Technical Efficiency for a Sample of Chilean Wine Grape Producers: A Stochastic Production Frontier Analysis

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The increase in wine production in New World Countries has been a recent success which has led to losses in market share by traditional wine exporting countries like France, Spain and Italy.

Chile has become an increasingly important player in international wine markets, together with other emerging countries of the “New World”, such as Argentina, Australia, New Zealand and South Africa.

The remarkable expansion of the Chilean wine industry over the past two decades has been fueled primarily by the opportunities offered by the growth in international markets.
In 1990 most of the wine produced in Chile was consumed domestically and 7% was exported.

By 2009 about 64% of Chilean wines were exported.

During this same time period, vineyard plantations almost doubled, going from 65,000 to 117,600 hectares.

Production quadrupled from 2.6 to 10.0 million hectolitres.

The wine industry is dominated by two groups of firms, big corporations (tends to market a more massive product) and family-owned estates (focused on sophisticated wines, produced at a reduced scale), known as boutique vineyards.
Evolution of Chilean vineyards

- Major red wines
- Major white wines
- País wine
- Total land

Time:
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Land (hectare)
Many studies have been published internationally examining the Technical Efficiency (TE) component of productivity in farming using production frontier methodologies (Bravo-Ureta et al., 2007). But, only a handful focus on productivity and TE in wine grape production.

Townsend et al. (1998): relationship between farm size, productivity and returns to scale for wine grape producers, four regions of South Africa (1992 to 1995).

Conradie et al. (2006): examined the relationship between technical efficiency and farm size using a SPF, samples of Western Cape Province producers of South Africa.

Henriques et al. (2009): non-parametric techniques to measure TE, sample of 22 wine grape farms from the Alentejo region of Portugal (2001 and 2004).
Outline

- Objective
- Data
- Econometric Model
- Main Results
- Concluding Remarks and Implications
The purpose of this paper is to analyze the Technical Efficiency (TE) component of productivity for a sample of wine grape producers in Chile using a stochastic production frontier (SPF) approach and cross sectional data.

TE should be understood as a measure of managerial performance.
Outline

- Objetive
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38 farms that export 90% of their wine production on average

1 period (2005/2006)
Total: 263 observations

Valleys (N to S):
- Limarí 4%
- Aconcagua 6%
- Casablanca 8%
- San Antonio 2%
- Maipo 15%
- Cachapoal 11%
- Rapel 2%
- Colchagua 30%
- Curicó 6%
- Maule 16%

All vineyards are affiliated with Tecnovid
### Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Average</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vineyards</td>
<td></td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of vineyards</td>
<td>ha</td>
<td>86.8</td>
<td>4.0</td>
<td>414.0</td>
</tr>
<tr>
<td>Number of blocks</td>
<td></td>
<td>7</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Size of blocks</td>
<td>ha</td>
<td>12.5</td>
<td>0.2</td>
<td>108.7</td>
</tr>
<tr>
<td>Grape production</td>
<td>kg/ha</td>
<td>10,445</td>
<td>1</td>
<td>27,132</td>
</tr>
<tr>
<td>Labor</td>
<td>US$/ha</td>
<td>849</td>
<td>315</td>
<td>1,515</td>
</tr>
<tr>
<td>Machinery</td>
<td>US$/ha</td>
<td>346</td>
<td>65</td>
<td>809</td>
</tr>
<tr>
<td>Inputs (pestic., fert.)</td>
<td>US$/ha</td>
<td>339</td>
<td>38</td>
<td>1,214</td>
</tr>
<tr>
<td>Age of plantation</td>
<td>years</td>
<td>16</td>
<td>3</td>
<td>118</td>
</tr>
</tbody>
</table>

#### Type of wine:

- Red % 71
- White % 29

#### Grape quality:

- Premium % 50
- Varietal % 50

#### Training system:

- Double cordon % 13
- Simple cordon % 73
- Pergola % 7
- Others % 7
Outline

- Objective
- Data
- **Econometric Model**
- Main Results
- Concluding Remarks and Implications
Two-sided error term (Battese and Coelli, 1992):

\[ Y = f(x) + (v_i - u_i) \]

\( v = \text{random error term (two sided)} \)

\( u = \text{technical inefficiency (one sided)} \)
Stochastic Production Frontier

Frontier Output $f(x_i\beta + v_i)$, if $v_i > 0$

Random Error

Stochastic Inefficiency

Deterministic Production Frontier $y = f(x_i\beta)$

Frontier Output $f(x_i\beta + v_i)$, if $v_i < 0$

Observed Output
Stochastic Frontier: Empirical Model

Functional form: Cobb-Douglas (CD)

\[ Y_i = \alpha_0 + \sum_{k=1}^{4} \beta_k X_{ki} + \beta_A AG_i + \beta_W WN_i + \beta_Q QL_i + \sum_{l=1}^{4} \beta_l FR_l + \sum_{m=1}^{7} \beta_m VL_m + v_{it} - u_{it} \]

\( X_1 \): block size measured in hectares

\( X_2 \): the total cost of labor measured in Ch$

\( X_3 \): the total cost of machinery measured in Ch$

\( X_4 \): the total cost of fertilizer and pesticides measured in Ch$
Empirical Model of Stochastic Frontier

\[ Y_i = \alpha_0 + \sum_{k=1}^{4} \beta_k X_{ki} + \beta_A AG_i + \beta_W WN_i + \beta_Q QL_i + \sum_{l=1}^{4} \beta_l FR_l + \sum_{m=1}^{7} \beta_m VL_m + v_{it} - u_{it} \]

AG: is a binary variable equal to 1 if a block is five years or older and 0 otherwise;

WN: is a binary variable equal to 1 for red wine grapes and 0 otherwise;

QL: is a proxy for grape quality and is equal to 1 for Premium and 0 for varietal;

FR: training system, including simple and double cordon, pergola and other training systems and the excluded category is other training systems;

VL: location of farm: Aconcagua and Cachapoal; Colchagua and Rapel; Casablanca; Curicó; Maipo; Maule; and Limarí and San Antonio, the excluded category;

\( v \): is the random error term; and

\( u \): is an unobservable and non-negative term.
Outline

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<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>4.160</td>
<td>1.070</td>
<td>ns</td>
</tr>
<tr>
<td>Labor cost</td>
<td>0.285</td>
<td>0.072</td>
<td>***</td>
</tr>
<tr>
<td>Machinery cost</td>
<td>0.099</td>
<td>0.053</td>
<td>*</td>
</tr>
<tr>
<td>Inputs</td>
<td>0.021</td>
<td>0.030</td>
<td>ns</td>
</tr>
<tr>
<td>Size of block</td>
<td>0.617</td>
<td>0.084</td>
<td>***</td>
</tr>
<tr>
<td><strong>Control variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantation age</td>
<td>0.334</td>
<td>0.091</td>
<td>***</td>
</tr>
<tr>
<td>White/Red</td>
<td>-0.174</td>
<td>0.042</td>
<td>***</td>
</tr>
<tr>
<td>Premium/Varietal</td>
<td>-0.179</td>
<td>0.040</td>
<td>***</td>
</tr>
<tr>
<td><strong>Training System</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple cordon</td>
<td>-0.217</td>
<td>0.078</td>
<td>***</td>
</tr>
<tr>
<td>Double cordon</td>
<td>-0.198</td>
<td>0.098</td>
<td>***</td>
</tr>
<tr>
<td>Pergola</td>
<td>0.027</td>
<td>0.100</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Location (Valley)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aconcagua+Cachapoal</td>
<td>0.220</td>
<td>0.090</td>
<td>***</td>
</tr>
<tr>
<td>Colchagua+Rapel</td>
<td>0.311</td>
<td>0.084</td>
<td>***</td>
</tr>
<tr>
<td>Casablanca</td>
<td>-0.153</td>
<td>0.107</td>
<td>ns</td>
</tr>
<tr>
<td>Curicó</td>
<td>0.409</td>
<td>0.110</td>
<td>***</td>
</tr>
<tr>
<td>Maipo</td>
<td>-0.109</td>
<td>0.090</td>
<td>ns</td>
</tr>
<tr>
<td>Maule</td>
<td>0.305</td>
<td>0.087</td>
<td>**</td>
</tr>
</tbody>
</table>
## Main Results: TE

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>By farm</td>
<td>77.2%</td>
<td>10.6%</td>
<td>41.4%</td>
<td>92.0%</td>
</tr>
<tr>
<td>By block</td>
<td>77.8%</td>
<td>13.9%</td>
<td>23.4%</td>
<td>95.0%</td>
</tr>
</tbody>
</table>

B.B-U. et al 2007

Other crops 74.4%

165 studies 76.6%
## Main Results: TE

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of plantation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=5 years</td>
<td>75.9%</td>
<td>23.4%</td>
<td>94.4%</td>
</tr>
<tr>
<td>&gt;5 years</td>
<td>77.9%</td>
<td>24.5%</td>
<td>95.0%</td>
</tr>
<tr>
<td><strong>Type of wine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>77.3%</td>
<td>23.4%</td>
<td>94.6%</td>
</tr>
<tr>
<td>Red</td>
<td>78.0%</td>
<td>24.5%</td>
<td>95.0%</td>
</tr>
<tr>
<td><strong>Grape quality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Varietal</td>
<td>79.2%</td>
<td>39.7%</td>
<td>94.6%</td>
</tr>
<tr>
<td>Premium</td>
<td>76.3%</td>
<td>23.4%</td>
<td>95.0%</td>
</tr>
<tr>
<td><strong>Training system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>79.7%</td>
<td>54.4%</td>
<td>92.4%</td>
</tr>
<tr>
<td>Simple cordon</td>
<td>78.2%</td>
<td>35.6%</td>
<td>95.0%</td>
</tr>
<tr>
<td>Double cordon</td>
<td>74.8%</td>
<td>23.4%</td>
<td>94.6%</td>
</tr>
<tr>
<td>Pergola</td>
<td>76.4%</td>
<td>43.3%</td>
<td>92.7%</td>
</tr>
</tbody>
</table>
# Main Results: TE

<table>
<thead>
<tr>
<th>Valley</th>
<th>Average</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limarí+San Antonio</td>
<td>69.9%</td>
<td>23.4%</td>
<td>91.9%</td>
</tr>
<tr>
<td>Aconcagua+Cachapoal</td>
<td>77.6%</td>
<td>38.5%</td>
<td>95.0%</td>
</tr>
<tr>
<td>Colchagua+Rapel</td>
<td>78.5%</td>
<td>38.2%</td>
<td>93.7%</td>
</tr>
<tr>
<td>Casablanca</td>
<td>79.1%</td>
<td>62.8%</td>
<td>94.4%</td>
</tr>
<tr>
<td>Curicó</td>
<td>79.6%</td>
<td>58.1%</td>
<td>92.2%</td>
</tr>
<tr>
<td>Maipo</td>
<td>80.9%</td>
<td>67.0%</td>
<td>94.6%</td>
</tr>
<tr>
<td>Maule</td>
<td>75.3%</td>
<td>35.6%</td>
<td>93.4%</td>
</tr>
</tbody>
</table>
Outline

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**Concluding Remarks and Implications**

- The most influential variables, according to partial production elasticities, are: labor cost (0.29), machinery cost (0.10) and block size (0.62). The partial elasticity for purchased inputs is 0.02, but is non significant.

- The results shows CRS.

- TE Farm level: Avg. 77.2%; Range: 41% to 92%

- These results reveal considerable heterogeneity in managerial performance.

- Least efficient have a major gap to close to achieve average performance levels.
Concluding Remarks and Implications

✓ Location of farms influence grape production, but no clear pattern is found in the Chilean grape producers.

✓ Detailed benchmarking exercises would be helpful to spell out the management practices that lead to improved performance.

✓ This work would need to be done at the block level since the results also suggest considerable TE variability within farms

✓ Further Work: Collaborative Efforts with the FADN data??
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