Land market distortions: Theory and evidence from Guatemala

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Preliminary and incomplete
Introduction

- Difference in agriculture explains large disparities in labor productivity between developing and developed countries (Caselli; Restuccia et al. (2008); Lagakos & Waugh (2013))

- Poor countries employ most of their workers in agriculture and are much more unproductive than rich countries

- Farm size and land allocation are important factors in explaining this lagging agricultural productivity (Adamopolous & Restuccia (2014))

- Large differences in the size distribution of farms. In poor countries we observe many more small farms and the labor productivity gap between large and smaller farms is larger
Introduction

- **Objective 1:** Develop a theoretical framework to assess the impact of agricultural land market distortions

- **Objective 2:** Quantify the magnitude of these distortions (in Guatemala)
Model

- Two-sector model of agriculture and non-agriculture (following A&R 2014) with endogenous size distribution of farms and farm location
- No capital
- In each period the economy produces two consumption goods: an agricultural good \(a\) and a non-agricultural good \(n\)
Farmers

- The agricultural good is produced with land \((l)\) by a farmer with managerial skills \(s\).

- Decreasing returns to scale in the agricultural sector:

\[
y_{a,i} = s_i l_i^\alpha
\]

\(\alpha\) captures the land elasticity.

- The economy is endowed with a fixed amount of total land \(L\).

- Productivity of farmers is realized after the sectoral allocation decision.
Farmers

- Household decides fraction of members ($N_a$) working in agricultural, then draws farmer managerial ability from distribution with cdf $F(s)$ and pdf $f(s)$, with support $S = [s, \bar{s}]$.

- Discrete number of $N$ types of farmers with different managerial skills $s_i$, for $i = 1, \ldots, N$, distributed in $N$ regions.

- There is only one type of farmer per region. We rank the managerial ability such that $s_1 > s_2 > \ldots > s_N$. 
Regions are located linearly in terms of proximity... subindex $i$ identifies both the region and the managerial ability... $r_1$ is the most productive region...

Transaction cost $\tau$ for trading land across regions is increasing with distance:

$$\tau_{ij} = \tau(d_{i,j}), \text{ with } \tau_{ii} = 0 \text{ and } \tau'(\cdot) > 0,$$

where $d_{i,j}$ is the distance between region $i$ and $j$. 
Farmer’s maximization problem (rental prices of land ($q$), the relative price of the agricultural good $p_a$)

$$\max \left\{ \pi(s_i) = \left\{ p_a s_{ij} l_{ij}^{\alpha} - \sum_{j=1}^{N} (q_j + \tau_{ij}) l_{ij} \right\} \right\}$$

where $l_{ij}$ is the demand for land in market $j$ of a farmer in region $i$, and $l_i = \sum_{j=1}^{N} l_{ij}$ is the total demand for land of farmer $i$.

The optimal condition for farmer $i$ is

$$\alpha p_a s_{ij} l_{ij}^{\alpha-1} = q_j + \tau_{ij} \quad \text{in all markets}$$
Competitive Equilibrium

(assumption) land supply is the same across regions, i.e., $l_j^s = l^s$ for all $j = 1, ..., N$

Land market clearing condition in each region:

$$N_a \sum_{i=1}^{N} l_{ij} = l_j^s = l^s.$$ 

Aggregate land market clearing condition:

$$L = N_a \sum_{i=1}^{N} l_i$$
**Competitive Equilibrium**

**Assumption 1:** $l_{ii} > 0$ for all $i$.

**Assumption 2:** Rental price in autarky $q_i^A$. We assume $\tau_{ij} < |q_i^A - q_j^A|$ for all $i$ and $j$.

**Result 1:** Given that $s_1 > s_2 > ... > s_N$, then $l_{ij} = 0$ for $j < i$ (i.e. $l_{21} = l_{32} = ... = 0$).

The optimal farm size of less productive farmers will be lower than the optimal farm size of more productive ones. Farmers in less productive regions does not rent land in more productive markets.
A Simple Example

- Two types of farmers, two regions
- Technology: \( y_a = s_i l_i^\alpha \).
- Consider the following parameter values:

<table>
<thead>
<tr>
<th>( \alpha )</th>
<th>( s_1 )</th>
<th>( s_2 )</th>
<th>( l )</th>
<th>( \tau_{12} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>
A Simple Example

The optimal allocation is equal to,

\[
\begin{array}{cccccc}
  l_1^* & l_{12}^* & l_{21}^* & l_{22}^* & q_1^* & q_2^* \\
  1 & 0.4 & 0 & 0.6 & 0.85 & 0.65 \\
\end{array}
\]

Cost of the distortion: if \( \tau_{12} = 0 \)

\[
\begin{array}{cccccccc}
  l_1^* & l_{12}^* & l_{21}^* & l_{22}^* & q_1^* & q_2^* & \frac{y_1}{y_1^*} & \frac{y_2}{y_2^*} \\
  1 & 0.6 & 0 & 0.4 & 0.79 & 0.79 & 0.93 & 1.22 \\
\end{array}
\]
A Simple Example

Equilibrium in the Simple 2-Region model

Equilibrium without distortions
Equilibrium with distortions
Marginal Product of Farmer 2
Marginal Product of Farmer 1
Land in Region 1
Land in Region 2
Data

- IV Censo Nacional Agropecuario 2003

- Three-year panel survey of households collected between 2012 and 2014 as part of the monitoring and evaluation of the Zero Hunger Pact (176 municipalities out of 340)

- These surveys included a module on agricultural land markets that inquired about land prices, past transactions and general perceptions on the development of local land markets

- Income indices at the department level from UNDP “National Human Development Report 2005”
Data

Figure: Guatemala - Regions
### Data

#### Size Distribution of Farms (% of Farms by Size)

<table>
<thead>
<tr>
<th>Landholding size</th>
<th>All regions</th>
<th>Altiplano</th>
<th>Corredor Seco</th>
<th>Petén-Izabal</th>
<th>Pacífico-Bocacosta</th>
<th>Verapaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 Ha</td>
<td>59.7%</td>
<td>73.5%</td>
<td>49.7%</td>
<td>15.8%</td>
<td>51.8%</td>
<td>36.0%</td>
</tr>
<tr>
<td>1 - 2 Ha</td>
<td>17.6%</td>
<td>13.9%</td>
<td>26.4%</td>
<td>15.4%</td>
<td>19.4%</td>
<td>24.3%</td>
</tr>
<tr>
<td>2 - 5 Ha</td>
<td>13.2%</td>
<td>8.3%</td>
<td>16.0%</td>
<td>24.4%</td>
<td>16.5%</td>
<td>24.1%</td>
</tr>
<tr>
<td>5 - 10 Ha</td>
<td>3.6%</td>
<td>2.1%</td>
<td>3.5%</td>
<td>8.7%</td>
<td>4.3%</td>
<td>7.6%</td>
</tr>
<tr>
<td>10 - 20 Ha</td>
<td>2.3%</td>
<td>1.3%</td>
<td>2.0%</td>
<td>6.9%</td>
<td>3.4%</td>
<td>4.5%</td>
</tr>
<tr>
<td>More than 20 Ha</td>
<td>3.5%</td>
<td>1.0%</td>
<td>2.5%</td>
<td>28.6%</td>
<td>4.5%</td>
<td>3.5%</td>
</tr>
</tbody>
</table>
Land Markets in Guatemala

- We focus on the size and level of productivity of agricultural units producing maize and beans, the two most common and extended crops in Guatemala (we do not analyze crop choice decision).

**Dispersion of Productivity (yields) across Farms**

<table>
<thead>
<tr>
<th></th>
<th>All regions</th>
<th>Altiplano Occidental</th>
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</tr>
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<tbody>
<tr>
<td><strong>White Maize</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>26.2</td>
<td>29.0</td>
<td>23.0</td>
<td>22.4</td>
<td>37.0</td>
<td>19.8</td>
</tr>
<tr>
<td>Median</td>
<td>23.4</td>
<td>27.3</td>
<td>20.0</td>
<td>20.0</td>
<td>35.0</td>
<td>16.0</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>13.4</td>
<td>13.7</td>
<td>12.5</td>
<td>10.0</td>
<td>13.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Ratio P75/P25</td>
<td>2.0</td>
<td>2.1</td>
<td>2.2</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Number of Obs.</td>
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<td>204,907</td>
<td>57,955</td>
<td>45,192</td>
<td>23,963</td>
<td>76,794</td>
</tr>
</tbody>
</table>

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<tbody>
<tr>
<td><strong>Yellow Maize</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>26.2</td>
<td>27.9</td>
<td>19.8</td>
<td>19.8</td>
<td>30.3</td>
<td>18.3</td>
</tr>
<tr>
<td>Median</td>
<td>24.7</td>
<td>27.2</td>
<td>18.0</td>
<td>16.0</td>
<td>30.0</td>
<td>16.0</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>12.2</td>
<td>12.1</td>
<td>9.2</td>
<td>10.3</td>
<td>12.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
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<td>2.0</td>
<td>1.8</td>
<td>2.0</td>
<td>2.1</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>143,308</td>
<td>115,490</td>
<td>5,446</td>
<td>1,284</td>
<td>790</td>
<td>20,038</td>
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</table>

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<thead>
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<tbody>
<tr>
<td><strong>Black Beans</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12.3</td>
<td>13.2</td>
<td>11.7</td>
<td>11.8</td>
<td>13.3</td>
<td>12.3</td>
</tr>
<tr>
<td>Median</td>
<td>11.4</td>
<td>12.5</td>
<td>10.7</td>
<td>10.4</td>
<td>12.5</td>
<td>11.2</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>4.7</td>
<td>6.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Ratio P75/P25</td>
<td>2.0</td>
<td>1.9</td>
<td>1.9</td>
<td>1.9</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>108,552</td>
<td>31,189</td>
<td>31,735</td>
<td>19,084</td>
<td>4,454</td>
<td>21,945</td>
</tr>
</tbody>
</table>
Land Markets in Guatemala

**Figure:** Share of Small and Large Farms across Departments (maize and beans)
The model predicts that higher transaction costs $\tau$ imply more sub-optimal land allocation... most productive farmers operate at a lower scale, unproductive farmers operate at larger scales compared to the optimal allocation.

The inverse relationship is indicative of land market imperfections and inefficient land allocation.
A Measure of Farm Total Productivity

- Total productivity at the farm level for maize and beans

- Residual of the production function after controlling for farmer’s age and years of education, whether he/she uses enhanced seeds, type and quantity of input used, use of irrigation systems and number of crops cultivated (to capture the level of specialization)

\[ y_{ij} = s_{ij}(l_{ij})^{\alpha} \]

- We estimate the calculated series of \( s_{ij} \) (using fixed effects at the administrative area) as the residual of this regression

- For the country the correlation between farm productivity and landholding size results in the range of 0.23 – 0.25, depending on the crop considered
First, we solve a simple optimization problem of a hypothetical social planner.

Second, we compare the estimated aggregate output (from efficient allocation) with the actual aggregate output, defined as

\[ Y^c = \sum_{i=1}^{N} s_{ij} (l_{ij}^c)^\alpha \]

where \( l_{ij}^c \) denotes the actual land extension of an individual farmer observed in the census data.
## Results

Efficiency Ratio ($Y^c / Y^*$)

<table>
<thead>
<tr>
<th>Crop</th>
<th>All regions</th>
<th>Altiplano Occidental</th>
<th>Corredor Seco</th>
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<th>Pacífico-Bocacosta</th>
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</tr>
</thead>
<tbody>
<tr>
<td>White Maize</td>
<td>76.9%</td>
<td>79.3%</td>
<td>79.2%</td>
<td>86.7%</td>
<td>76.7%</td>
<td>83.5%</td>
</tr>
<tr>
<td>Yellow Maize</td>
<td>80.7%</td>
<td>83.0%</td>
<td>75.3%</td>
<td>86.7%</td>
<td>63.7%</td>
<td>83.5%</td>
</tr>
<tr>
<td>Black Beans</td>
<td>75.3%</td>
<td>79.9%</td>
<td>77.3%</td>
<td>88.6%</td>
<td>80.0%</td>
<td>81.5%</td>
</tr>
</tbody>
</table>
Final Comments

- Agricultural land market distortions can have sizeable effects on aggregate outcomes (only static effects, much more with dynamic effects)

- This is a first attempt to develop a tractable theoretical framework to quantify impact and inefficiencies

- Agricultural land market data is scarce

- This type of framework is crucial to evaluate the cost-benefit analysis of policy recommendations