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INEFFICIENCY AMID SUSTAINABILITY? EVALUATING TECHNICAL EFFICIENCY IN MOLDOVA'S ORGANIC FARMING SECTOR

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Abstract

This study investigates the technical efficiency of organic farms in the Republic of Moldova, aiming to assess how efficiently certified organic farms utilize available resources to produce economic outputs. The research draws on primary data collected through a structured survey conducted between March and June 2023, covering 63 farms managing a total of 19,456 hectares, including 5,320 hectares under certified organic farming. Due to data consistency requirements, 35 farms with complete and non-zero input-output records were selected for the technical efficiency analysis. To evaluate efficiency, a non-parametric methodology was applied using an input-oriented Data Envelopment Analysis (DEA) under Variable Returns to Scale (VRS). The results reveal a low average technical efficiency (TE) score of 0.32 indicating that most farms operate significantly below their potential. Only 8.6% of farms were found to be highly efficient (TE > 0.7), while over 60% fell into the low-efficiency category (TE ≤ 0.4). High-efficiency farms tend to exhibit leaner input structures, better cost control, and more consistent revenue streams, while low-efficiency farms often manage substantial organic land without generating proportional output. Spatial disparities were also observed in certain districts (Falesti, Telenesti, and Singerei) outperforming others (Riscani and Edinet). The findings suggest that technical efficiency in Moldova's organic farming sector is constrained not by land area or subsidies, but by managerial practices, input-output alignment, and market integration. A shift from uniform subsidy programs to performance-based support, combined with peer learning from high-performing farms and targeted training for underperforming districts, is essential to improve technical efficiency across the organic farming sector.

Key words: *agriculture, economic performance, technical efficiency, organic farming*

INTRODUCTION

Organic farming is increasingly promoted as an environmentally friendly alternative to conventional agriculture, aligning with broader sustainability goals such as biodiversity conservation, reduced chemical use, and improved soil health. However, from point of view of efficiency, particularly technical efficiency there are both advantages and disadvantages compared to traditional/ conventional agricultural systems.

Some research points out empirical evidence that organic farms generate lower yields and revenues comparing to conventional agriculture due to the existing restrictions on input use [16, 17]. Despite organic farms can exhibit higher technical efficiency comparing to its out-production frontier, but still behind conventional agricultural systems in absolute terms. Also, organic farms can experience a lower efficiency during the conversion period, as more applied knowledge on organic practices and experience is accumulated [12, 14, 18].

There is evidence that organic agricultural systems can be more efficient than conventional ones due to better input use in terms of labor and costs [11]. In some cases, organic agriculture experienced higher efficiency and profitability due to market premiums for organic products [1, 9].

Organic agriculture efficiency can be increased from innovation and knowledge transfer. Thus framers that adopt innovative practices tend to achieve higher total factor of productivity (TFP) [10]. A great role in improving efficiency has the diffusion of knowledge, particularly during conversion phase. At the same time, geographical location and clustering effects can be crucial to improve efficiency of organic farms, as those that are located in regions with higher density of organic farms benefit from localized economies of scale, better market access and knowledge spillovers [12].

While organic farming is often perceived as less efficient in terms of output maximization, its sustainability benefits challenge traditional metrics of technical efficiency. By integrating ecological services—such as soil regeneration and reduced pollution—into efficiency assessments, some studies argue that organic systems may exhibit a different kind of "multi-dimensional efficiency" that conventional systems lack [10, 13]. Some studies [10] provided more evidence into the source of inefficiencies. Using DEA, they found that while both organic and conventional households showed suboptimal economic efficiency, the primary constraint for organic producers was allocative inefficiency. These findings are consistent with previous research [6], who emphasized that allocative inefficiency is often rooted in market imperfections or lack of managerial know-how, particularly relevant for organic farmers who operate under different regulatory and input constraints. Although organic farms may have lower productivity and efficiency indicators, these can result from the limited and less intensive use of inputs, which aligns with the ecological objectives of organic agriculture. However, inefficient input combinations can undermine the economic sustainability of organic farming systems. This dual challenge calls for targeted policy interventions: improving farmer education and access to tailored advisory services, while promoting organic input markets and appropriate pricing mechanisms.

In the context of Moldova, organic farming has received policy support through several legal and institutional initiatives. Financial support mechanisms, such as post-investment subsidies and compensation for conversion costs, have been introduced to encourage ecological farming. Nevertheless, challenges remain, particularly the limited recognition of Moldovan certification on the EU market, insufficient trained specialists, and reduced land conversion to organic production in recent years [4].

At the international level, organic agriculture has expanded rapidly. The EU-27 has shown a consistent increase in organic land in countries such as Spain, Italy, Germany, and France [15].

The aim of this research is to analyze the performance of organic farms in Moldova based on estimating farms technical efficiency. This research tries to assess if under sustainability aims, organic farms are desirable from ecologic point of view and/or efficient use of resources in terms of input-output conversion.

MATERIALS AND METHODS

The assessment of technical efficiency (TE) in organic farming has become increasingly significant in recent years due to the dual emphasis on sustainability and economic viability. While organic farming systems contribute to environmental preservation and the reduction of chemical inputs, they often face challenges related to optimizing resource use and minimizing production costs. Evaluating efficiency in this context provides critical insights into how well farms utilize their available resources to achieve maximum outputs without compromising their ecological goals.

Efficiency analysis in production economics assumes that the overall efficiency of a firm can be decomposed into two primary components: technical efficiency (TE) and allocative efficiency (AE) [8]. Technical efficiency reflects how effectively a farm utilizes its available inputs to achieve the highest possible output, or conversely, how efficiently it can use the least amount of inputs to produce a given level of output.In contrast, allocative efficiency reflects the farm's capability to combine inputs in optimal proportions, taking into account the relative prices of those inputs and the prevailing production technology. Together, TE and AE form economic efficiency (EE), which represents the overall cost-effectiveness of production [7, 3]. In organic agriculture, both TE and AE play a crucial role because farms often operate under constraints that affect input choices, such as limited availability of certified organic inputs, higher labor requirements, and market imperfections. Results of previous research observe that inefficiencies in organic farms often are more from allocative inefficiencies—misalignments in input use relative to price signals—than from purely technical inefficiencies [3].

Various approaches have been developed in the literature to estimate TE, broadly classified into parametric and non-parametric methods. Parametric approaches like Stochastic Frontier Analysis (SFA) rely on a predetermined functional form for the production function and allow for the separation of inefficiency effects from statistical noise. In contrast, non-parametric techniques, such as Data Envelopment Analysis (DEA), build the efficiency frontier directly from the observed data, without imposing assumptions about the underlying production technology [5]. DEA is widely used in agricultural research due to its flexibility in dealing with diverse farm types and its capability to incorporate multiple inputs and outputs simultaneously.

For this study, DEA was chosen due to its suitability for small to medium-sized samples and its capacity to evaluate farms relative to a "best-practice" frontier. DEA is advantageous when production processes are diverse or poorly defined, as is often the case with organic farming systems [6,7]. Moreover, DEA facilitates both input-oriented and output-oriented models, making it adaptable to different research objectives.

An input-oriented DEA model under Variable Returns to Scale (VRS) was applied. This specification is appropriate for the organic farming sector in Moldova for two main reasons. First, farmers typically have greater control over input use—such as land allocation, labor hours, and input purchases—than over output levels, which are often influenced by weather conditions and market demand. Second, the VRS assumption accounts for differences in scale efficiency across farms, which is essential given the structural diversity ranging from smallholder family farms to larger enterprises. Using a Constant Returns to Scale (CRS) assumption would have ignored these scale variations and potentially distorted the efficiency estimates [2]. This study is based on primary data collected through a survey conducted between March and June 2023, targeting certified organic farms in the Republic of Moldova. The initial sample included 63 farms, managing a total of 19,456 hectares of agricultural land, of which 5,320 hectares were cultivated under certified organic practices. The reference period for data collection was 2020–2022.

The sample reflects the sector's diversity in terms of legal form, size, and regional distribution. Limited Liability Companies (LLCs) represent the majority (73%) and manage 89% of the surveyed agricultural land, with 87.7% of it under organic production. Family farms (individual farms and enterprises) account for the remaining share. Regionally, 51% of the farms are located in the north, 38% in the center, and 11% in the south. Farms also vary widely in size, with 29% cultivating under 20 hectares and 17% managing more than 500 hectares.

For the technical efficiency (TE) analysis, the number of farms was reduced to 35, excluding those with missing or zero values for critical input or output variables such as land area, labor, costs, or revenue. This step ensured the reliability of the results and avoided computational errors related to undefined or skewed efficiency scores. DEA calculates an efficiency score for each farm—ranging from 0 to 1. A score of 1.0 indicates that the farm lies on the efficiency frontier, meaning it is fully technically efficient relative to its peers. Scores below 1.0 signal that the farm is inefficient and could proportionally reduce input use while maintaining the same output level. The decomposition of efficiency can also reveal the relative importance of technical versus allocative inefficiencies, though this study focuses primarily on TE [3].

To capture spatial variations, the TE scores were aggregated and analysed at the district level. This spatial mapping helps identify high-performing regions and potential problem areas, offering insights into where policy interventions and capacity-building programs might be most needed.

RESULTS AND DISCUSSIONS

To examine technical efficiency (TE) of organic farms were selected 35 farms from the survey data set.

The average registered TE score is 0.32 which suggests that surveyed farms produce only 23.3 percent of the output given the existing input levels. A score of 0.25 for the median suggests that above 50 percent of farms are operating at or below one quarter of their optimal efficiency (Table 1).

Table 1. Descriptive statistics

Statistic	Value
Count	35
Mean	0.323
Median	0.250
Standard Deviation	0.239
Minimum	0.020
25th Percentile	0.120
75th Percentile	0.520
Maximum	0.840
Skewness	0.98
Kurtosis	2.74

Source: Own calculation.

Standard deviation had a value of 0.239 which assumes large variation across farms, indicating a heterogenous farm sector, most of which are underperforming or near-efficient farms.

Minimum value is 0.02 which assumes extreme inefficiency, while maximum value of 0.84 indicated that the farm operates at 84% of their potential, almost approaching the efficiency frontier.

The TE scores are positively skewed (skewness = 0.98), revealing that most farms cluster at the lower end of the efficiency spectrum, while a smaller number perform relatively well.

The kurtosis of 2.74 further indicates that the distribution is leptokurtic — characterized by a sharp peak and heavier tails — pointing to the presence of outliers on both extremes.

This asymmetric distribution suggests that while a few farms have achieved notable efficiency gains, the majority face operational inefficiencies, possibly due to suboptimal input use, lack of technical knowledge, or limited market access.

To further interpret the variability in performance among the surveyed organic farms, the computed technical efficiency (TE) scores were categorized into three performance categories: high efficiency (TE > 0.7), moderate efficiency (0.4 < TE ≤ 0.7), and low efficiency (TE ≤ 0.4) (Table 2). This classification framework allows for a better understanding of the relative positioning of farms along the efficiency spectrum and facilitates the identification of specific intervention needs.

Table 2. Technical efficiency of organic farms in Moldova

Efficiency Category	Number of Farms	Percentage
High Efficiency (TE > 0.7)	3	8.6%
Moderate Efficiency (0.4 < TE ≤ 0.7)	10	28.6%
Low Efficiency (TE ≤ 0.4)	22	62.9%

Source: Own calculation.

The majority of farms (62.9%) fall into the low-efficiency category, meaning they operate at less than 40% of their potential output, given current input levels. This finding is consistent with the earlier observation that the mean technical efficiency for the sample is approximately 0.323. The moderate-efficiency group comprises just under a third of the sample (28.6%), reflecting farms with some capacity for optimization but still falling significantly short of best-practice benchmarks. Only 3 farms (8.6%) exhibit high efficiency, suggesting that a very limited number of operators are successfully managing inputs and resources to maximize output.

The analysis reveals a cluster of farms at the lower end of the efficiency distribution, with technical efficiency scores ranging from 0.02 to 0.07. Despite managing large areas of certified organic land (between 100 and 195 hectares), these farms demonstrate minimal or even negligible revenue generation from organic production In contrast, the top 10% of performers had TE scores above 0.68, with notably different operational patterns. These farms vary in scale — from 22 ha to over 333 ha — but share common traits: better conversion of costs into organic revenue, consistent productivity levels, and lean input structures. The disparity between top and bottom performers within Moldova's organic farming sector underscores a pronounced heterogeneity in both operational structure and outcomes. High-efficiency farms tend to

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exhibit several defining characteristics. These farms generally operate with well-optimized input structures, allowing for cost-effective resource use and relatively stable, consistent revenue streams. Despite often being small or medium-sized in scale, they manage to sustain profitability, largely due to superior managerial capacity, access to markets, and perhaps closer integration with consumer preferences or international demand. Their performance reflects strategic decision-making and an ability to align certification with actual production and marketable output, maximizing the value derived from their organic status.

In contrast, low-efficiency farms experience a different case. Although some of these farms manage or possess large tracts of certified organic land, they often fail to translate this advantage into meaningful economic returns. Many such farms generate extremely low income levels, which suggests fundamental inefficiencies in how land and resources are utilized. There are clear signs of underutilization of certified areas, with production either insufficient, inconsistent, or poorly aligned with market opportunities. This is compounded by evident disconnects between the processes of certification, actual production practices, and the capacity to market or sell organic products at a premium. These disparities indicate that organic certification alone is not a sufficient predictor of performance; rather, success hinges on the effective integration of land, management, production strategies, and access to appropriate sales channels.

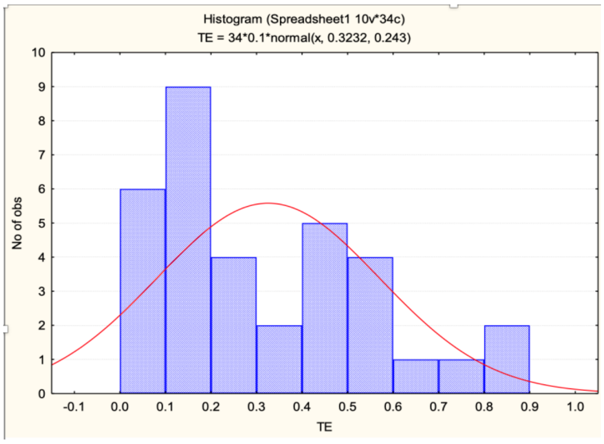

Fig.1. Distribution of technical efficiency (TE) among organic farms
Source: own processing.

The histogram (Fig. 1) clearly illustrates a strongly right-skewed distribution of technical efficiency (TE) scores among organic farms in Moldova. This skewed pattern reveals a sector where the vast majority of farms operate with relatively low efficiency, while only a small number manage to achieve high performance. The calculated skewness coefficient of 0.98 quantitatively confirms the presence of asymmetry, indicating that a significant concentration of farms performs far below the efficiency frontier. The average TE score across all farms stands at approximately 0.32, suggesting that, on average, farms convert only about one-third of their available inputs—land, labor, and capital—into productive organic output. Even more telling is the median TE score of 0.25, which implies that more than half of the farms perform below the already modest average. The range of scores, spanning from a low of 0.02 to a high of 0.84, underscores the stark variability in performance across the sector, from extreme inefficiency to near-optimal use of resources.

This distribution has several significant implications for understanding the structure and dynamics of Moldova's organic farming sector. First, the pronounced clustering of farms in the lower efficiency bands ($TE < 0.4$) points to a widespread problem of underperformance. Such inefficiencies may stem from poor managerial practices, inadequate training or technical support, suboptimal allocation of inputs, or limited access to profitable markets for organic products. Many farmers may lack the necessary knowledge, tools, or incentives to improve efficiency, resulting in low productivity.

Second, the presence of a small group of isolated high performers—those with TE scores above 0.75—suggests that it is indeed possible to operate organic farms efficiently in Moldova, but that success remains the exception rather than the rule. These top-performing farms may benefit from better technical expertise, stronger organizational capacity, closer alignment with certification and organic standards, and superior access to infrastructure or market networks. Their ability to operate near the efficiency frontier serves as a benchmark for what is achievable in the sector under the right conditions.

Third, the relatively thin middle tier of efficiency (TE between 0.4 and 0.7) highlights a missing ladder of progressive improvement. This absence of a critical mass of moderately efficient farms suggests that many producers are either unable to overcome initial inefficiencies or are hindered by structural barriers that prevent incremental gains in productivity. It indicates a polarized landscape where farms tend to remain stuck in low-efficiency traps or, in rare cases, leap to high performance, bypassing intermediate stages of development. This gap challenges policymakers and development practitioners to identify and address the specific constraints—whether technical, financial, institutional, or infrastructural—that hinder the broad-based improvement of organic farming efficiency in Moldova. Bridging this gap could be key to unlocking more inclusive and sustainable growth within the sector. The geographic distribution of technical efficiency (TE) among organic farms in the Republic of Moldova reveals notable disparities. Based on the obtained results (Table 3), TE values vary significantly across districts, indicating that the efficiency of converting inputs into economic outputs is not uniform nationwide.

Table 3. Economic performance of organic farms based on TE score, by districts

District	Technical efficiency (TE)
Anenii Noi	0.59
Causeni	0.11
Drochia	0.16
Dubasari	0.17
Edinet	0.09
Falesti	0.66
Floresti	0.2
Glodeni	0.375
Hincesti	0.29
Ialoveni	0.12
Orhei	0.49
Rezina	0.29
Riscani	0.03
Singerei	0.46
Soroca	0.12
Stefan-Voda	0.14
Telenesti	0.46

Source: own processing.

According to the efficiency scores, the top-performing districts include Falesti (0.66), Anenii Noi (0.59), Orhei (0.49), Telenesti (0.46), and Singerei (0.46). These regions demonstrate a relatively high capacity to utilize land, labor, and capital efficiently in organic farming. The consistent performance of these districts likely reflects the presence of more structured farm management, better access to extension services, and stronger integration into organic value chains. Their role as regional efficiency hubs could be further leveraged to support peer learning and capacity-building initiatives.

In contrast, several districts continue to underperform, with TE values well below the national average. Notably, Riscani (0.03), Edinet (0.09), Causeni (0.11), and Ialoveni and Soroca (both 0.12) report the lowest efficiency scores. These low values suggest that farms in these areas face structural or operational challenges—such as limited market access, weak technical knowledge, or ineffective use of support programs—which hinder their ability to generate proportional economic returns from their organic production efforts. The persistence of such inefficiencies highlights the need for targeted interventions tailored to district-specific constraints.

Some districts occupy a middle ground. For instance, Glodeni (0.375), Hincesti and Rezina (both 0.29), and Floresti (0.20) present moderate efficiency scores. These regions may benefit from targeted training and advisory services to help transition farms from moderate to higher efficiency levels. Moreover, the moderate averages could also reflect a mix of well-managed and struggling farms within the same district, indicating internal variability and potential for improvement through localized support strategies.

Overall, the data show that central and northern regionsgenerally perform better in terms of efficiency, while eastern and southern regions appear to lag. This geographic representation adds a spatial dimension to the farm-level analysis, helping to identify efficiency clusters and priority areas for intervention. Policymakers and development agencies could use this information to prioritize technical training, infrastructure investment, and subsidy optimization in underperforming districts, while also scaling up best practices from high-performing ones.

CONCLUSIONS

This study investigated the technical efficiency of certified organic farms in the Republic of Moldova, utilizing a non-parametric analytical approach based on a DEA-style input-output ratio adjusted through log transformation. Drawing on detailed farm-level data, the results reveal that the organic farming sector in Moldova currently operates well below its productive potential. The average technical efficiency (TE) score across the sample is only 0.32 indicating that most farms are producing less than one-third of the output they could achieve with existing resources. These findings point to a widespread underutilization of inputs suggesting critical inefficiencies not just in production but also in resource allocation, market integration, and knowledge application.
A key pattern identified is the high proportion of low-performing farms. Over 60% of all surveyed farms fall into the low-efficiency category, with TE scores below 0.4. Many of these farms manage considerable organic areas and receive state subsidies but generate very limited revenues from organic products. This highlights a misalignment between certification status and effective participation in organic markets. Furthermore, efficiency does not appear to be strongly correlated with the scale of production or the volume of subsidies received. Several farms with large input volumes—including those with over 100 hectares of certified land—appear in the bottom 10% of the efficiency distribution, often reporting very low revenues. Conversely, the top-performing farms—representing only 8.6% of the total sample—tend to have leaner cost structures, moderate landholdings, and consistent, even not exceptionally high, revenues. These farms demonstrate that technical efficiency is not simply a function of input scale but rather of managerial capability, cost control, and effective market engagement.
District-level analysis reveals clusters of higher-efficiency farms in areas such as Falesti, Anenii Noi, and Orhei**,** while consistent underperformance is evident in Riscani, Edinet, and Causeni**.** These geographic patterns likely reflect a combination of infrastructural, institutional, and informational factors, including proximity to markets, access to training, and the quality of local extension services. The variation observed within individual districts—such as Glodeni and Hincesti—also suggests that intra-regional disparities, possibly tied to farm-level managerial differences or social capital, play a significant role in shaping outcomes.
The findings highlight the need to shift from input-based subsidies to performance-based support**,** rewarding farms for outcomes like revenue, yield, and improved efficiency. Low-performing farms should receive targeted assistance, including training, diagnostics, and advisory services, while top-performing farmscan serve as models for peer learning. Addressing spatial disparities requires prioritizing underperforming districts for investment in infrastructure and human capital.
In conclusion, the low average technical efficiency observed across Moldova's organic farms signals a critical need for reform in both farm management practices and public support policies. However, the presence of a small but significant group of highly efficient farms demonstrates that achieving high performance under organic principles is possible. Unlocking this potential will require a dual strategy: investing in underperforming farms to build capacity and scaling up the success factors evident in leading farms. Through regionally differentiated interventions, performance-based incentives, and a stronger knowledge-sharing infrastructure, Moldova can enhance the viability and competitiveness of its organic agriculture sector while advancing broader sustainability goals.

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