Background

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 hectoliters.

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.
Background: Literature

Very few studies using frontier methodologies to analyze 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 TE and farm size using a Stochastic Production Function (SPF) - Western Cape Province producers of South Africa.
- Moreira et al. (2011): TE of wine grape producers using a SPF - Chilean producers (2005/06).

Outline

- Background
- **Objective**
- Data
- Econometric Model
- Main Results
- Concluding Remarks and Implications

General Objective

To analyze Technical Efficiency (TE) for a sample of wine grape producers in Chile using.

We use a Stochastic Production Frontier (SPF) approach and “interesting” cross sectional data which permits the application of panel data techniques.
Data Structure

The dataset contains production variables at the sub-farm (block or plot) level.

Thus, we have several observations for each farm by block.

The data therefore mimics a panel structure which allows us to control for individual (farm-level) heterogeneity.

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>1,372</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
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Stochastic Production Frontier (SPF)

Model: “True Fixed Effects Stochastic Frontier” (Greene, 2005)

\[
y_{lt} = \alpha_l + \beta' x_{lt} + v_{lt} - u_{lt}
\]

Where:
\( v_{lt} \sim N(0, \sigma_v^2) \) random error term (two sided)
\( u_{lt} \sim N^+(0, \sigma_u^2) \) technical inefficiency (one sided)

Empirical Model: Yield Function

Functional form: Cobb-Douglas (CD)

\[
y_{lb} = \alpha_l + \beta' x_{lb} + \gamma' z_{lb} + v_{lb} - u_{lb}
\]

Where:
\( y \) is output (wine grape production)
\( x \) is a vector of inputs
\( z \) is a vector of control variables
\( v \) is the symmetric random error term
\( u \) is the one-sided technical inefficiency term
output and inputs are per hectare.

Stochastic Frontier: Empirical Model

\[
y_{lb} = \alpha_l + \sum_{k=1}^{3} \beta_k x_{kb} + \sum_{m=1}^{5} \gamma_{m} z_{mb} + \sum_{n=4}^{6} \gamma_{n} z_{nb} + v_{lb} - u_{lb}
\]

Where:
\( x_1 \) : the total cost of labor measured in Ch$/ha
\( x_3 \) : the total cost of machinery measured in Ch$/ha
\( x_4 \) : the total cost of fertilizer and pesticides measured in Ch$/ha
\( z_1 \) : binary variable equal to 1 if a block is five years or older and 0 otherwise;
\( z_2 \) : binary variable equal to 1 for red wine grapes and 0 otherwise;
\( z_3 \) : binary variable equal to 1 for Premium grape type and 0 for varietal;
\( z_4 - z_6 \) : binary variables equal to 1 for training system (simple frame; double frame; and trellis) where excluded category is other training systems.
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Main Results
Block-level TE Scores

<table>
<thead>
<tr>
<th>Model</th>
<th>Mean</th>
<th>Min.</th>
<th>Max.</th>
<th>S. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Frontier</td>
<td>0.71</td>
<td>0.33</td>
<td>0.91</td>
<td>0.12</td>
</tr>
<tr>
<td>True FE Frontier</td>
<td>0.72</td>
<td>0.44</td>
<td>0.90</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Main Results
Rank Correlations of TE Scores
CS Frontier vs. True FE Frontier

<table>
<thead>
<tr>
<th></th>
<th>Block-level efficiency scores</th>
<th>Mean farm-level efficiency scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Weighted (by block size)</td>
</tr>
<tr>
<td>Spearman’s ρ</td>
<td>0.62</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Main Results: TE Scores by Categories

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pooled Frontier</th>
<th>True Fixed Effects Frontier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall TE by block</td>
<td>0.712 0.334 0.907</td>
<td>0.722 0.435 0.898</td>
</tr>
<tr>
<td>Age of plantation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 5 years</td>
<td>0.723 0.334 0.830</td>
<td>0.709 0.502 0.841</td>
</tr>
<tr>
<td>&gt; 5 years</td>
<td>0.711 0.368 0.907</td>
<td>0.722 0.435 0.898</td>
</tr>
<tr>
<td>Type of wine:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>0.712 0.334 0.907</td>
<td>0.727 0.502 0.898</td>
</tr>
<tr>
<td>Red</td>
<td>0.712 0.368 0.906</td>
<td>0.720 0.435 0.871</td>
</tr>
<tr>
<td>Grape quality:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitis</td>
<td>0.715 0.398 0.899</td>
<td>0.725 0.502 0.845</td>
</tr>
<tr>
<td>Premium</td>
<td>0.708 0.334 0.907</td>
<td>0.718 0.435 0.898</td>
</tr>
<tr>
<td>Conduction frame:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single frame</td>
<td>0.710 0.385 0.907</td>
<td>0.725 0.478 0.871</td>
</tr>
<tr>
<td>Double frame</td>
<td>0.715 0.334 0.878</td>
<td>0.737 0.502 0.898</td>
</tr>
<tr>
<td>Trellis</td>
<td>0.717 0.435 0.862</td>
<td>0.707 0.534 0.825</td>
</tr>
<tr>
<td>Others</td>
<td>0.715 0.420 0.858</td>
<td>0.673 0.435 0.800</td>
</tr>
<tr>
<td>Farm location - valley:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limarí and San Antonio</td>
<td>0.637 0.334 0.868</td>
<td>0.705 0.502 0.898</td>
</tr>
<tr>
<td>Aconcagua and Cachapoal</td>
<td>0.709 0.435 0.878</td>
<td>0.720 0.502 0.859</td>
</tr>
<tr>
<td>Colchagua and Rapel</td>
<td>0.749 0.385 0.907</td>
<td>0.726 0.547 0.871</td>
</tr>
<tr>
<td>Casablanca</td>
<td>0.602 0.405 0.825</td>
<td>0.717 0.478 0.841</td>
</tr>
<tr>
<td>Curicó</td>
<td>0.778 0.579 0.871</td>
<td>0.730 0.647 0.785</td>
</tr>
<tr>
<td>Maipo</td>
<td>0.655 0.420 0.878</td>
<td>0.726 0.435 0.845</td>
</tr>
<tr>
<td>Maule</td>
<td>0.754 0.487 0.900</td>
<td>0.717 0.520 0.863</td>
</tr>
</tbody>
</table>

Main Results
TE Scores from FE and True FE Frontiers

Note. Efficiency scores from FE frontier calculated as \( \exp(a_i - \max(a_i)) \)
True FE farm efficiency scores calculated by weighting block-levels scores by output/ha.

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Concluding Remarks and Implications

- The estimated production frontiers highlight the importance of labor in the production of wine grapes.
- Tests favor frontier specification over average production function specification.
- Tests also show existence of individual effects, justifying use of panel techniques to control for unobserved farm-level heterogeneity.
- Average farm-level TE: 72.2% (Range: 43.5%-89.8%)
- By controlling for unobserved heterogeneity, the variation in TE scores is much lower than when using cross-section frontier methods.