Improved Seeds and Profitability: An Analysis of Maize Production in Mexico

Laura Donnet and Damaris Lopez
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Diversity of Maize Production in Mexico

- Diversity of production environments
  - Geographies
  - Altitude
  - Rainfall
  - Temperature
  - Daylength
- Diversity of maize varieties
  - Tuxpeño in the humid tropical lowlands
  - Celaya, Bolita, and Cónico Norteño in the mid-altitude lands
  - Cónico and Chalqueño in the highlands of Mexico
  - Comiteco and Olotón in Chiapas
- Other production inputs and practices
  - Tillage system
  - Planting density
  - Water system
- Producers’ characteristics
  - Farm size
- Maize uses and markets:
  - Flour industry, dough and tortilla industry, animal production, maize starch, subsistence consumption and differentiated maize uses
  - Commodity and specialty, retail and local, via intermediary and direct to consumer,
  - Scale–related “profitability crossover” (Kelleman et al 2013)
Need for Maize Productivity Growth


Growth rates 1960-2012
- Consumption: 3.3%
- Production: 2.6%
- Imports: 10.1%
- Exports: 1.2%
Seed Profitability and Productivity Growth

1. In a market based economy, profitability is the measure to look at for sustainable productivity growth
2. Seed is the core of the technical and business package
3. **Our approach in this study:**
   1. Understand what determines and modifies profitability
   2. In our case, profitability of improved seeds
4. Empirical studies on profitability of productivity increase technologies
   - Profitability of fertilizer use on maize in Zambia (Xu et al., 2009): effects of production inputs, producers’ household characteristics and government programs
5. Adoption literature:
   - Assumes profitability
   - Empirical results:
     - Profitability is found to be major a determinant in adoption (Kafle et al 2010)
     - Mixed findings: positive effect of technology on yield but negative on profitability
Research Question

- What factors influence profitability of improved seed use on maize in Mexico?
  - Focus on the main factors of variation of the impact of improved seeds on profitability.
  - Estimate main and interaction effects of production environment, production inputs, producers’ characteristics and maize regions variables
  - Present results of separate and joint maize profitability regressions for producers using improved and own seed.
Maize production regions

- Capture a combination of various sources of heterogeneity
Maize Production Budgets Database

- **Source:** Maize and Beans Program. PROMAF. 2007. N = 2,059

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>All</th>
<th>Own Seed</th>
<th>Improved Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>t/ha</td>
<td>4.5</td>
<td>2.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Price</td>
<td>MXN$/t</td>
<td>2,754</td>
<td>2,956</td>
<td>2,527</td>
</tr>
<tr>
<td>Revenue</td>
<td>MXN$/ha</td>
<td>11,808</td>
<td>8,366</td>
<td>15,688</td>
</tr>
<tr>
<td>Production Cost</td>
<td>MXN$/ha</td>
<td>6,391</td>
<td>5,087</td>
<td>7,862</td>
</tr>
<tr>
<td>Profit Margin</td>
<td>MXN$/ha</td>
<td>5,417</td>
<td>3,279</td>
<td>7,826</td>
</tr>
<tr>
<td>Farm Size</td>
<td>ha</td>
<td>3.4</td>
<td>2.2</td>
<td>4.9</td>
</tr>
<tr>
<td>Maize regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highlands Mexico</td>
<td></td>
<td>28</td>
<td>41</td>
<td>14</td>
</tr>
<tr>
<td>Highlands Oaxaca</td>
<td></td>
<td>6</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Bajio</td>
<td></td>
<td>14</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Center North</td>
<td></td>
<td>10</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>North</td>
<td></td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>West</td>
<td></td>
<td>20</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>South East</td>
<td></td>
<td>20</td>
<td>23</td>
<td>16</td>
</tr>
</tbody>
</table>

10.90 MXN$ = 1 US$ in 2007
The table below presents data on maize production budgets, including variations in altitude, planting density, tillage system, and water management. The data categorizes production potential into low, medium, and high productivity levels, and distinguishes between conventional and minimal water systems.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>All</th>
<th>Own Seed</th>
<th>Improved Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>masl</td>
<td>1,606</td>
<td>1,807</td>
<td>1,380</td>
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<tr>
<td>Production potential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low productivity</td>
<td></td>
<td>33</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>Medium productivity</td>
<td></td>
<td>37</td>
<td>38</td>
<td>35</td>
</tr>
<tr>
<td>High productivity</td>
<td></td>
<td>31</td>
<td>26</td>
<td>36</td>
</tr>
<tr>
<td>Planting density</td>
<td>plants/ha</td>
<td>46,278</td>
<td>40,313</td>
<td>53,001</td>
</tr>
<tr>
<td>Tillage system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
<td>70</td>
<td>76</td>
<td>63</td>
</tr>
<tr>
<td>Minimal</td>
<td></td>
<td>21</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>Conservation</td>
<td></td>
<td>9</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfed</td>
<td></td>
<td>85</td>
<td>94</td>
<td>74</td>
</tr>
<tr>
<td>Irrigation</td>
<td></td>
<td>15</td>
<td>6</td>
<td>26</td>
</tr>
</tbody>
</table>
Maize Profitability Model

- The profit margin of the $i$-th maize producer is a function of the environment, producer, production and region independent variables $X_j$ and their interactions $Z_j$ ($j=1,\ldots,m$):

$$PM_i = \beta_0 + \sum_j \beta_j X_{ij} + \sum_j \varphi_j Z_{ij} + \varepsilon_{ij}$$

- where $X_j$ are the $j$-th main effect variables:
  Improved seed, Tillage Systems, Irrigation, Planting density, Altitude, Production Potential, Size and Maize Region, and

- $Z_j$ are the $j$-th interaction terms:
  Improved Seed×Irrigation, Improved Seed×Highlands Mexico, Improved Seed×Highlands Oaxaca, Improved Seed×Center North, Improved Seed×North, Improved Seed×West, Improved Seed×South East
## Results: Statistical Significance

<table>
<thead>
<tr>
<th>Effect</th>
<th>Unit</th>
<th>All</th>
<th>Own Seed</th>
<th>Improved Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Seed&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1,360 *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tillage system: base group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>-135</td>
<td>-1,880 ***</td>
<td>954 **</td>
<td></td>
</tr>
<tr>
<td>Conservation</td>
<td>349</td>
<td>-208</td>
<td>346</td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>-703</td>
<td>-351</td>
<td>3,103 ***</td>
<td></td>
</tr>
<tr>
<td>Interactions</td>
<td>4,106 ***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved seed Irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting density</td>
<td>plants/ha</td>
<td>0.13 ***</td>
<td>0.07 ***</td>
<td>0.17 ***</td>
</tr>
<tr>
<td>Altitude</td>
<td>masl</td>
<td>-1.46 ***</td>
<td>-0.76 **</td>
<td>-2.15 ***</td>
</tr>
<tr>
<td>Production potential: base group</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium productivity</td>
<td>1,812 ***</td>
<td>2,098 ***</td>
<td>1,235 ***</td>
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<tr>
<td>High productivity</td>
<td>3,196 ***</td>
<td>2,866 ***</td>
<td>3,251 ***</td>
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</tr>
<tr>
<td>Size</td>
<td>ha</td>
<td>25</td>
<td>109</td>
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### Results: Statistical Significance, cont’

<table>
<thead>
<tr>
<th>Effect</th>
<th>Unit</th>
<th>All</th>
<th>Own Seed</th>
<th>Improved Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize region: base group Bajio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highlands Mexico</td>
<td>2,282</td>
<td>1,747</td>
<td></td>
<td>3,222</td>
</tr>
<tr>
<td>Highlands Oaxaca</td>
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<td>Center North</td>
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<tr>
<td>North</td>
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<tr>
<td>West</td>
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<td>616</td>
<td></td>
<td>1,706</td>
</tr>
<tr>
<td>South East</td>
<td>665</td>
<td>1,533</td>
<td></td>
<td>-1,773</td>
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<tr>
<td>Interactions Improved seeds &amp; Maize regions</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highlands Mexico</td>
<td>-25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highlands Oaxaca</td>
<td>-5,270</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Center North</td>
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<td></td>
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<tr>
<td>North</td>
<td>1,775</td>
<td></td>
<td></td>
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<tr>
<td>West</td>
<td>553</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South East</td>
<td>-2,496</td>
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<tr>
<td>Constant</td>
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<tr>
<td>Adj R2</td>
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<td>0.4567</td>
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<tr>
<td>Observations</td>
<td>2,059</td>
<td>1,091</td>
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<td>968</td>
</tr>
</tbody>
</table>
Results: Economic Significance

1. Controlling for all factors the effect of improved seeds on profitability is MXN$ 1,360

2. The margin differential of improved seeds crucially depends on regions, capturing market and cultural issues:
   1. Oaxaca: - MXN$ 5,270
   2. South East: - MXN$ 2,496

3. Maize production is most profitable in the Highlands:
   1. On average: MXN$ 2,282
   2. With own seed: MXN$ 1,747
   3. With improved seed: MXN$ 3,222
4. Production environment:
   1. Own seed perform better in medium productivity and improved seeds in high productivity
   2. Profitability degrades with altitude, at a lower rate with own than with improved seeds

5. Production inputs and practices:
   1. Increase planting density with improved seeds
   2. Improved seeds outperform own seed under irrigation by MXN$ 4,106

6. Size is not important but the scale-related profitability cross-over is important
Managerial Implications

- Strategies for expanding the benefits of improved seeds to broader sets of producers ⇒ target breeding and commercial efforts more specifically:
  - Market segmentation of maize producers
  - Needs assessment of each segment
  - New seed products with new traits and multiple traits, including adaptation and output / quality traits for specialty markets

- Strategies for enhancing the benefits of producers’ own seeds
Thank you