Research Article

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Organizational-economic efficiency of raspberry farming – case study of Kosovo

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Abstract: The raspberry sector in Kosovo is increasingly recognized for its potential to drive economic growth and improve livelihoods in rural communities, yet it faces significant technical challenges. This study evaluates the organizational-economic efficiency of raspberry farms in Kosovo, using data envelopment analysis and Tobit regression in R. The findings indicate that raspberry farms are operating at 57.3% of their potential production under constant returns to scale, with considerable room for improvement. Variable returns to scale analysis shows efficiency at 80.7%, suggesting efficiency varies with operating scale. Inefficient farmers are advised to reduce labor and orchard maintenance costs to improve the efficiency of their farms. Tobit regression highlights the positive effects of farmer experience and education on efficiency. This study underscores the raspberry sector's potential to contribute significantly to Kosovo's economy through improved input optimization and scale efficiency enhancements. By focusing on education and experience, policymakers and farmers can work together to unlock the sector's full potential, ultimately benefiting local communities and promoting sustainable agricultural practices.

Keywords: raspberry farmers, technical efficiency, data envelopment analysis, Tobit regression model, Kosovo

1 Introduction

According to the Food and Agriculture Organization (FAO), global raspberry production has been increasing steadily over the past few decades, driven by rising consumer demand and expanding cultivation areas in countries like Serbia, Poland, and the United States [1]. Raspberry is one of the most profitable fruit products. The economic significance of its production is manifested in the high level of merchandising, competitiveness, and growing need for frozen raspberries on the market of the European Union [2].

Raspberry cultivation is a significant agricultural activity with a substantial economic impact worldwide. According to the FAO, global raspberry production has seen a consistent increase due to rising consumer demand and expanding cultivation areas. Countries like Serbia, Poland, and the United States have been at the forefront of this growth, leveraging favorable climatic conditions and advancements in agricultural practices to boost production [1]. Raspberries are not only consumed fresh but also processed into various products such as jams, juices, and frozen goods, which are highly demanded in the European Union market [2].

Technological advancements have played a crucial role in enhancing raspberry production efficiency. Innovations in irrigation, pest control, and post-harvest handling have significantly reduced losses and improved the quality of produce. In addition, the development of high-yield and disease-resistant raspberry varieties has contributed to increased productivity. Countries with advanced agricultural research facilities have been able to introduce these innovations to their farmers, resulting in higher yields and better market prices. Several studies have explored the organizational-economic efficiency of various agricultural sectors, providing insights into how efficiency can be improved through better resource management and technological adoption. For example, a study on the technical efficiency of rice farms in Indonesia highlighted the importance of efficient input use and the adoption of modern farming techniques to enhance productivity [3]. Similarly, research on agricultural households in East Java, Indonesia, underscored the role of technical efficiency in ensuring food security and improving household incomes [4].

Studies across the globe have focused on the factors influencing efficiency, the role of technology, and the marketing dynamics of agricultural products. Shanmugam and Venkataramani [5] analyzed district-level agricultural efficiency in India, identifying socio-economic and ecological factors as key determinants. The study highlighted that

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access to education, technology, and credit facilities played a vital role in improving efficiency. Berhanu and Mesfin [6] assessed the efficiency of smallholder wheat farmers in Ethiopia. The study concluded that land fragmentation and limited access to extension services were significant barriers to efficiency, while better input use and training programs were associated with higher productivity.

Another study investigated the technical efficiency of small-scale raspberry producers in Central Chile. The study emphasized the role of diversified marketing channels in improving efficiency. Farmers who accessed multiple sales outlets achieved better efficiency scores, highlighting the importance of market access and knowledge [7]. Maldonado et al. [8] explored the relationship between commercialization channels and technical efficiency among raspberry farmers in Chile. The study concluded that better market integration and the use of cooperative marketing strategies were pivotal in achieving higher efficiency. Tapia et al. [9] analyzed efficiency levels among raspberry farmers, focusing on the impact of marketing channels. The study highlighted that producers utilizing cooperative channels or direct sales performed better than those relying solely on intermediaries.

The study done in Chilean raspberry farmers emphasized the importance of improving farm-to-market logistics to reduce inefficiencies [10]. Bekele et al. [11] studied the technical efficiency of periurban farms, including raspberry cultivation. The research revealed that proximity to urban markets and access to modern inputs significantly improved farm efficiency.

The economy of Kosovo was severely damaged by the 1999 war, particularly its agricultural sector. The rural population was forced to abandon their homes, leaving behind livestock and equipment [12]. Consequently, after the war, the agricultural sector was in a dire state, with unused land and a shortage of seeds, fertilizers, pesticides, and basic equipment [13]. The relevance of these studies to Kosovo's raspberry sector cannot be overstated. Kosovo's unique geographical and climatic conditions make it well-suited for raspberry cultivation. However, the sector faces several challenges, including small farm sizes, low productivity, and insufficient advisory services. By learning from global best practices and technological advancements, Kosovo can significantly enhance its raspberry production efficiency.

The economic importance of agriculture is higher than in most regions of Europe. The sector played a significant role in employment in Kosovo after the war. The main characteristics of Kosovo's agriculture include the dominance of small farms, low productivity, and insufficient extension services. However, the sector contributes about 11–12% of gross domestic product and employs 25–30% of total employment, mainly in the informal sector. It also accounts for around 16% of total export value [14]. Subsistence farming is widespread in the Western Balkans, making Kosovo a compelling case for development studies. Even though rural areas, which account for 60% of the population, are predominant, they do not significantly drive economic growth. One of the key reasons for this is that agriculture is at a standstill, mainly because most farms focus on producing for their own consumption.

One of Kosovo's agricultural success stories is the raspberry industry. Growing raspberries has become a major horticultural activity in the country, thanks to its unique geography and climate, as well as the hard work of local farmers. Raspberries have emerged as a key fruit in the economy, with great potential for growth due to favorable natural conditions. Although currently grown on a small scale, there's room for expansion to meet both local and export demands. Currently, there are 1,300 hectares of cultivated raspberry. In 2018, raspberry cultivation covered 1,537 hectares, which is an increase of 306 hectares compared to 2017.

In 2011, in Kosovo, there were cultivated about 20 ha with raspberries, while, in 2020, the surface increased significantly, and reached up to 1,500 ha. In Kosovo from 2014 to 2020, around 30,000 metric tons of raspberries were produced, and the average production for these 7 years showed to be 4,200 metric tons annually. In 2020, around 4,000 tons of raspberries were produced locally [15]. Almost all of this amount is dedicated to export markets, to the EU countries, especially to Germany. At present, 98% of the raspberries are sold in frozen form on the international frozen market, and only 2% are sold in the domestic fresh market [16].

The raspberry sector is crucial for Kosovo for several reasons, and its impact goes beyond just the agricultural industry. First, raspberries have become one of Kosovo's top agricultural exports, generating vital income for thousands of farmers and rural communities. This sector creates jobs, supports family farms, and helps lift people out of poverty in rural areas where employment opportunities can be limited. By boosting local economies, the raspberry industry helps improve living standards and keeps young people engaged in farming, reducing rural-urban migration. Additionally, Kosovo's climate and soil are ideal for growing raspberries, making this crop a natural fit for the region. The country's entry into the European raspberry market has also given it an edge in international trade. Kosovo's raspberries are known for their high quality, and their popularity in Europe helps establish the country as a competitive player in the global market. Beyond

economics, the raspberry sector supports community development by encouraging local cooperation, such as the creation of farmer cooperatives and associations. These groups not only help farmers improve their production techniques but also provide a unified voice to advocate for better policies and market access. The success of the raspberry industry shows how agriculture can be a powerful driver of development in Kosovo, providing sustainable growth and promoting social stability.

The purpose of this study goes beyond just measuring efficiency. It aims to gain a deeper understanding of the factors that affect the performance of raspberry farms in Kosovo. By using input-oriented data envelopment analysis (DEA), the study highlights which farms are making the best use of their resources. Tobit regression is then applied to explore how factors like farm size, farmer education, and access to resources influence efficiency. The insights gained from this research are meant to help improve productivity in the raspberry sector. The findings can guide policymakers and industry leaders in making informed decisions to increase farm efficiency, enhance the livelihoods of farmers, and ensure the long-term sustainability of raspberry farming in Kosovo. This study not only sheds light on current challenges but also offers a clear path for future improvements. All of the data were entered into SPSS, then imported, read, and analyzed with *R*.

2 Methodology

2.1 Study area and data collection

Kosovo is strategically located in southeastern Europe, with its borders touching Albania to the southwest, North Macedonia to the southeast, Serbia to the north and northeast, and Montenegro to the northwest. Kosovo is positioned in the central part of the Balkan Peninsula (Lat. 42°34′59.88″ Nand Long. 21°00′0.36″E) and has a surface area of 10,908 km^2. Kosovo is ranked among the top

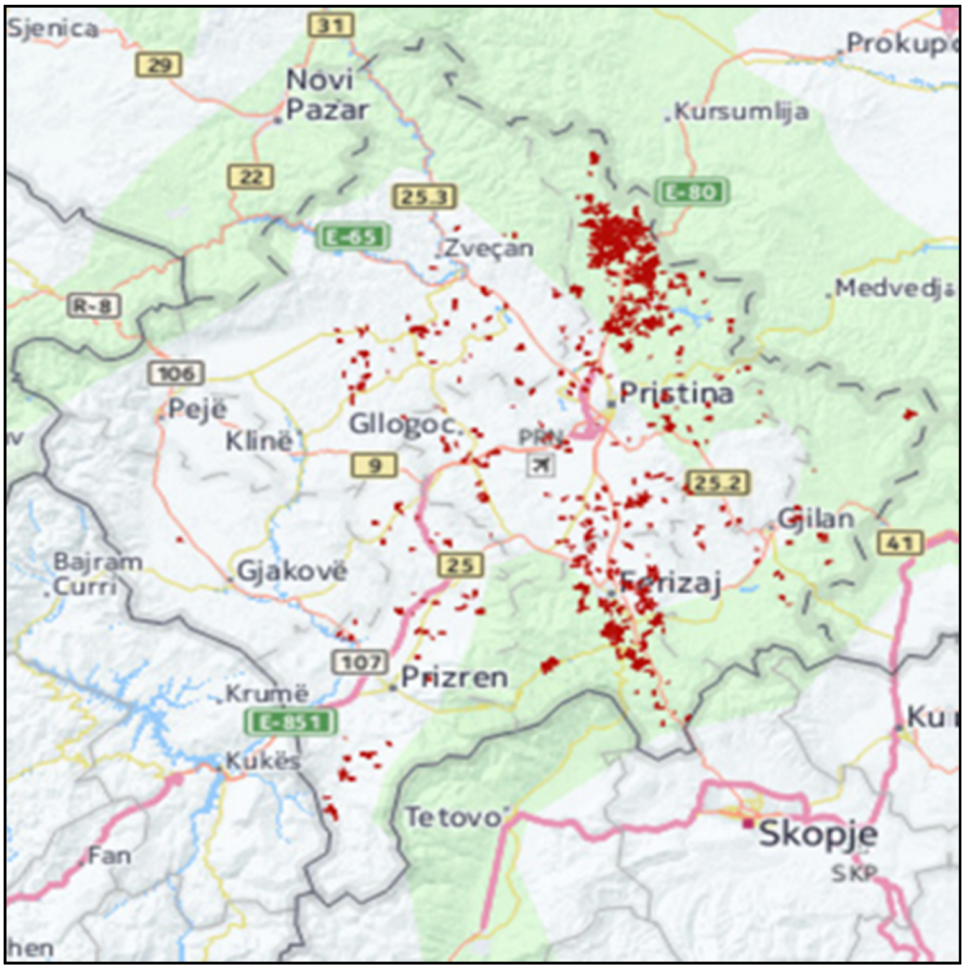

Figure 1: Raspberry cultivation in Kosovo. Source: Mjedra e Kosovës, 2023.

European countries for floristic assets due to its favorable physical and geographical conditions.

This geographical position endows Kosovo with a unique blend of climatic conditions, including a continental climate in the interior and a Mediterranean climate in the southern regions. Such diversity facilitates the cultivation of a wide range of crops and makes it particularly favorable for the production of raspberries.

The study area comprises major raspberry-producing regions in Kosovo (Figure 1). Visits to 50 raspberry farms were conducted from November 2023 to December 2023. Primary data (e.g. demographic data; labor force engaged in the sector, cultivated area, yields, costs, and income from raspberry culture) were collected through a structured questionnaire using a random sampling technique. This approach enables a better understanding of the state of the sector as well as the development of the raspberry sector in Kosovo. DEA was used to evaluate organizational-economic efficiency, considering inputs (labor, area, and maintenance costs) and outputs (quantity, income). Tobit regression analyzed the impact of socio-economic factors (age, experience, and education) on efficiency. Data analysis was conducted using SPSS and R.

Informed consent: Informed consent has been obtained from all individuals included in this study.

2.2 Efficiency measurement

DEA was used to evaluate organizational-economic efficiency, because it can handle more input and more output variables. This method emphasizes individual observations over statistical estimates (as in regression analysis) [3]. DEA has been successfully employed to study the comparative performance of units that consume similar inputs to produce similar outputs. Generally, these units are referred to as decision-making units (DMUs) [17].

Based on the research assumptions, the DEA model consists of two types: the Charnes–Cooper–Rhodes (CCR) DEA model assumes constant return to scale (CRS), while Banker–Charnes–Cooper (BCC) DEA model assumes variable return to scale (VRS). Based on the orientation, we can distinguish between input-oriented and output-oriented DEA models. The input-oriented DEA model focuses on reducing inputs while keeping the output level constant. In contrast, the output-oriented DEA model seeks to maximize the proportional increase of output for a given input set [18]. DEA allows for the assessment of the relative efficiency of DMUs by comparing the observed input-output combinations with the best-performing units in the sample. The CCR model assumes CRS, while the BCC model accounts for VRS.

The conventional DEA model for estimating organizational-economic efficiency can be written as follows [18]:

$$\mathrm{Min}_{\theta,\lambda}\theta_k.$$

Subject to:

$$\begin{aligned} -y + Y\lambda &\geq 1, \\ \theta_{xk} - X\lambda &\geq 0, \\ \sum_{j=1}^{n}\lambda_j &= 1, \\ \lambda_j &\geq 0, \end{aligned} \tag{1}$$

where $\boldsymbol{\theta_i}$ is the value of organizational-economic efficiency (in the following: OEE) ranging from 0 to 1, an OEE value equal to 1 implies that a raspberry farmer is efficient from an organizational-economic point of view. In contrast, an OEE value below 1 ($\mathbf{0} < \boldsymbol{OEE} < \mathbf{1}$) means that a raspberry farmer is technically inefficient. The vector $\boldsymbol{\lambda}$ is a weight vector (constant) Nx_1 that defines the linear combination of the counterparts of the kth DMU (each of N farmers). Y represents the vector of the output quantities (y_{1j} = quantity of raspberry, y_{2j} = income), and X represents the vector of the observed inputs (x_{1j} = full-time workers, x_{2j} = seasonal workers, x_{3j} = area of cultivation, x_{4j} = costs of the maintenance of orchard (cost of pesticides, fertilization, water, and mechanization)).

Y is the output vector of the ith DMU compared to the output vector of the theoretically efficient DMU ($\boldsymbol{Y\lambda}$). $\boldsymbol{X\lambda}$ is the minimum input of the theoretically efficient DMU, given the output level produced by the ith DMU (each of N farmers). X_i is the input level of the kth DMU [18]. Equation (1) represents the CRS, also known as overall organizational-economic efficiency, suggesting that farmers operate on an optimal scale. Overall efficiency is composed of two parts: from pure efficiency (PTE), which points to the management practice under the VRS assumption and the residual called the scale efficiency (SE) [3,18].

(i) The input-oriented CCR DEA model has the form [19]:

$$\max \ = \frac{\sum_{r=1}^{q} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}.$$

Subject to

$$\begin{cases} \dfrac{\sum_{r=1}^{q} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad (j = 1, \ldots, n), \\ u_r \geq 0 \ (r = 1, \ldots, q) \ v_i \geq 0 \ (i = 1, \ldots, m). \end{cases} \tag{2}$$

The output-oriented CCR DEA model has the following form [19]:

$$\min = \frac{\sum_{i=1}^{m} v_i x_{ik}}{\sum_{r=1}^{q} u_r y_{rk}}.$$

Subject to

$$\begin{cases} \dfrac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{q} u_r y_{rj}} \geq 1 \ (j = 1, \ ..., \ n), \\ u_r \geq 0 \ (r = 1, \ ..., \ q) \ v_i \geq 0 \ (i = 1, \ ..., \ m). \end{cases} \quad (3)$$

(ii) the input-oriented BCC DEA model has the form [19]:

$$\max = \sum_{r=1}^{q} \mu_r y_{rk} + \mu_0.$$

Subject to

$$\begin{cases} \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \mu_0 \leq 0 \quad (j = 1, \ ..., \ n) \\ \mu_r \geq 0 \left(r = 1, \ ..., \ q^{\sum_{i=1}^{m} v_i x_{ij} = 1} \right), \\ v_i \geq 0 \ (i = 1, \ ..., \ m) \mu_0 \epsilon R, \end{cases} \quad (4)$$

and the output-oriented BCC DEA model has the following form [19]:

$$\max = \sum_{i=1}^{m} v_i x_{ik} + v_0.$$

Subject to

$$\begin{cases} \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + v_0 \leq 0 \quad (j = 1, \ ..., \ n) \\ \mu_r \geq 0 \left(r = 1, \ ..., \ q^{\sum_{i=1}^{m} \mu_r y_{rk} = 1} \right), \\ v_i \geq 0 \quad (i = 1, \ ..., \ m) v_0 \ \epsilon R. \end{cases} \quad (5)$$

2.3 Regression analysis

Since socio-economic factors cannot be directly incorporated into the DEA model to evaluate their effect on efficiency, we employed Tobit regression analysis to examine the relationship between these variables and efficiency scores. Tobit regression models are statistical models that describe the relationship between at least one independent variable, xi, and a censored continuous dependent variable [20]. Tobit regression is very adequate to represent the model of the efficiency effect [4]. For more details with the following specifications [3]:

$$\text{OEE}_i = \beta_0 + \beta_1 X_1 + B_2 X_2 + ... + B_3 X_3 + \varepsilon_i. \quad (6)$$

For efficiency score

$$\text{OEE}_I = L_{1i}, \ \text{if} \ \text{OEE}_I \leq L_{1i} = \text{OEE}_i^*, \ \text{if} \ L_{1i} < \text{OEE}_i^* \leq L_{2i} = L_{2i}, \ \text{if} \ \text{OEE}_i^* \leq L_{2i},$$

where OEE_i is the dependent variable being reviewed; OEE_i^* is the organizational-economic efficiency of farmers in raspberry production; β_i is a vector of parameters to be estimated; X_i is an explanatory variable vector that represents socioeconomic characteristics; X_1 is the age of the farmers (years); X_2 is the experience in the raspberry farming (years); X_3 is the duration of formal education (years); ε_i is error term; and L_{1i} and L_{2i} are the lower and upper limit. This model has been estimated with *R*.

3 Results

The raspberry sector is one of the soft fruits in Kosovo that has recently emerged as a very profitable crop. The crop represents one of the most important strategic crops with potential for increasing productivity, expanding cultivated areas, as well as exporting the product to various countries at the same time. In rural areas, cultivation of this fruit reduces unemployment and increases farm incomes, while on the other hand, it can positively influence social welfare and revitalize economic development.

Kosovo's agricultural land is divided into fragmented parcels, which in many cases negatively affects the cost-effectiveness of production. The average area of the raspberry farm was just 1.09 hectares. Based on this study the predominant cultivated variety is Delniwa, which is the primary choice of 40% of the interviewed farmers. Additionally, 24% of farmers have opted to cultivate both Delniwa and Polka, while 16% have chosen to grow both Delniwa and Mapema. There are also several other varieties, such as Endrosadira, Mapeo, Miker, and Tulamen, though they have a smaller representation in terms of cultivated participation. In Kosovo, raspberries are harvested by hand.

A major challenge for raspberry growers is the lack of infrastructure in the rural areas surveyed. These deficiencies affect the quality of roads, water, and electricity networks. For this reason, irrigation is often only possible using farmers' own generators. The solution to these problems should not be the responsibility of farmers, but rather of governments and local authorities. The issue of plant protection, especially weed control, is a widespread problem in the sector. High-quality crop protection work is also negatively affected by limited knowledge and availability of appropriate pesticides for farmers [16].

Table 1: Descriptive statistics of farmers

	Minimum	Maximum	Mean	Std. deviation
Age in years	26	60	43.96	10.616
Experience in years	1	13	6.68	2.979
Education in years	8	18	12.48	0.707

Source: Authors' calculation.

The Table 1 provides a summary of key sample characteristics for a data set comprising 50 farmers. On average, the individuals in this data set are around 44 years old, with a standard deviation of approximately 10.6 years. This means that most people fall within the range of 33.4–54.6 years old. The minimum years of experience in the data set is 1 year, while the maximum is 13 years. On average, individuals have around 6.68 years of experience, with a standard deviation of approximately 3 years. The average education level of the farmers in the study is approximately 12.48, suggesting that, on average, they have completed secondary education.

3.1 Results of the raspberry farming organizational-economic efficiency

The estimated organizational-economic efficiency of raspberry farms in the sample according to the assumptions of CRS, VRS, and SE is presented in Table 2. In the case of CRS, OEE ranged between 0.073 and 1, with a mean score of 0.573, suggesting that, on average, the farms operate at 57.3% of their potential output given their scale of operation and inputs. This indicates there's considerable room for improvement in efficiency. Based on the mean CRS score, raspberry farmers must reduce inputs by 42.7% to make their raspberry farming efficient.

Under the VRS, OEE ranged between 0.284 and 1. The average efficiency score improves to 0.807 under the VRS assumption, meaning farms, on average, operate at 80.7% of their potential output when allowing for VRS. According to the mean VRS score, the raspberry farmers in the sample must reduce inputs by 19.3% to make their raspberry production efficient. Under SE, OEE ranged between 0.087 and 1, with a mean score of 0.708. Based on the mean SE score, the sample of raspberry farmers must reduce inputs by around 29.2% to ensure that their raspberry production is efficient.

The increase in mean efficiency from CRS to VRS indicates that some of the inefficiencies under CRS are due to scale inefficiencies. Farms appear more technically efficient when adjustments for their scale of operation are made. The SE scores are lower than OEE VRS but higher than OEE CRS, suggesting that while scale inefficiencies exist, they are not the sole contributors to overall inefficiency. This means some farms could improve their efficiency by adjusting the size of their operations, but there are also other inefficiencies present.

The evaluation of the efficiency results suggests that all inefficient farmers should reduce the use of inputs in order to make their farming more efficient. Table 3 shows the extent to which expenditure needs to be reduced. According to OEE CRS, OEE VRS, and SE, farmers to increase the organizational-economic efficiency of raspberry production should reduce about 42.62% of full-time workers, 13.05% of seasonal workers, 18.19% of the area, and 41.07% of orchard maintenance costs.

3.2 Determinants of efficiency

In our study, we investigate the determinants of the impact of demographic characteristics on the efficiency of raspberry farming. Our calculations were carried out using three dependent variables: OEE CRS, OEE VRS, and SE scores. The log-likelihood statistics that determine the fit of the model show that the Tobit regression model using the dependent variables can be applied with a significant chi-square test (p-value) at the 1 and 5% level.

Table 2: Raspberry farming organizational-economic efficiency score

Efficiency	Mean	Std. Dev.	Minimum	Maximum
OEE CRS	0.573	0.300	0.073	1
OEE VRS	0.807	0.232	0.284	1
SE	0.708	0.296	0.087	1

Source: Authors' calculation.

Table 3: Reduction of inputs by raspberry farming

Efficiency	Mean	Std. Dev.
Full-time workers in numbers	42.62	0.7054
Seasonal workers in numbers	13.05	2.7591
Area in Ha	18.19	0.4372
Orchard main costs in Euros	41.07	9.7673

Source: Authors' calculation.

Based on the Tobit regression model, we observed that the age variable has a negative coefficient. Specifically, an increase in age leads to a decrease in efficiency scores by 0.003 units. However, with a *p*-value of 0.54, this variable is not statistically significant at conventional levels (*p*-value = 0.05).

On the other hand, the experience variable significantly and positively affects efficiency scores in raspberry farming (*p*-value = 0.000207). The results suggest that a higher level of experience increases efficiency scores by 0.07% (Table 4). Regarding education, we found a positive impact on efficiency scores. An increase of 1 year in formal education increases efficiency scores by around 0.19%. This variable is statistically significant with a *p*-value of 0.018829.

4 Discussion

The raspberry sector in Kosovo offers a wonderful opportunity to improve the lives of people living in rural areas. It has the potential to generate income and create new jobs, which is essential for boosting local economies. However, our study reveals a troubling issue: many raspberry farmers are not using their resources efficiently. While this sector could significantly contribute to Kosovo's economy, there are inefficiencies that need to be addressed to tap into its full potential. Following the results obtained through the use of the DEA approach for organizational-economic efficiency of the raspberry farmers and Tobit regression using the *R*, it was found that on average raspberry farms operate at around 57.3% of their potential output when considering CRS.

This indicates a major opportunity for improvement in efficiency, with an estimated 42.7% reduction in inputs needed to achieve the optimal levels. Interestingly, when we take into account VRS, the average efficiency score rises to 80.7%. This indicates that farmers can perform better when they adapt their practices to fit the specific conditions of their farms. It highlights the importance of tailoring approaches based on each farm's unique circumstances. Additionally, the analysis reveals that inefficiencies related to scale play a major role in overall inefficiency, alongside other factors that need attention. Based on the results derived from the study all inefficient farmers are advised to reduce the use of inputs around 42.62% of full-time workers, 13.05% of seasonal workers, 18.19% of the area, and 41.07% orchard maintenance costs to make their farming efficient.

Our findings from the Tobit regression analysis provide valuable insights into what affects efficiency in raspberry farming. While age seems to have a negative effect on efficiency scores, it is not statistically significant. On the other hand, both experience and education are positively linked to organizational-economic efficiency and are statistically significant. This suggests that investing in training and education for farmers could make a real difference, leading to improved efficiency and productivity. In summary, the raspberry sector in Kosovo has great potential for economic growth and development, but addressing the inefficiencies we've identified is crucial. By optimizing resource use and providing farmers with the necessary education and training, we can help this sector thrive. Ultimately, this could lead to better lives for those in rural communities, ensuring that the raspberry industry plays a vital role in Kosovo's economic landscape.

Table 4: Determinants of raspberry farming efficiency

Coefficients	Estimate	Std. Error	*t* value	Pr (>|*t*|)
(Intercept)	2.048974	0.459769	4.457	8.33×10^{-6}
Age in years	−0.003495	0.005744	−0.609	0.542839
Experience in years	0.071805	0.019350	3.711	0.000207
Education in years	0.187437	0.079798	2.349	0.018829
LogSigma	1.144610	0.152679	7.497	6.54×10^{14}
Log-likelihood	21.72671			

Source: Authors' calculation.

5 Conclusions

This research provides valuable insights for policymakers and farmers aiming to enhance the raspberry sector in Kosovo. By quantifying the organizational-economic efficiency of raspberry farms, the study identifies areas where significant improvements can be made. The findings highlight the importance of optimizing input utilization, such as labor, land, and orchard maintenance costs, to increase productivity and profitability. For policymakers, the results underscore the need for targeted interventions to address the identified inefficiencies. Policymakers can develop strategies to improve infrastructure, access to finance, and extension services, thereby creating a more conducive environment for raspberry cultivation. Additionally, investments in research and development can lead to the adoption of advanced agricultural technologies, which can enhance productivity and sustainability.

For farmers, the study offers actionable recommendations to improve their farm management practices. By

understanding their efficiency scores and identifying areas for improvement, farmers can make informed decisions about resource allocation and input use. Furthermore, the study emphasizes the importance of experience and education in enhancing efficiency, highlighting the need for capacity-building programs and training opportunities for farmers.

In conclusion, several improvements must be undertaken to enhance the efficiency of the raspberry sector in Kosovo. First, the government should improve its extension services by offering more training and educational programs for farmers. These services could focus on teaching modern agricultural techniques and best practices to increase productivity and resource efficiency. By providing tailored guidance on how to optimize the use of inputs such as fertilizers, water, and labor, farmers can significantly improve their production while minimizing waste. Furthermore, more detailed and accessible information should be made available regarding the proper use of inputs. This would help farmers make informed decisions on how to effectively manage their resources, ensuring that they achieve the best possible yields with the resources they have.

Finally, attention should be given to improving packaging and handling standards. By enhancing packaging methods and ensuring that raspberries are transported and stored correctly, the sector can reduce post-harvest losses and improve the overall quality of the product. This would not only help farmers increase their profits but also make Kosovo's raspberries more competitive in the international market. These improvements, along with better coordination between the government, agricultural institutions, and the private sector, could help create a more efficient, profitable, and sustainable raspberry industry in Kosovo.

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Data availability statement: The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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