productivity in the agricultural sector.

**Table 3.** Measurement approaches for labor productivity across reviewed studies.

| Study | Measurement Approach | Units | Time Period |
|---|---|---|---|
| 1. J. Polcyn et al., 2021 [50] | Value of agricultural production per work hour per hectare | Per work hour per ha | 2019 |
| 2. N. Galluzzo et al., 2022 [12] | Not defined (focus on technical efficiency) | – | – |
| 3. S. Maican et al., 2021 [10] | Not specifically defined | – | – |
| 4. K. Smedzik-Ambrozy et al., 2021 [9] | Ratio of annual income to minimum wages per employee | Per FWU per farm (net) | Annual |
| 5. E. Gheorghe et al., 2022 [51] | Agricultural factor income (AFI) and Labor productivity in agriculture (LPA) | EUR per AWU (net) | 2005–2019 |
| 6. O. Coca et al., 2023 [73] | Labor efficiency measured by value of standard production per AWU | EUR per AWU (gross) | 2010 |

Notes: AWU = Annual Work Unit; FWU = Family Work Unit.

**Table 4.** Romania: Standard Output per Annual Work Unit (SO/AWU) at NUTS2 level.

| Region (NUTS2) | SO Total (mil. EUR) | AWU (Thousand) | SO/AWU (EUR/AWU) |
|---|---|---|---|
| 1. North-East | 5200 | 780 | 6667 |
| 2. South-East | 6800 | 720 | 9444 |
| 3. South-Muntenia | 7500 | 710 | 10,563 |
| 4. South-West Oltenia | 4900 | 630 | 7778 |
| 5. West | 5600 | 450 | 12,444 |
| 6. North-West | 6200 | 580 | 10,690 |
| 7. Center | 5900 | 520 | 11,346 |
| 8. Bucharest-Ilfov | 2800 | 170 | 16,471 |
| 9. Romania (total) | 44,900 | 4560 | 9846 |

Sources: Authors' own calculations based on Eurostat datasets on structural farm statistics (SO) and agricultural labor input (AWU), aggregated at NUTS2 level for Romania (reference year: 2022).

The evolution of agricultural output value per 1000 AWU in Romania during 2016–2025 reveals a moderate but consistent upward trend in labor productivity despite short-term fluctuations. The indicator stood at EUR 11.74 million in 2016, declined gradually to EUR 10.85 million in 2019–2020, reflecting a temporary slowdown in labor productivity growth, and then resumed an upward trajectory. From 2021 onwards, agricultural output value per 1000 AWU increased steadily from EUR 11.01 million to EUR 13.16 million in 2025, the highest value recorded during the analyzed period. This recovery is consistent with continued capital deepening, technological modernization, greater mechanization, and a gradual reduction in agricultural labor input, all of which contributed to improving labor efficiency. The polynomial trend line ($y = -0.0576x^2 + 2.0049x + 9.3207$; $R^2 = 0.8806$) provides a descriptive representation of the observed long-term trajectory in labor productivity, with approximately 88.1% of the variance explained by the trend model. The coefficient of determination indicates that the fitted curve captures a substantial proportion of the variation observed within this ten-year series; it does not establish the causes of

the trajectory. Overall, the productivity gains recorded during the period are consistent with higher capitalization levels, technological modernization, mechanization, and the increasing adoption of digital and precision agriculture practices, alongside the gradual transition from subsistence-oriented farming toward more commercially integrated agricultural production. Although the temporary decline observed during 2017–2020 suggests that the adjustment process was not entirely linear, the subsequent recovery is consistent with an improvement in sectoral performance of the Romanian agricultural sector and its continued convergence toward higher productivity levels.

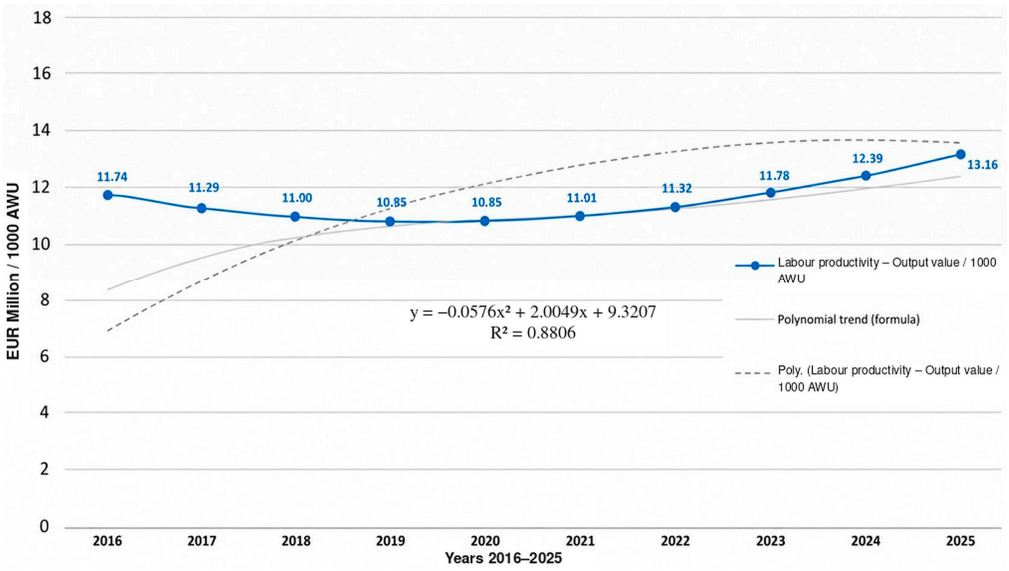



**Figure 3.** Agricultural Output Value per 1000 AWU in Romania, 2016–2025, (Million EUR). Source: Authors' own calculations and graphical representation based on Eurostat data [69–71,74].

To complete the analysis of the determinants of labour productivity and economic sustainability in family farms in Romania, Figure 4 highlights the evolution of gross value added per 1000 AWU during the period 2016–2025, a relevant indicator for assessing the agricultural sector's capacity to transform labour into economic value and to support the differentiated performance of farms according to their economic size class.

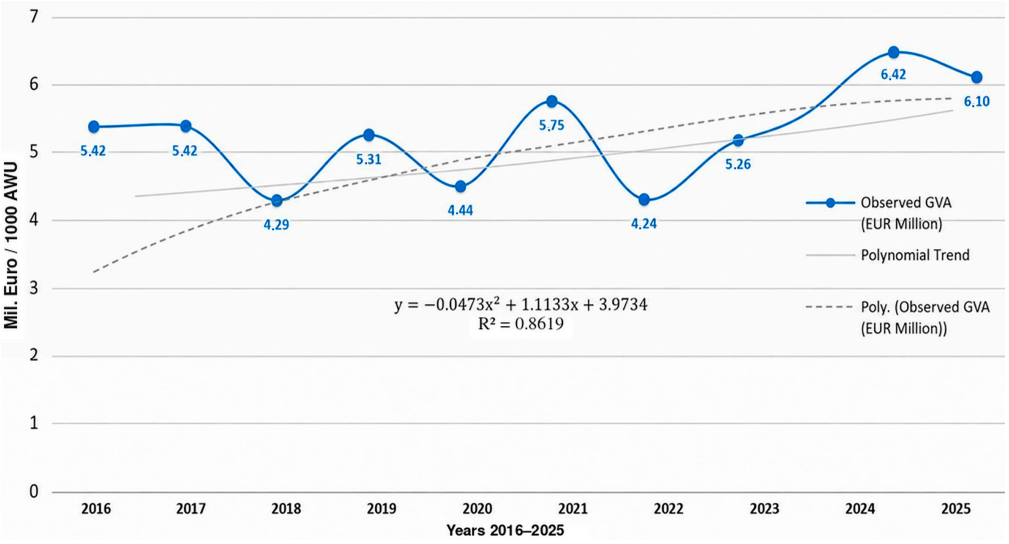



**Figure 4.** Gross value added per 1000 AWU, in Romania, 2016–2025 (Million EUR). Source: Authors' own calculations and graphical representation based on Eurostat data [69–71,74].

Figure 4 presents the evolution of gross value added per 1000 AWU in Romanian agriculture during 2016–2025, offering a key indicator of labour-based economic performance and the sector's capacity to generate value. The trajectory is predominantly positive, unfolding in three distinct phases that together are consistent with a strong long-term upward trend, occasionally interrupted by short periods of adjustment.

Between 2016 and 2025, the indicator displayed noticeable year-to-year fluctuations while maintaining a clear long-term upward trend. Gross value added per 1000 AWU amounted to EUR 5.42 million in 2016 and remained at the same level in 2017, before declining to EUR 4.29 million in 2018. The indicator recovered to EUR 5.31 million in 2019, decreased again to EUR 4.44 million in 2020, and reached EUR 5.75 million in 2021. A temporary decline to EUR 4.24 million occurred in 2022, followed by a sustained recovery, with gross value added increasing to EUR 5.26 million in 2023 and EUR 5.79 million in 2024, before reaching a peak of EUR 6.42 million. A slight adjustment was recorded in 2025, when the indicator declined marginally to EUR 6.10 million per 1000 AWU. Overall, despite these periodic fluctuations, the series indicates a gradual improvement in labour-based value creation, reflecting the progressive modernization and structural transformation of Romanian agriculture.

The polynomial trend model provides a descriptive fit to the observed trajectory: $y = -0.0473x^2 + 1.1133x + 3.9734$, with a coefficient of determination of $R^2 = 0.8619$, indicating that approximately 86.2% of the variation in gross value added per 1000 AWU is explained by the fitted trend.

This high explanatory power suggests an overall upward pattern but does not, by itself, establish that this pattern reflects a genuine structural transformation rather than short-term fluctuation; the residual variance still points to the potential influence of factors such as farm economic size, technological investment and specialization, access to subsidies, production structure, and market integration.

In relation to the research topic, the figure supports the argument that economic sustainability in Romanian family farms depends on the capacity to transform agricultural labour into added value. Semi-subsistence farms, characterized by excessive labour use and limited market orientation, remain less able to generate high GVA per AWU. In contrast, small commercial and medium-sized family farms tend to achieve stronger performance when they combine labour efficiency, specialization, technology, and better market access. The sustained upward trend observed in Figure 4, despite the slight correction recorded in 2025, does not reflect uniform progress across all farms but rather a gradual and increasingly consistent structural transformation across different economic size classes.

The slight decline from EUR 6.42 million in 2024 to EUR 6.10 million in 2025 suggests that recent productivity gains remain sensitive to external economic and climatic conditions. This reinforces the need for policies supporting technological modernization, irrigation infrastructure, farm advisory services, value-chain integration, and a more balanced distribution of CAP support. Overall, Figure 4 indicates that Romanian agriculture has recorded an overall improvement in its capacity to generate gross value added per labour unit, although these gains remain uneven across farm size classes and continue to depend on the pace of structural modernization.

### *4.4. Economic Determinants of Labour Productivity*

The studies covered a wide spectrum of economic determinants that may influence labour productivity in Romanian family farms. Table 5 groups these economic determinants by category.

**Table 5.** Categories of economic and contextual factors associated with labour productivity in the reviewed studies.

| Determinant Category | Specific Factors Examined | Studies |
| --- | --- | --- |
| 1. Input costs | Mineral fertilizer consumption, fuel expenditure, electricity expenditure; specific costs (seeds, fertilizers, pesticides); material costs | [51,65,75] |
| 2. Management factors | Education, continuing education; motivation, job satisfaction; digitalization; farmers' education and knowledge leverage | [10,51,54,72,76] |
| 3. Market factors | EU integration, CAP subsidies; prices, transport, sales to processing plants; market integration | [52–54,67,72] |
| 4. Production factors | Scale (farm area); technology adoption; production value, specialization; land fragmentation | [9,51,52,54,63] |
| 5. Labor-related factors | Age of farmer; aging population; labour use, cost, productivity trends; labour input | [9,52–54,63] |
| 6. Policy and institutional | CAP subsidies (both pillars); farm incomes and subsidies effects; direct payments; agro environmental support | [53,62,75,77] |

Sources: authors' contribution.

### *4.5. Relationships Between Economic Determinants and Labour Productivity*

To facilitate the interpretation of the Eurostat-based sectoral analysis, Table 6 provides a comparative synthesis of the main structural and economic determinants associated with labour productivity and economic sustainability across different economic size classes of family farms. The synthesis integrates the evidence presented in the previous analyses (Tables 1, 2 and 4; Figures 3 and 4) and highlights the observed relationships between farm structural characteristics, labour productivity measured by Standard Output per Annual Work Unit (SO/AWU), and economic sustainability measured by Gross Value Added per Annual Work Unit (GVA/AWU). Rather than implying causal relationships, the table summarizes the consistent patterns identified in the sectoral analysis and provides an integrated framework for interpreting the performance of family farms across different structural conditions.

Table 6 summarizes the main structural and economic characteristics associated with labour productivity and economic sustainability across different economic size classes of family farms, integrating the evidence obtained from the Eurostat-based sectoral analysis. Overall, the comparative assessment indicates that larger economic size classes and higher average utilized agricultural area are consistently associated with higher values of both Standard Output per Annual Work Unit (SO/AWU) and Gross Value Added per Annual Work Unit (GVA/AWU), suggesting a more efficient use of labour resources and a stronger capacity to generate economic value.

Conversely, a high prevalence of small and fragmented holdings is associated with lower levels of labour productivity and weaker economic performance. This pattern is particularly evident in countries where farms below 10 ha represent a substantial share of the agricultural structure, highlighting the structural constraints imposed by land fragmentation. Although these findings do not imply causality, they indicate that structural characteristics may play an important role in shaping differences in labour productivity across family farms.

**Table 6.** Comparative evidence on the structural determinants associated with labour productivity and economic sustainability in family farms across different economic size classes (Eurostat-based sectoral analysis).

| Determinant | Eurostat Indicator | Association with Labour Productivity (SO/AWU) | Association with Economic Sustainability (GVA/AWU) | Evidence from the Present Sectoral Analysis |
|---|---|---|---|---|
| Economic size of farms | Standard Output classes | Positive | Positive | Medium and large family farms consistently generate higher SO/AWU and GVA/AWU values than very small farms (see Table 2). |
| Average utilised agricultural area | Average UAA per holding | Positive | Positive | Countries with larger average holdings generally exhibit higher labour productivity (see Table 1). |
| Farm fragmentation | Share of holdings < 10 ha | Negative | Negative | Highly fragmented farm structures are associated with lower productivity levels and reduced economic performance (see Table 1). |
| Standard Output | SO/AWU | Direct indicator | Indirect | Higher standard output per worker reflects greater labour productivity (see Table 4). |
| Gross Value Added | GVA/AWU | Indirect | Direct indicator | Increased value added per annual work unit reflects higher economic sustainability (see Figure 4). |
| Labour utilisation | AWU | Context-dependent | Context-dependent | Productivity depends primarily on output generated per worker rather than labour input alone. |
| Structural transformation | Evolution of farm structure | Positive | Positive | Structural consolidation contributes to improved economic performance over time (see Figures 3 and 4). |
| Technological development | Long-term productivity trend | Positive | Positive | Progressive increases in SO/AWU and GVA/AWU indicate continuous technological and managerial improvements (see Figures 3 and 4). |

Source: Authors' own calculations and synthesis based on Eurostat datasets: Economic Accounts for Agriculture (aact_eaa01), Agricultural Labour Input Statistics (aact_ali01), and Farm Structure Statistics—area, labour force, and Standard Output by agricultural size class and NUTS-2 region (ef_kvftaa and ef_kvaareg), complemented by the authors' sectoral analysis. The reported associations represent observed sectoral patterns and do not imply causal relationships.

The comparison further shows that labour productivity should be interpreted as a multidimensional concept. While SO/AWU primarily reflects production efficiency, GVA/AWU captures the economic value generated by each unit of labour, providing complementary information on the economic sustainability of agricultural holdings. Consequently, both indicators should be considered jointly when assessing the performance of family farms.

Finally, the observed long-term increases in SO/AWU and GVA/AWU across most of the analysed countries are consistent with gradual structural transformation, technological

progress and improvements in farm management. However, the magnitude of these improvements differs considerably among countries and economic size classes, indicating that labour productivity remains strongly associated with structural characteristics rather than with labour input alone.

### *4.6. Heterogeneity of Labour-Productivity Effects by Farm Size*

The relationship between economic determinants and labour productivity was found to vary significantly according to farm economic size. Table 7 presents the findings on how determinant effects vary by size category.

**Table 7.** Size-related effects on labour productivity.

| Size-Related Finding | Evidence | Study |
| --- | --- | --- |
| 1. Eco-efficiency increases with farm size | Eco-efficiency and human capital efficiency increase with area for small- and medium-sized farms | Polcyn et al., 2021 [50] |
| 2. Human capital underutilization in small farms | Increase in human capital efficiency with area indicates inefficiency in smaller farms | Polcyn et al., 2021 [50] |
| 3. Economies of scale in farm area | Larger farm areas associated with greater economic sustainability | Smedzik-Ambrozy et al., 2021 [9] |
| 4. Diseconomies of scale in labor | Labor input shows negative influence on economic sustainability | Smedzik-Ambrozy et al., 2021 [9] |
| 5. Large farms absorb most subsidies | Large-scale farms absorbed most Direct Payments funds | Gheorghe et al., 2022 [51] |
| 6. Land fragmentation affects small farms more | Land fragmentation and education are more significant impediments for smaller farms | Prigoreanu et al., 2025 [5]; Gheorghe et al., 2022 [51] |
| 7. Policy effectiveness varies by size | Policy measures are less effective for semi-subsistence and subsistence farms | Jitea et al., 2014 [77] |
| 8. Volume of production vs. area | Volume of production significant for market integration; farm area not significant | Stepien et al., 2022 [78] |
| 9. Specialization allows activity increase | Specialization key factor allowing increased activity without more land | Stepien et al., 2022 [78] |
| 10. Medium farms perform best | Medium-sized farms achieve best performance (Sustainable Value) | Burja et al., 2016 [72] |
| 11. Small farms provide safety net | Small farm consolidation slow due to safety net role for poor rural populations | Trienekens J.H. 2011 [79] |

Sources: Authors' own synthesis and interpretation based on the reviewed literature [5,9,50,52,72,77,79].

Table 7 shows that the associations between farm characteristics and labour productivity vary across farm-size categories. The reviewed evidence generally associates larger farm area with stronger eco-efficiency and economic sustainability, although the direction and magnitude of these relationships differ across national and institutional contexts. Borychowski et al. [52], for example, reported positive farm-area effects in Poland and Moldova but negative effects in Lithuania and Serbia, while production volume displayed a more consistent association with market integration than farm area alone. Specialization may therefore enable farms to increase their activity without necessarily expanding their land base [52,78]. Medium-sized farms appear to achieve a comparatively favourable balance between resource use, labour productivity, and Sustainable Value [72], whereas smaller farms remain more frequently associated with fragmentation, limited capitaliza-

tion, and underutilized human resources [5,9,50,51]. These findings represent associations reported in the reviewed studies and should not be interpreted as uniform causal effects across all farming systems.

### *4.7. Synthesis and Hypothesis Testing*

The combined evidence from the systematic literature review and the descriptive Eurostat-based sectoral analysis enables a structured assessment of the extent to which the observed patterns are consistent with the four research hypotheses. In this context, "supported" means that the relationship proposed by a hypothesis is consistently reflected in the reviewed literature and in the descriptive sectoral evidence. "Partially supported", means that the proposed relationship is present but varies across farm-size classes or depends on structural, financial, and institutional conditions. These terms are used as interpretive classifications of evidence consistency; they do not refer to formal causal hypothesis testing. Overall, the findings indicate that labour productivity is associated with a combination of structural, financial, technological, production, market, and human-capital conditions, but the study design does not permit causal attribution to any individual factor.

**H1.** *Supported. The evidence synthesized from the systematic literature review, including the reviewed FADN-based studies, and the descriptive farm-size profiles is consistent with a non-linear association between farm size and labour productivity. Small commercial farms (5–20 ha) appear particularly responsive to production specialization, market integration, and technological modernization, whereas semi-subsistence farms are associated with land fragmentation, surplus labour, and weak commercialization [5,9,50,51,72,78]. Medium-sized farms display a comparatively balanced relationship between labour efficiency and economic sustainability [72], while studies examining larger farms report economies of scale alongside possible diminishing returns to additional labour inputs [9,50].*

**H2.** *Partially supported. Financial resources, CAP support, investment capacity, and capital intensity are positively associated with technical efficiency and labour productivity in several reviewed studies, particularly among medium-sized and large farms [51,62,75,77]. However, direct payments alone are not consistently associated with sustained productivity growth and may, under certain structural and institutional conditions, be accompanied by subsidy dependence rather than stronger market orientation [5,51,77]. The relationship between financial support and productivity therefore appears to depend on its interaction with technological investment, production specialization, and market integration [33,37,46].*

**H3.** *Partially supported. Human capital is generally positively associated with labour productivity, farm performance, and market integration, but the strength of this relationship varies across farm-size classes and institutional contexts. Higher educational attainment and stronger technological capabilities are associated with better performance, particularly among commercially oriented farms [31,33,51,80]. In smaller farms, the contribution of human capital may be constrained by limited investment capacity, fragmented land resources, and restricted access to innovation and advisory services [50,51]. Human capital should therefore be interpreted as a context-dependent enabling condition rather than as a universally operative determinant.*

**H4.** *Supported. The reviewed evidence indicates that production intensity, specialization, and market integration show more consistent associations with labour productivity than agricultural area alone [52,78]. Specialization may enable farms to increase output and value added without necessarily expanding their cultivated area, which is particularly relevant in Romania, where land fragmentation remains an important structural constraint [5,75]. Small commercial farms appear*

*to benefit most from specialization and stronger market integration, whereas semi-subsistence farms remain associated with structural barriers that restrict productivity growth [50,72,78].*

Overall, the assessment of the hypotheses indicates that labour productivity in Romanian family farms is associated with a combination of structural, financial, technological, production, market, and human-capital conditions rather than with farm size alone. Evidence from the systematic literature review and the descriptive Eurostat-based sectoral analysis suggests that sustainable productivity improvements are more likely to be associated with integrated policy measures supporting technological modernization, production specialization, market integration, investment capacity, and human-capital development across different farm-size classes [5,37,46,51,72,80]. These findings support a size-differentiated interpretation of labour-productivity patterns but do not permit causal attribution to any individual determinant.

### *4.8. The Area–Volume Distinction and Size-Dependent Mechanisms*

A key interpretive insight concerns the distinction between farm area and production volume as drivers of labour productivity. While most reviewed studies report a positive association between farm area and economic performance, Borychowski et al. [52] found this relationship to be non-significant for Romania. This inconsistency is resolved by the findings of Stepien et al. [78], who demonstrated that production volume—rather than area—is the significant predictor of market integration across all countries examined. This distinction is central to understanding why specialization emerges as a critical factor: specialized farms can increase output without expanding their land base, a mechanism particularly relevant in the Romanian context where 94% of holdings operate on less than 10 hectares (Table 1).

This finding also clarifies the nonlinear pattern documented in Table 2. The relationship between farm size and labour productivity is curvilinear: small farms face constraints of inefficient scale and human capital underutilization, medium-sized farms achieve optimal sustainable performance [75], and large farms encounter coordination costs and diminishing marginal returns to labour [9,81]. The implication is that farmers must reach minimum production volume thresholds to access profitable markets and technologies, but can do so through intensification rather than area expansion [13,16].

### *4.9. Policy Effectiveness and Financial Determinants*

The evidence on CAP subsidies reveals an important asymmetry. The combination of both pillars contributed to technical efficiency, whereas second-pillar subsidies alone showed no discernible impact [82]. This suggests synergistic effects between direct payments and rural development programs that do not operate independently. Furthermore, the finding that large-scale farms absorbed the majority of Direct Payments, combined with the low policy effectiveness observed for semi-subsistence farms, points to a structural pro-large-farm bias in current policy design. Direct payments also exhibited a slightly negative effect on market value, raising questions about whether subsidy dependence may crowd out market-oriented strategies in certain farm categories.

### *4.10. Human Capital, Demographics, and Contextual Mediation*

Farmer age consistently shows a negative association with economic outcomes [76], with younger farmers being more likely to manage larger and more sustainable operations. The role of education is more nuanced: it is positively associated with market value [83] but non-significant in relation to resilience. This divergence likely reflects differences in outcome measurement; market value captures potential earning capacity from owned assets, whereas resilience measures actual farm stability under stress. The reviewed comparative

studies further suggest that the education–performance relationship is mediated by institutional context, appearing significant in some Central and Eastern European countries but not in others [9,52]. These findings suggest that human capital functions as a context-dependent enabler rather than a universally operative determinant, partially qualifying Hypothesis H3.

### *4.11. Limitations and Future Research Directions*

This review is subject to several limitations. First, the heterogeneity of labour productivity measurement across studies (Table 3) constrains the direct comparability of quantitative findings; standardization of measurement approaches is recommended for future research. Second, the predominance of cross-sectional designs limits the ability to capture dynamic transitions between farm-size categories; longitudinal studies tracking farms through size transitions would provide more robust evidence on threshold effects. Third, the bibliometric coverage, although extensive, may not fully capture grey literature or non-English publications relevant to the Romanian agricultural context. Fourth, because the sectoral analysis relies on national and NUTS-2 aggregate Eurostat data, it cannot track individual farms as they move between economic size classes, which limits the extent to which the observed sectoral trends can be linked to farm-level behaviour.

Future research should address: (1) threshold effects for farm-size transitions, particularly within the 5–20 hectare range, where responsiveness to economic determinants appears highest; (2) interaction effects among digitalization, human capital, and farm size; (3) comparative analysis of intensification versus land-consolidation strategies; (4) behavioural factors influencing farmer motivation and its relationship to market integration; and (5) the effects of the post-2020 CAP reform on size-dependent productivity dynamics.

## 5. Conclusions

This study provides an integrated assessment of the determinants associated with labour productivity and the economic sustainability of Romanian family farms. It combines a systematic literature review conducted in accordance with the PRISMA 2020 framework, covering 34 empirical studies, with an original sectoral analysis based on Eurostat data for 2016–2025 and calculations performed at national and NUTS-2 regional levels. This approach makes it possible to relate the determinants identified in previous research to the structural and productivity patterns observed in Romanian agriculture.

The findings indicate that labour productivity is associated with a combination of structural, financial, technological, production, market, and human capital conditions rather than with farm size alone. Land fragmentation, surplus family labour, limited capitalization, and weak market integration remain the main constraints affecting semi-subsistence farms. Conversely, specialization, technological adoption, investment capacity, managerial skills, and access to profitable markets are consistently associated with higher output and value added per annual work unit.

The relationship between farm size and labour productivity is non-linear and must be interpreted by distinguishing between responsiveness to productivity-enhancing factors and the absolute level of economic performance. Small commercial farms of 5–20 ha display the greatest responsiveness to specialization, improved market access, and technological modernization. Medium-sized farms achieve the most balanced combination of labour efficiency and economic sustainability, while larger farms generally record higher absolute levels of SO/AWU and GVA/AWU because of capitalization and economies of scale. However, their marginal gains may weaken when additional labour inputs increase organizational and coordination costs. Semi-subsistence farms remain the least responsive

category because their structural constraints limit the effective use of capital, technology, and human resources.

The combined evidence supports H1 and H4 and provides partial support for H2 and H3. H1 is supported by the non-linear relationship between farm size and labour productivity, while H4 is supported by the greater importance of production volume, specialization, and market integration compared with agricultural area alone. H2 is only partially supported because CAP subsidies and financial resources improve stability and investment capacity, particularly in medium and large farms, but direct payments alone do not ensure sustained productivity growth. H3 is also partially supported because education and technological capabilities improve farm performance, although their effects depend on farm size, commercial orientation, access to investment, advisory services, and the wider institutional environment. Human capital should therefore be regarded as a context-dependent enabler rather than a universally effective determinant.

The sectoral analysis indicates a general improvement in Romanian agricultural labour productivity during 2016–2025, despite substantial annual fluctuations. The polynomial models provide a good fit for the evolution of agricultural output per 1000 AWU and GVA per 1000 AWU, with coefficients of determination of 0.8806 and 0.8619, respectively. These trajectories are consistent with gradual capitalization, mechanization, technological adoption, and declining labour intensity. Nevertheless, the trend models describe the temporal pattern and should not be interpreted as direct causal evidence of structural modernization. Regional results also reveal pronounced disparities: SO/AWU ranges from approximately EUR 6667 in the North-East region to EUR 16,471 in Bucharest–Ilfov, illustrating the continuing structural duality between regions dominated by fragmented and labour-intensive holdings and those characterized by higher capitalization and stronger commercial integration.

The policy implications are therefore size-specific. Semi-subsistence farms require measures that facilitate voluntary cooperation, access to advisory services, land consolidation, diversification, and transition towards commercially viable activities. Small commercial farms should be prioritized for investment finance, digital technologies, vocational training, specialization, producer organizations, and integration into higher-value supply chains, as they present the greatest potential for productivity gains. Medium-sized farms require support for innovation, risk management, energy efficiency, and sustainable intensification. For larger farms, policy instruments should focus on resource efficiency, environmental performance, labour organization, and stronger conditionality linking public support to measurable productivity and sustainability outcomes. CAP support should consequently complement, rather than replace, technological investment, market orientation, and managerial development.

The study is limited by the heterogeneity of labour productivity indicators used in the reviewed literature, the predominance of cross-sectional studies, and the aggregate nature of the Eurostat sectoral data. These limitations prevent causal inference and do not allow individual farms to be tracked as they move between economic size classes. Future research should therefore employ longitudinal farm-level data, including harmonized FADN observations, to estimate size thresholds and examine interactions among digitalization, human capital, subsidies, specialization, and market integration.

Overall, the results indicate that the long-term competitiveness and economic performance of Romanian family farms are associated not only with agricultural area but also with the capacity to generate output and value added from available labour and land resources. The main contribution of this study is the development of a size-differentiated analytical framework that connects systematic evidence with national and regional productivity patterns. This framework can support the design of more targeted agricultural

policies for Romania and other Central and Eastern European countries characterized by fragmented farm structures and persistent productivity disparities.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The sectoral analysis conducted by the authors is based exclusively on publicly available Eurostat datasets. The dataset codes, indicators, reference periods, and calculation procedures are reported in Section 3.2. No confidential FADN/RICA microdata were used in the authors' original sectoral analysis. FADN/RICA data appear only as data sources in some of the studies included in the systematic literature review. The bibliographic records and data extraction materials used for the review are available from the corresponding author upon reasonable request.

**Acknowledgments:** The authors gratefully acknowledge the support received during the preparation of this manuscript, including access to institutional research infrastructure and bibliographic resources. During the preparation of this study, the authors used generative artificial intelligence tools exclusively for graphical visualization based on bibliometric data. The authors have reviewed and edited all AI-assisted outputs and assume full responsibility for the content of this publication.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## Abbreviations

| | |
|---|---|
| CAP | Common Agricultural Policy |
| CEE | Central and Eastern Europe |
| EU | European Union |
| FADN | Farm Accountancy Data Network |
| FSS | Farm Structure Survey |
| FWU | Family Work Unit |
| SO | Standard Output |
| UAA | Utilized Agricultural Area |
| AWU | Annual Work Unit |
| AFI | Agricultural Factor Income |
| LPA | Labor Productivity in Agriculture |
| NUTS | Nomenclature of Territorial Units for Statistics |

## Appendix A

**Table A1.** Characteristics of included studies.

| No | Study | Geogr. Scope | Type | Data Source | Time Period |
|---|---|---|---|---|---|
| 1 | J. Polcyn et al., 2021 [50] | CEE comparative | Primary | Survey | 2019 |
| 2 | A. Nowak, T. Kijek, 2016 [67] | Poland | Primary | N/S | 2016 |
| 3 | S. Stepien et al., 2022 [78] | CEE comparative | Primary | Questionnaires | 2018–2019 |
| 4 | A. Andrejovska et al., 2022 [83] | EU comparative | Primary | FADN | 2009–2018 |
| 5 | S. Maican et al., 2021 [10] | Romania | Primary | Quest., FADN | 2019 |
| 6 | K. Smedzik-Ambrozy et al., 2021 [9] | CEE comparative | Primary | Surveys, FADN | 2018–2019 |
| 7 | W. Poczta; J. Średzińska; M. Chenczke [30] | EU-wide | Primary | FADN | N/S |
| 8 | E. Gheorghe et al., 2022 [51] | Romania | Primary | Intl. databases | 2005–2019 |
| 9 | C. Alexandri, 2017 [84] | Romania—regional | Empirical—secondary data | FSS, FADN | 2007–2012 |
| 10 | M. Borychowski et al., 2020 [52] | CEE comparative | Primary | Surveys | 2018–2019 |

**Table A1.** *Cont.*

| No | Study | Geogr. Scope | Type | Data Source | Time Period |
|---|---|---|---|---|---|
| 11 | Kryszak, Ł.; Guth, M.; Czyżewski, B. [14] | EU-wide | Primary | Surveys | 2019 |
| 12 | Burja Camelia et al., 2016 [72] | Romania | Primary | FADN | 2007–2016 |
| 13 | N. Galluzzo, 2020 [59] | Romania | Primary | FADN | 2007–2018 |
| 14 | A. Nowak et al., 2019 [55] | EU-wide | Primary | FADN | 2013–2016 |
| 15 | C.G. Bocean, 2024 [85] | EU-wide | Empirical—secondary data | Eurostat | Cross-sectional |
| 16 | I. Prigoreanu et al., 2025 [5] | EU and Romania | Primary | FADN | 2013–2022 |
| 17 | P. Kostov et al., 2019 [61] | EU comparative | Primary | FADN | 2008 |
| 18 | N. Galluzzo et al., 2022 [12] | Romania | Primary | FADN | 2007–2018 |
| 19 | A. Muntean et al., 2024 [80] | Romania | Primary | Surveys | N/S |
| 20 | C. Gavrilescu et al., 2012 [86] | Romania | Primary | N/S | N/S |
| 21 | I. Jitea et al., 2014 [77] | Romania | Primary | N/S | 1998–2013 |
| 22 | A. Popescu et al., 2016 [11] | Romania and EU-28 | Empirical—secondary data | Eurostat and official agricultural statistics | 2003–2013 |
| 23 | C. Alexandri et al., 2020 [87] | Romania | Empirical—secondary data | Public FADN database | 2007–2017 |
| 24 | M. Taylor et al., 2018 [62] | Romania | Primary | N/S | N/S |
| 25 | M. Guth et al., 2020 [37] | CEE comparative | Primary | Surveys | 2009–2018 |
| 26 | I. V. Burja et al., 2020 [27] | Romania | Primary | N/S | 2007–2015 |
| 27 | C. Hubbard et al., 2014 [76] | RO and Bulgaria | Primary | FADN | 2010–2012 |
| 28 | H. Klikocka et al., 2021 [88] | EU-wide | Empirical—secondary data | Eurostat, FADN | 2016 |
| 29 | A. Coppola et al., 2022 [58] | Italy | Primary | FADN | 2018–2020 |
| 30 | A. Ursu et al., 2023 [89] | Romania | Empirical—secondary data | NIS, Eurostat | 2014–2022 |
| 31 | C. Ivascu, A.E. Danuletiu, 2021 [90] | Romania—regional | Empirical—secondary data | INSSE (National Institute of Statistics) | 2008–2020 |
| 32 | A.H., Kagan, 2021 [65] | EU-wide | Primary | FADN | 2025 |
| 33 | R. Rys-Jurek, 2018 [57] | EU-wide | Primary | FADN | 2004–2017 |
| 34 | O. Coca et al., 2023 [73] | EU comparative | Primary | N/S | 2010 |

Note: CEE = Central and Eastern Europe; FADN = Farm Accountancy Data Network; FSS = Farm Structure Survey; NIS/INSSE = (Romanian) National Institute of Statistics; N/S = not specified.

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