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International Journal of Food and Agricultural Economics
ISSN 2147-8988, E-ISSN: 2149-3766
Vol. 12, No. 2, 2024, pp. 159-170

ASSESSING TECHNICAL EFFICIENCY IN WINE GRAPE PRODUCTION: THE CASE OF SOUTH BRAZIL

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Abstract:

The aim of this study is to calculate the technical efficiency of wine grape production in the South region of Brazil. Specifically, our main objective is to understand the key farm and farmer characteristics that affect agricultural productivity at the municipality level. The data from IBGE's Brazilian Agricultural Census 2017 are used. The analysis is conducted in two stages. In the first stage, production efficiency using a VRS DEA model is estimated. In the second stage, a Tobit model is used to evaluate the main drivers that influence farm efficiency. The results show that maximum efficiency can be achieved in any of the three South Brazilian states. Efficiency is strongly related to factors such as the size of the vineyard. Moreover, the farmer's age, as well as the participation of women and family members in management, also contribute positively to higher levels of farm efficiency.
Keywords*: data envelopment analysis, regression analysis, vineyards, winegrapes, efficiency, Brazil.*
JEL Codes*: Q10, D24, C14*

1. Introduction

The consumption of wine in Brazil has experienced a remarkable growth in the last two decades (Almeida, Bragagnolo, and Chagas, 2015). Brazilian vineyards, from small family-operated plots to large industrial production plants, have established from the extreme south of the country to areas near the equator (5°S) (Protas, 2008). Traditionally, the South region, particularly Rio Grande do Sul, Santa Catarina, and Paraná, boasts the most favorable climatic conditions for grape cultivation.

Rio Grande do Sul is responsible for 60% of Brazilian wine grape production (Mello, 2016). In 2019, the number of wineries in Rio Grande do Sul increased from less than 500 at the end of the 20th century to around 1,100 (Nierop, 2011; Poletto, 2019). In the state of Rio Grande do Sul, the most important production region is the Serra Gaúcha (Gaúcha mountains), where many small vineyards have been settled for decades (Fensterseifer, 2007; Mello, 2016; Poletto, 2019; J. F. da S. Protas et al., 2002; J. F. S. Protas & Camargo, 2011). A second important grape-producing region in the same state is the Campanha Central (Protas, Camargo, and Mello., 2002; Protas & Camargo, 2011). In contrast to the family vineyards of the Serra Gaúcha, the scale of Campanha Central vineyards is substantially large, and characterized by the intensive use of capital, both in mechanization and labor-intensive resources. In addition to these two main production areas, there are other smaller grape-producing regions in the southeastern mountains. For instance, the central region has also seen a gradual increase in production over the years (Protas & Camargo, 2011).

Wine grape production is also well-established in Santa Catarina, the second state in our analysis. The state is very similar to the Serra Gaúcha Region in terms of soil, climate, and topography. The types of grapes cultivated are similar, and the vineyards, such as those of Serra Gaúcha, are predominantly small and family-operated (Protas et al., 2002). Most vineyards are concentrated in the Peixe River Valley Region (Porro & Stefanini, 2016; Protas et al., 2002), but there are also grape-producing farms in the South Coast, the Santa Catarina Plateau, and the Tijucas River Valley (Protas & Camargo, 2011).

There are also two well-known wine-producing regions in the state of Paraná. The first is the Metropolitan Region of the state capital, Curitiba, which has long been known for its wine production (Protas & Camargo, 2011). The second is the northern region of the state. It has traditionally produced fine grapes and diversified into wine grapes since the 1990s (Protas et al., 2002; Protas & Camargo, 2011; Sato & Roberto, 2004).

The focus of this research is to understand the socioeconomic characteristics of wine grape producers and the factors influencing their production efficiency in the southern states of Brazil. Since agricultural practices and economics in the three states differ significantly while these farmers also have to compete with Argentinean and Chilean wines, the first question to be answered is: Are there differences in efficiency in wine production in these three states? If so, what characteristics of the farmers could be responsible for the differences?

To date, it is noteworthy that few studies on the efficiency of wine-making activity in Brazil have been carried out. To fill this gap, this study investigated the determinants of efficiency in the production of grapes for wine production in South states of Brazil using datasets generated by the Brazilian Agricultural Census of 2017. The focus is to understand which characteristics of producers and production are most directly related to productive efficiency in the South region.

In addition to providing initial information on the subject the efficiency of wine grape production in Brazil, our results may contribute to defining policies regarding Brazilian wine production to protect the livelihoods of small farmers.

The paper is divided into five sections. Following this brief introduction, section 2 describes the data source, the empirical strategy, and the econometric methods adopted for this study. The results and conclusions are presented in sections 3 and 4, respectively.

2. Theoretical Foundation

The analysis in this paper is conducted in two stages. Firstly, we estimate the efficiency of production units, and secondly, we investigate the factors influencing this efficiency.

In the first stage, the efficiency measure allows for comparison of different production units and ranking based on their performance. Common methods for assessing wine grape efficiency cited in literature include ordinary least squares (OLS), production functions, Stochastic Frontier Analysis (SFA), and Data Envelopment Analysis (DEA). Among these, SFA and DEA are the most relevant (Goncharuk, 2018; Krüger, 2012). DEA methodology utilizes mathematical programming techniques without assumptions about data distribution, while SFA estimates parameters econometrically through specific functional forms.

For this study, we utilize a DEA model to calculate efficiency. Previous studies, such as Aparicio, Borras, Pastor, and Vidal (2013), Barros and Santos (2007), Barth (2007), Goncharuk (2018), Goncharuk and Figurek (2017), Maietta and Sena (2008), Sellers, Alampi-Sottini, and Menghini (2016), Sellers and Alampi-Sottini (2016), Townsend, Kirsten, and Vink (1998), Urso, Timpanaro, Caracciolo, and Cembalo (2018), Vázquez-Rowe, Villanueva-Rey, Iribarre, Moreira, and Feijoo (2012) and Vidal, Pastor, Borras, and Pastor (2013), have employed DEA methodology to analyze winery and wine grapes production efficiencies.

Data envelopment analysis (DEA) is a linear programming methodology that aims to measure the efficiency of decision-making units (DMUs) in multi-product, multi-input production processes. DEA, in its current form, was originally introduced in 1978 by Charnes, Cooper and Rhodes (1978), who described it as a mathematical model applied to observable data. In this context, a production unit may achieve higher efficiency by either increasing the amount of product generated with the same number of inputs or decreasing the quantity of inputs for the same level of production. The main advantages of using this methodology over others are its empirical orientation and the absence of assumptions, in contrast to econometric approaches such as stochastic frontier models (Cooper, Seiford, and Zhu, 2004).

To be efficient, a production unit must either maximize the output generated or minimize the inputs employed. According to the classical production theory, a firm uses a variety of inputs to produce a given product through a production function. For this, a given production function must follow some properties, such as: non-negativity, weak essentiality, non-decreasing in inputs and concavity in inputs (Coell, Rao, and Battese, 1998). The DEA approach requires that the DMUs be homogeneous. The solution to problems of this nature occurs through linear programming, maintaining assumptions about production technologies, concavity and monotonicity (Duarte, Salgado, Lemos, Souza, and Antunes, 2019; Gómez, 2016; Salazar-Ordóñez, Pérez-Hernández, and Martín-Lozano, 2013).

There are a variety of studies that calculate the production efficiency of a given industry and then evaluate the determinants of these efficiencies using a Tobit model as a second-stage analysis (Fethi, Jackson, and Weyman-Jones, 2000; Kirjavainen & Loikkanen, 1998). The use of a Tobit model as a second-stage analysis, in the context of models employed in this study, helps to understand the main drivers determining the efficiencies calculated in the first stage of the analysis.

3. Methodology

The first stage of the analysis consists of estimating an input-oriented multi-input DEA with variable returns to scale to assess the efficiency (θ) in wine-grape production in the municipalities of South region of Brazil. The basic DEA model (also called CCR DEA) was first developed by Charnes et al. (1978), based on the studies of Farrell (1957). The extension to the original DEA model applied in this study, called VRS DEA or BCC DEA, considers variable returns to scale (Banker, Charnes, and Cooper, 1984). The input-oriented BCC DEA model evaluates the efficiency of DMUs (decision-making units or farms) ($o = 1, \dots, n$) by solving the linear programing given by equations (1) to (5) (Cooper et al., 2011).

(BCC_0)
$$\min_{\theta_B, \lambda} \theta_B \quad (1)$$

Subject to
$$\theta_B x_o - X\lambda \geq 0 \quad (2)$$

$$Y\lambda \geq y_o \quad (3)$$

$$e\lambda = 1 \quad (4)$$

$$\lambda \geq 0 \quad (5)$$

where θ_B free is a scalar.

In the second stage of the analysis, we use a Tobit model to evaluate the factors that influence the efficiency calculated in the first stage. We opt for the use of the Tobit model because of the censored nature of the efficiency generated by the first stage of analysis based on the DEA model. This is a widely used procedure in the literature when the relationship between exogenous factors and DEA efficiency scores is assessed (Hoff, 2007).

Given the variable of interest θ, the Tobit model considers a censored variable (θ) oriented by a latent variable, w_i, observed only for positive values, that is,

$$\theta_i = \begin{cases} 0, if \;\; w_i \leq 0 \\ w_i, if \;\; w_i > 0 \end{cases} \tag{6}$$

where θ_i is the efficiency obtained by DEA with $i = 1,2, \dots, n$ for the i^{th} unit. We consider that the latent variable, w_i, can be modeled by a set of observable variables, or

$$w_i = \alpha + X'_i\beta + \varepsilon_i \tag{7}$$

where α is the estimated coefficient of the intercept, β is a vector of estimated coefficients, X_i is a matrix composed of the explanatory variables of the model, and ε_i is the stochastic error of the model with distribution $\varepsilon_i \sim N(0, \sigma^2)$.

4. Data and Sample

The basic source of data for this paper is the recent 2017 Brazilian Agricultural Census released by the Brazilian Institute of Geography and Statistics (IBGE), which includes information from all rural farms across the country.

Microdata from individual farms is not publicly available due to IBGE confidentiality issues. Therefore, the unit of analysis adopted for this study is the averaged data for each municipality's wine grape crops. Our study is based on the data available for 311 municipalities in the South region of Brazil, belonging to the states of Paraná, Santa Catarina, and Rio Grande do Sul, as previously described.

For the estimations, we use the Gross Value of Agricultural Production (GPV) of wine grape production from farms at the municipality level as a proxy for production. The inputs include land, labor, and capital employed in grape cultivation. Land is defined as the mean area (in hectares) cultivated with wine grapes in each municipality. Labor force is represented by the mean number of people occupied in production, regardless of their family ties to the farm's owner. Capital employed in wine grapes production is quantified by the number of agricultural tractors, machines, and tools available in the municipality, multiplied by their prices, sourced from the Department of Rural Economy of the Secretariat of Agriculture and Supply of the State of Paraná (SEAB/DERAL) for January 2020. We then divide the total capital by the number of farms in each municipality to obtain the average capital value for the farms.

In the second stage of the model, we used 2017 IBGE agricultural census data at the municipal level. This census provides information on other variables, such as the price received for the grapes, the operational status of the farm (family-operated or not), women's participation in property management, the age of the farm's head, the size of the area cultivated with wine grapes, and the proportion of the municipality's total area devoted to wine grapes cultivation.

5. Results and Discussion

5.1. Descriptive Statistics

Table 1 presents the statistics of all variables used for calculating the two stages of the proposed model. As shown in Table 1, the average GPV, serving as a proxy for production output, is 21.4 thousand Brazilian Reais per farm. For comparative purposes, this value represents an average monthly income approximately 70% higher than the Brazilian minimum wage. Regarding the variables treated as inputs in the production function, the average area cultivated with wine grapes is 1.2 hectare per farm; the number of people employed averages 2.5 workers; and the capital stock amounts to 238.6 thousand Brazilian Reais. The average area cultivated with grapes on rural properties in the South of Brazil is small compared to Brazilian production in other regions. This discrepancy can be attributed primarily to two facts. Firstly, the size of farms in the South of Brazil is smaller than in the rest of the country. Secondly, wine production in these regions is labor intensive, farm income is low, and there are few government incentives to hire labor outside of the family. Consequently, a significant portion of the rural properties producing grapes for wine rely on family labor, which inherently limits the scale of production.

Table 1. Descriptive statistics of the data used, 2017

Variable	Mean	Median	Standard Deviation
Gross Production Value – GPV (R$ 1,000)	21.3586	13.1667	25.4487
Land (hectares)	1.1919	0.8000	1.1220
Labor (workers)	2.4997	2.4787	0.4242
Capital (R$ 1,000)	238.5557	210.8735	139.1057
Price (R$/kg)	2.2250	1.9444	1.1964
Style of farming (% of family farming)	0.8154	0.8401	0.1070
Gender (% of women)	0.1030	0.0979	0.0417
Age of the farm owner	55.2286	55.4708	2.7781
Wine land participation (% in total area)	0.0108	0.0004	0.0445

The Brazilian agricultural census of 2017 indicates that the average price received by farmers was 2.20 Brazilian Reais per kilogram of wine grape. The proportion of family farms involved in wine grape production is 81.5%. The participation of women as the heads of farms in Brazil is still small - only 10.3%. The census also shows that in general, the percentage of young people in the countryside is decreasing, and consequently, the average age of farmers is increasing. In line with this aging trend, the average age of wine grape producers in Brazil is also rising, with an average age of 55 years for our sample. In 2006, the average age of farmers in the three South Brazilian states was approximately 50 years. The average proportion of land cultivated with wine grapes to the total agricultural area of a municipality is 1.08%. This suggests that, in general, agriculture in these states is relatively diversified.

5.2. Efficiency Analysis

Table 2 presents the descriptive statistics (frequency, distribution, mean, median, and standard deviation) for production efficiency calculated by the BCC DEA model in the first stage of the analysis for each state and for the South region, as proposed.

The participation of Rio Grande do Sul in the sample of municipalities is 58.2%, as shown in Table 2. As previously mentioned, Rio Grande do Sul is the largest Brazilian producer of wine grapes. Santa Catarina and Paraná are responsible for 23.8% and 18.0% of the wine grapes in our sample, respectively.

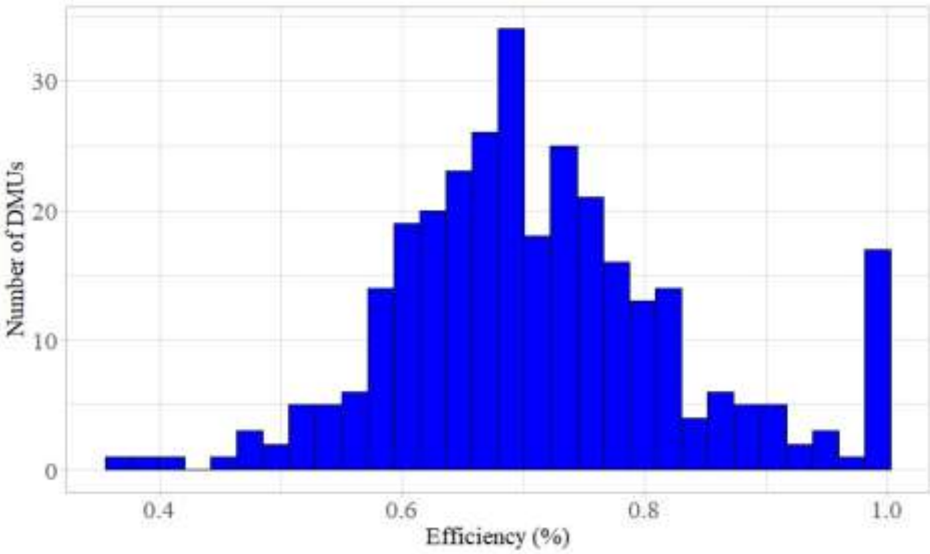
Table 2. Frequency, Distribution, Mean, Median and Standard Deviation of the wine production efficiency in the South region of Brazil, 2017

Region	Frequency	Distribution	Mean	Median	Standard Deviation
Paraná	56	18.0	0.715	0.691	0.1114
Santa Catarina	74	23.8	0.716	0.697	0.1272
Rio Grande do Sul	181	58.2	0.713	0.700	0.1216
South region of Brazil	311	100.0	0.714	0.697	0.1208

Table 2 also presents the average, median, and standard deviations of wine grape production efficiency in the three states. Despite important differences in soil and climate between the states, the efficiency statistics for the complete sample and for each state separately are remarkably similar. The overall average efficiency for the three states is 0.714. Specifically, Rio Grande do Sul has an average efficiency of 0.713, Santa Catarina 0.716, and Paraná 0.715. The calculated medians for the three states are closely aligned: 0.697 overall, 0.700 for Rio Grande do Sul, 0.697 for Santa Catarina, and 0.691 for Paraná. Furthermore, the standard deviations of efficiency show no significant differences: 0.1208 for the complete sample, 0.1216 for Rio Grande do Sul, 0.1272 for Santa Catarina, and 0.1114 for Paraná.

The results reveal that there are no substantial efficiency differences in wine grapes production among the municipalities of the three states. Comparatively, production in Rio Grande do Sul has a longer historical tradition and is more extensive than in the other South states of Brazil. Figure 1 presents the histogram of efficiency calculated using the BCC DEA model for the 311 municipalities.

Figure 1. Histogram of technical efficiency score of the 311 municipalities



Of the 311 municipalities analyzed, 16 reach maximum efficiency, which corresponds to approximately 5% of the sample. Among these, eight are in Rio Grande do Sul, five in Santa Catarina, and three in Paraná. This suggests that achieving 100% efficiency is possible in the three states. The distribution of efficiency shows a greater concentration around the mean of the results. The highest concentration lies in the efficiency range between 0.68 and 0.70. Specifically, 34 municipalities - 11% of the sample – are in this efficiency range.

The map in figure 2 displays the spatial distribution of the 311 municipalities covered by the study and classifies the technical efficiency of the municipalities into six quantiles.

Figure 2. Spatial distribution of technical efficiency score of the 311 municipalities, 2017

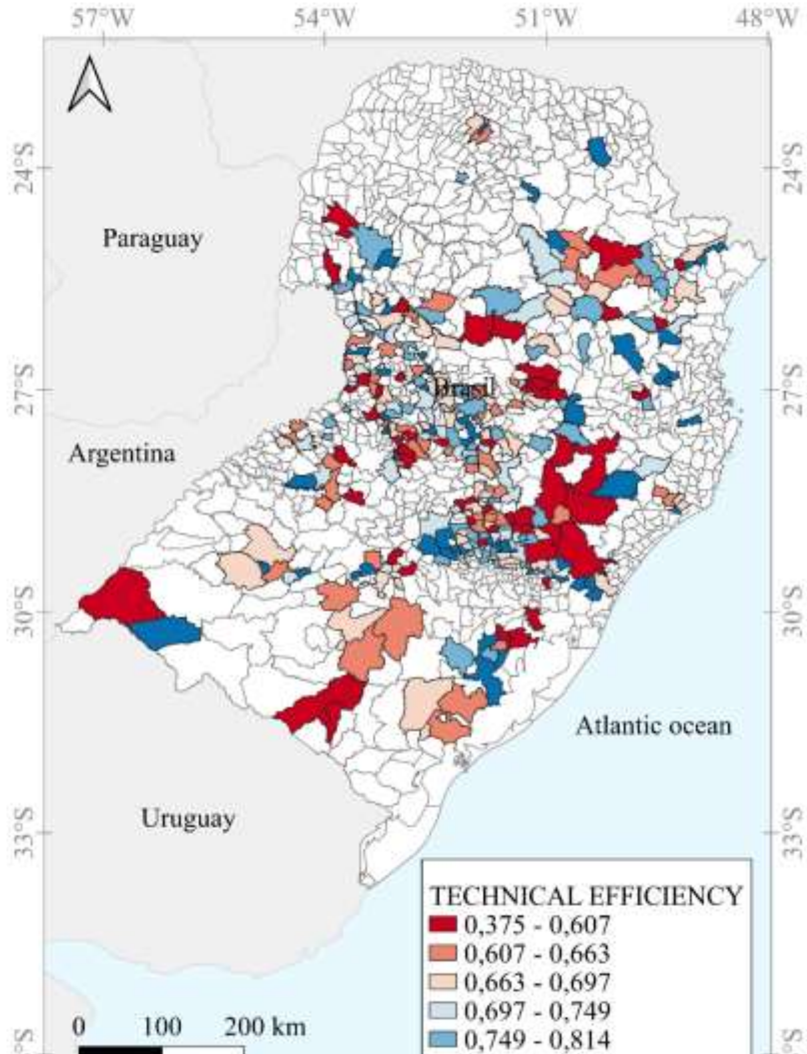


Figure 2 shows that areas of high and low technical efficiency occur equally in the three states. It is not possible to find higher concentrations of technical efficiency in a single region or state.

5.3. Determinants of Efficiency

Table 3 presents the results for two different specifications of the Tobit model designed to evaluate the factors that influence the efficiency calculated in the first stage of the analysis. The first model includes dummies for the states of Paraná and Santa Catarina. The second model, which we used to discuss the results, includes only the statistically significant variables. This allows us to assess the robustness of the results.

Table 3. Tobit Model Results for Wine Grape Producers, 2017

Variable	**Model with state dummies**	**Model without state dummies**
	(1)	**(2)**
Intercept 1	0.2399	0.1960
Intercept 2	-2.1870***	-2.1863***
Price	0.0409***	0.0405***
Style of farming (% of family farming)	0.1495*	0.1583**
Gender (% of women)	0.3367*	0.3201*
Age of the farm owner	0.0046	0.0053**
Land	-0.0280***	-0.0281***
Wine land participation (% of total area)	0.8461***	0.8415***
Paraná	-0.012053	-
Santa Catarina	0.0024	-

Notes: The asterisks (***), (**) and (*) indicate significance at 1%, 5%, and 10% respectively.

To compare the impact of one variable on efficiency against the impact of others, the variables listed in Table 3 are multiplied by the corresponding averages presented in Table 1. The results of these calculations are displayed in Table 4.

Table 4. Coefficients calculated by the Tobit model multiplied by the mean of the variable, 2017

Variable	**Statistic**
Price	0.090
Style of farming (% of family farming)	0.129
Gender (% of women)	0.033
Age of the farm owner	0.293
Land	-0.033
Wine land participation (% of total area)	0.009

The results indicate that there is no significant difference in the level of technical efficiency in the production of wine grapes related to locality, municipality, or state. The variables that are statistically significant include prices, participation of family farming in the municipalities' agriculture, participation of women in farm management, age of the farmer, mean of the cultivated area with wine grapes within a municipality, and proportion of the total municipal area devoted to wine grapes.

According to the results presented in Table 3, as the prices for wine grapes increase, so does the efficiency of farms in the municipalities; that is, producers who receive higher prices are observed to have higher efficiency for their product. Winegrowers who receive higher prices for their grapes have a higher GPV, which automatically increases their measure of efficiency. Although our data does not allow us to test this hypothesis, we believe that these producers are likely associated with wineries that produce higher-quality wine. In the production of higher-quality wines and sparkling wines, which are very popular domestically and for export, the stability of quality and quantity is considered a prerequisite for consolidating a winery's position and the branding of its products (Miele & Zylbersztajn, 2005). Higher-quality wines require higher-quality grapes. To ensure a consistent grape quality, a trusting relationship between suppliers and wineries is essential. Therefore, it is expected that wineries producing better-quality products will sell them at a higher price, and generally, they may have farmers that produce better-quality, higher-priced grapes.

As the participation of family farming in production increases, efficiency in the production of grapes also rises, as shown in Table 3. One of the distinctive feature of fruit farming in the South region of Brazil, and of vitiviniculture in particular, is the intensive use of skilled labor, which occurs on many farms, especially on farms historically managed by their family members (João et al., 2002). Moreover, in some parts of the South region of Brazil, there is a shortage of hired labor for this kind of work (Taffarel & Falcade, 2015; Tonezer, Trzcinski, and Arns, 2017). Farmers who depend predominantly on family labor tend to enhance their workers' skill levels more than those that do not use this type of labor.

As we can see in Table 3, the results also indicated that municipalities with a higher women participation in the production of wine grapes have greater efficiency in production. A similar result is found for a sample of wine producers in Italy, where the productive efficiency of wineries run by women is greater (Urso et al., 2018). To date, no studies in the literature on Brazilian agriculture specifically address the relationship between technical efficiency in agriculture and the owner's gender in grape agriculture. However, the number of women as rural landowners in Brazil has slightly increased, as well as the use of female labor on farms. Despite this increase, the proportion of women who are responsible for managing these properties remains relatively low.

The results presented in Table 3 also show that in the municipalities where the average age of the producers is higher, the farm productivity is higher. When multiplied by the average value (Table 4), this variable has more impact than the others to explain the difference in the efficiency of the municipalities.

As the average area of farms in the municipality decreases, production efficiency increases. In our sample, family farming prevails, and for this type of farm, the smaller the cultivated area is, the more intensive the investment – both in terms of capital (including subsidized credit) and labor. Our evidence also supports the hypothesis that the intensive expenditure of capital and labor in the area ultimately leads to increased productive efficiency, especially in places where the scale of farming is smaller.

Finally, as the proportion of wine grape production in the cultivated area of the municipality increases, so does the efficiency. In other words, the fact that a municipality has a greater number of farms and more extensive areas producing wine grapes means that, on average, production leads to more efficient levels compared to other areas.

6. Conclusions

In this study we estimated the productive efficiency in the production of wine grapes in the South region of Brazil. We also investigated the main drivers of the efficiency. The major results did not show significant differences between the actual efficiency calculated to produce wine grapes in the three South states of Brazil and the maximum potential efficiency. Thus, the 100% efficiency can be achieved in any of the three states (Paraná, Santa Catarina, and Rio Grande do Sul).

Regarding the efficiency determinants, the statistically significant variables were price, family farming, participation of women in property management, the age of the farmer, municipality average size of the cultivated area with wine grapes and participation of the cultivated area with wine grapes compared to the total cultivated area. To compare the impact of one variable on efficiency with the impact of the others, we multiplied the coefficients of the variables by the averages of the variables. We found that among the tested variables, the most significant variable was the age of the farmer (0.29), followed by the style of farming variable (0.13), the price variable (0.09), the gender variable (0.03) and the wine land participation variable (0.01). The land variable showed no significant impact (-0.03).

In summary, this study can be useful as a source of information for researchers and policymakers to understand the current state and efficiency levels in wine-producing regions in southern Brazil, as well as for policy design to enhance income and welfare.

Recently, another region has been recognized as also an important wine producer in Brazil and in South America. The São Francisco River Valley, located in Northeast region, is mostly characterized by a larger scale of production operated by a few large firms covering extensive irrigated areas. Such region is completely the opposite of the family labor – oriented production found in the South region being also a promising avenue for future studies.

References

Almeida, A. N., Bragagnolo, C., & Chagas, A. L. S. (2015). Demanda por Vinho no Brasil: Elasticidades no consumo das famílias e determinantes da importação. *Revista de Economia e Sociologia Rural*, *53*(3), 433–454.

Aparicio, J., Borras, F., Pastor, J. T., & Vidal, F. (2013). Accounting for slacks to measure and decompose revenue efficiency in the Spanish Designation of Origin wines with DEA. *European Journal of Operational Research*, *231*(2), 443–451.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale ineddiciencies in data envelopment analysis. *Management Science*, *30*(9), 1078–1092.

Barros, C. P., & Santos, J. C. G. (2007). Comparing the productive efficiency of cooperatives and private enterprises: The Portuguese wine industry as a case study. *Journal of Rural Cooperation*, *35*(2), 109–122. https://doi.org/https://doi.org/10.22004/ag.econ.58683

Barth, J. E. (2007). Customer engagement and the operational efficiency of wine retail stores. *International Journal of Wine Business Research*, *19*(3), 207–215.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, *2*(6), 429–444.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). Handbook in Data Envelopment Analysis. In W. W. Cooper, L. M. Seiford, & J. Zhu (Eds.), *International Series in Operations Research & Management Science* (second, Vol. 164). Springer.

Duarte, A., Salgado Jr, A. P., Lemos, S. V., Souza Jr, M. A. A., & Antunes, F. A. (2019). Proposal of operating best practices that contribute to the technical efficiency in Brazilian sugar and ethanol mills. *Journal of Cleaner Production*, *214*, 173–184.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society. Series A (General)*, *120*(3), 253–290.

Fensterseifer, J. E. (2007). The emerging Brazilian wine industry: Challenges and prospects for the Serra Gaúcha wine cluster. *International Journal of Wine Business Research*, *19*(3), 187–206.

Fethi, M. D., Jackson, P. M., & Weyman-Jones, T. G. (2000). *Measuring the Efficiency of European Airlines: An Application of DEA and Tobit Analysis* (No. 6; EPRU Discussion

Papers).

Gómez, J. M. (2016). Analysis of the variation in the efficiency in the production of biofuels in Latin America. *Estudios Gerenciales*, *32*(139), 120–126.

Goncharuk, A. G. (2018). Wine business performance benchmarking: a comparison of German and Ukrainian wineries. *Benchmarking: An International Journal*, *25*(6), 1864–1882.

Goncharuk, A. G., & Figurek, A. (2017). Efficiency of winemaking in developing countries: Evidence from the Ukraine and Bosnia and Herzegovina. *International Journal of Wine Business Research*, *29*(1), 98–118. https://doi.org/10.1108/IJWBR-02-2016-0007

Hoff, A. (2007). Second stage DEA: Comparison of approaches for modelling the DEA score. *European Journal of Operational Research*, *181*(1), 425–435.

João, P. L., Rosa, J. I. da, Ferri, V. C., & Martinello, M. D. (2002). *Levantamento da Fruticultura Comercial do Rio Grande do Sul* (1st ed.). Emater-RS/ASCAR.

Kirjavainen, T., & Loikkanen, H. A. (1998). Efficiency Differences of Finnish Senior Secondary Schools: An Application of DEA and Tobit Analysis'. *Economics of Education Review*, *17*(4), 377–394.

Krüger, J. J. (2012). A Monte Carlo study of old and new frontier methods for efficiency measurement. *European Journal of Operational Research*, *222*(1), 137–148.

Maietta, O. W., & Sena, V. (2008). Is competition really bad news for cooperatives? Some empirical evidence for Italian producers' cooperatives. *Journal of Productivity Analysis*, *29*(3), 221–233.

Mello, L. M. R. de. (2016). *Desempenho da vitivinicultura brasileira em 2015. Embrapa Uva e Vinho-Artigo em periódico indexado (ALICE)*. Embrapa Uva e Vinho. Mello, L. M. R.

Miele, M., & Zylbersztajn, D. (2005). Coordenação e desempenho da transação entre viticultores e vinícolas na Serra Gaúcha. *Revista de Administração - RAUSP*, *40*(4), 330–341.

Nierop, M. J. R. M. van. (2011). The evolution of the Brazilian wine industry. *Utrech University Faculty of Geosciences Thesis*.

Poletto, G. (2019). *Estruturação do observatório brasileiro vitivinícola.* [Universidade de Caxias do Sul].

Porro, D., & Stefanini, M. (2016). *Tecnologias para o desenvolvimento da vitivinicultura de Santa Catarina: Relatório das atividades desenvolvidas* (third). Provincia Autonoma di Trento.

Protas, J. F. da S. (2008). A produção de vinhos finos: um flash do desafio brasileiro. Embrapa Uva e Vinho-Artigo em periódico indexado (ALICE). *Agropecuária Catarinense*, *21*(1), 17–19.

Protas, J. F. da S., Camargo, U. A., & Melo, L. M. R. de. (2002). A vitivinicultura brasileira : realidade e perspectivas. *Viticultura e Enologia - Atualizando Conceitos (Embrapa Uva e Vinho)*, 17–32. http://www.cnpuv.embrapa.br/publica/artigos/vitivinicultura/

Protas, J. F. da S., & Camargo, U. A. (2011). Vitivinicultura Brasileira: Panorama Setorial em 2010. *IBRAVIN: Embrapa Uva e Vinho*, 109.

Salazar-Ordóñez, M., Pérez-Hernández, P. P., & Martín-Lozano, J. M. (2013). Sugar beet for bioethanol production: An approach based on environmental agricultural outputs. *Energy Policy*, *55*, 662–668.

Sato, A. J., & Roberto, S. R. (2004). *A viticultura no Paraná*. https://pitangui.uepg.br/departamentos/defito/labiovegetal/

Sellers, R., & Alampi-Sottini, V. (2016). The influence of size on winery performance: Evidence from Italy. *Wine Economics and Policy*, *5*(1), 33–41.

Sellers, R., Alampi-Sottini, V., & Menghini, S. (2016). International Journal of Wine Business Research. *International Journal of Wine Business RTesearch*, *28*(1), 1–21.

Taffarel, J.C.; Falcade, I. (2015). Caracterização da viticultura no município de Farroupilha (RS) - Brasil. *XV Congresso Latino-Americano de Viticultura e Enologia.*, 548.

Tonezer, C., Trzcinski, C., & Arns, C. E. (2017). Impactos da modernização agrícola nas áreas rurais do município de Águas de Chapecó – Santa Catarina. *PRACS: Revista Eletrônica de Humanidades Do Curso de Ciências Sociais Da UNIFAP*, *10*(2), 51.

Townsend, R. F., Kirsten, J., & Vink, N. (1998). Farm size, productivity and returns to scale in agriculture revisited: A case study of wine producers in South Africa. *Agricultural Economics*, *19*(1–2), 175–180.

Urso, A., Timpanaro, G., Caracciolo, F., & Cembalo, L. (2018). Efficiency analysis of Italian wine producers. *Wine Economics and Policy*, *7*(1), 3–12.

Vázquez-Rowe, I., Villanueva-Rey, P., Iribarren, D., Teresa Moreira, M., & Feijoo, G. (2012). Joint life cycle assessment and data envelopment analysis of grape production for vinification in the Rías Baixas appellation (NW Spain). *Journal of Cleaner Production*, *27*, 92–102.

Vidal, F., Pastor, J., Borras, F., & Pastor, D. (2013). Efficiency analysis of the designations of origin in the Spanish wine sector. *Spanish Journal of Agricultural Research*, *11*(2), 294–304.