Technical efficiency of grapevine producers in Mendoza
Felix Sebastian RIERA
Georg-August-Universitaet Goettingen
sriera@uni-goettingen.de

Abstract The growing reputation of Argentinean wines led to the settlement of international firms, which improved the industry in terms of technology adoption and market orientation. The increasing Argentinean wine production and exports have pushed this sector to make relevant changes in productive strategies, being especially focused on producing high quality grapes highly sensitive to water stress management.

Despite the major evolution of wine production and exports in Mendoza, the production of grapevine is undergoing significant challenges arising from low prices paid to producers, agronomic risks, and climate contingencies. More dependent on economic framework and local markets, the small wine grape producers may be trapped in a declining spiral of water scarcity, production quality and profitability. Although, the public sector creates policies oriented to small-scale producers, most of them aim to solve urgent needs instead of other core issues as quality and technical efficiency.

Introduction In Argentina, over the last three decades, agriculture has become a key and growing contributor to export earnings and wine has played a relevant and rising role to sustain the regional economies. Vineyard grapes are one of the most relevant crops in western Argentina. With over 240,000 hectares, the province of Mendoza concentrates 70 per cent of the grape production and 65 per cent of the wine elaboration.

The growing reputation of Argentinean wines led to the settlement of international firms, which improved the industry in terms of technology adoption and market orientation. The increasing Argentinean wine production and exports have pushed this sector to make relevant changes in productive strategies, being especially focused on producing high quality grapes highly sensitive to water stress management.

Despite the major evolution of wine production and exports in Mendoza, the production of grapevine is undergoing significant challenges arising from low prices paid to producers, agronomic risks, and climate contingencies. More dependent on economic framework and local markets, the small wine grape producers may be trapped in a declining spiral of water scarcity, production quality and profitability. Although, the public sector creates policies oriented to small-scale producers, most of them aim to solve urgent needs instead of other core issues as quality and technical efficiency.

Any input improvement or changes in management practices may increase profitability of grapevine producers, that sell their production at a yearly-stable price per quality paid by wine makers. Therefore, it is relevant to analyze the production efficiency to estimate general scores controlling for location, water quality and technology adoption among others.

Furthermore, this paper will focus in two issues: (i) the role of water in improving farm productivity and (ii) the implications that can be derived from the frontier analysis of technical efficiency. Following a stochastic frontier analysis (SFA), this paper seeks to provide a clear perspective on the use of natural resources, labor and other inputs by the grapevine producers in Mendoza.
Literature review A relevant strand in the economic literature to assess productivity and efficiency using frontier function methodologies. These methods determine a benchmark frontier and provide measure of efficiency in terms of input reduction or potential output expansion with respect to the frontier. This model was first applied by Farrell (1957), who decompose economic efficiency into technical efficiency (TE) and allocative efficiency (AE). The former measures the firm ability to maximize the output given the input set; the latter measures the capability of the firm to relocate inputs according to their prices.

It is widely known that agriculture is the main recipient of water resources. Additionally, there is a wide consensus that the agricultural sector is the less efficient in terms of input oriented efficiency. Bravo et al. (2016) carried a meta-analysis study on production and water use efficiency. In terms of water efficiency, Latin America has the lower average mean on technical efficiency (AMTE) with 55 percent, where US and Western Europe achieved above 80 percent.

In this line, the preliminary task is to define a functional form of the production function that accomplish the axioms of production and achieve the regularity conditions of monotonicity and curvature (Coelli, Prasada Rao, O’Donnell, & Battese, 2005; Greene, 2008). According to the scarce literature on quality grape efficiency, the Cobb-Douglas function is preferred to the transcendental logarithmic for modeling grapevine production (Bravo-Ureta, Moreira, Troncoso, & Wall, n.d.; T. Coelli & Sanders, 2012).

We start with Townsend, Kirsten and Vink (Townsend et al. 1998) who analyzed the relationship between farm size, productivity and returns to scale for wine grape producers located in four regions of South Africa for the years 1992 to 1995.

Moreira, Troncoso and Bravo-Ureta (Moreira L. et al. 2011) examined the TE of wine grape production for a sample of Chilean firms for 2005-06 using a standard cross sectional models. A Cobb-Douglas SPF model using data for 38 farms for which input-output information is available at block level. The results reveal an average farm level TE of 77.2 per cent, with block level TE ranging from 23.4 to 95.0 per cent. Ma et al. (2012) use 1020 farm level observations collected across 24 grape producing provinces in China to estimate a Cobb-Douglas SPF model. Coelli and Sanders (Coelli and Sanders 2013) used an unbalanced panel data set (2006–2007 to 2009–2010) for a sample of 135 farmers specializing in wine grape production located in the Murray and Murrumbidgee river basins in Australia. The authors used the translog functional form to fit SPF models using the Battese and Coelli (Battese and Coelli 1992) approach. The results revealed a mean TE equal to 79 per cent, a mean estimate of scale economies of 1.07, and a 2.7 per cent annual average rate of technological change. The findings also suggested that shadow price estimates for irrigation water exceeded average market prices.

Finally, Manevska-Tasevska (2013) uses a three-year (2006-2008) panel data set for a sample of 300 commercial grape producers from Macedonia along with a Cobb-Douglas SPF model and a second stage regression to analyze TE.

Methodology The selected methodology to assess technical efficiency (TE) is the stochastic frontier analysis (SFA), which belongs to the parametric methods in frontier methodology. This approach incorporates statistical noise through a composed error structure with a two-sided symmetric term and a one-sided component. The two-sided error captures random shocks outside the control of the firm whereas the one-sided component seeks to explain inefficiency (Bravo-Ureta et al., 2016; Kumbhakar & Knox Lovell, 2003).
As it is explained below, the data characteristics would allow the analysis into hierarchical models. The basic scheme for modelation is:

\[
Y_{ib} = \alpha_i + \sum \beta_i X_{ib} + \sum \gamma_i Z_{ib} + \varepsilon_{ib} \quad (1)
\]

\[
\varepsilon_i = v_{ib} - u_{ib} \quad (2)
\]

where:

- \(Y_{ib}\) = log of output of the \(i^{th}\) farm in the \(b^{th}\) plot;
- \(X_{ib}\) = log of inputs;
- \(Z_{ib}\) = variables that capture specific plot level characteristics;
- \(\alpha_i, \beta_i, \gamma_i\) = parameters to be estimated;
- \(v_{ib}\) = random error (\(v_i \sim iid N(0, \sigma_v^2)\));
- \(u_{ib}\) = \(|N(0, \sigma_u^2)|\) is a one sided error representing technical inefficiency of the \(b^{th}\) plot in the \(i^{th}\) farm.

In this traditional SPF model, the \(TE\) component is estimated as follows:

\[
TE_{ib} = E \left[ \exp(-u_{ib}) \mid \varepsilon_i \right] \quad (3)
\]

Further explanation of the potential variability of \(TE\) scores in terms of exogenous factors could be achieved with the so-called two-step model where \(TE\) is estimated with and without accounting the external factors (Wang & Schmidt, 2002).

**Data** The collected sample of 1,500 grapevine plots of 220 producers is representative of the study area and contains relevant input and output information with current prices, as well as management practices, water source, and technology adoption per plot. To correctly address the irrigation efficiency, soil typology will be considered and this information is available at the webpage of the National Institute of Agriculture Technology (INTA) at a reasonable scale for the analysis. The selected methodology will cluster plots and vineyards per producer into a multi-level efficiency analysis. Initially, three (3) hierarchical levels have been identified.

**Discussion and conclusions** After interpretation of collected data and interviews with experts, it is expected lower efficiency scores at some locations. At the southern end of the research area, within the districts of Ugarteche, El Carrizal and Anchoris, producers can only irrigate with deeper groundwater from the second aquifer due to salinization of the resource. DGI applied a zoning restriction for new drillings and later increased the annual fee for existing wells. By all means this translate into higher production costs and lower profitability which, limited investments, technology adoption and new practices. These characteristics were reviewed during data collection and might determine lower efficiency scores.