Smallholder vs. Large-Scale Farming Systems in Low- and Middle-Income Economies

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Today’s talk

• Describe renewed challenges to feeding a growing and wealthier world population in the 21\textsuperscript{st} Century
• Analyze the role of smallholder farming in low- and middle-income countries (LMIC) in addressing these challenges
• Talk about two recent papers that consider two developing-country production settings
  • A high-value export commodity
  • A domestic staple commodity
• Describe an economic model to compare smallholder farming with an alternative commercial-farming system wherein smallholders supply land and labor inputs to the commercial farms
• Parameterize the model to real-world data for simulation purposes
The Challenges: Demand Growth

• We must dramatically increase food production in response to rising incomes, growing populations, and inadequate (food insecure) diets for \( \frac{1}{7} \ (\frac{1}{3}) \) of world population
  • Population growth from 7.95 billion today to 9.7 billion by 2050
  • Income convergence between high-income and developing countries→income-elastic food demands
  • Hertel et al. ARRE 2016—projections from 2005 – 2050 range from +52% to +116%.

• Fukase and Martin World Dev. 2020: Average annual CE food demand growth 2009 – 2050 is 1.72%, consisting of 1.03% increase per capita and 0.68% due to higher pop → 102% demand growth,
The challenges to supply expansion

• A slowdown in agricultural productivity growth in the West
• Pest resistance to traditional treatments
• Yield-reducing impacts of climate change
• Advent of biofuels and the need to provide increasing portions of the fuel supply
• Demands to provide an increasing complex suite of differentiated, “credence-attribute” products, nearly all associated with reduced yields
• Calls for agriculture to provide ecosystem services and environmental benefit, reduce carbon emissions, and conform to society’s evolving beliefs about fairness
Current growth rates may not be enough

- Ray et al. *PLOS ONE* 2013: Yields for maize, rice, wheat, and soybean (source of two-thirds of global agricultural calories) are increasing at 1.6%, 1.0%, 0.9%, and 1.3% per year
  - < 2.4% per year rate required to double global production by 2050.
  - <1.72% annual demand growth predicted by Fukase and Martin

- Models summarized by Hertel et al. *ARRE* 2016 vary greatly in food price projections for 2050: -16% to +46%
  - These macro models ignore key supply chain developments
Smallholder Farming in Emerging Economies

Part of the solution?  Part of the problem?
Smallholder farming

• Among 570 million farms worldwide, Lowder et al. (*World Dev. 2016*) estimate 80% are less than 2 ha in size

• Average farm size has been decreasing in many LMICs

• LMIC governments and prominent NGOs such as the UN and World Bank devote considerable resources to supporting and preserving smallholder agriculture
Rationales in Support of Smallholder Farming

• Smallholder farming can achieve higher land productivity by avoiding moral hazard problems associated with hired farm labor relative to household labor and having more intensive labor input
  • Known as the inverse size-yield (productivity) relationship

• Agricultural productivity advancements will directly benefit smallholder farming and alleviate rural poverty

• Advent of large-scale farming will create rural unemployment, cause migration to cities, and exacerbate urban poverty problems
Arguments in Opposition to Smallholder Farming

• Commercialization of agriculture that has fueled economic growth in the West can do the same for LMICs
• Next wave of agricultural productivity growth, e.g., precision agriculture, is scale and capital intensive and will not benefit smallholder farms
• Evolution of supply chains, including contract farming, dominance of large supermarkets, and trade liberalization, does not favor smallholder farms (Professor Otsuka’s keynote at this conference)

• Relatively low total factor productivity of small farms causes high local food prices and exacerbates urban poverty
Critical arguments in the smallholder farming debate

• Is the purported labor-efficiency advantage, due to the principal-agent problem, of small farms real?

• How disadvantaged are small farms on the selling side due to buyer market power, price discounts for low volumes, lack of market information, lack of access to markets, etc.?

• How do credit constraints affect smallholder efficiency?

• How important are economies of scale?
Discuss results from two papers

• Ma and Sexton *Agricultural Economics* 2021: Examine conversion of smallholder farms to commercial-sized operations for a **high-value export commodity**—e.g., coffee, cacao, pineapples

• Ma, Lin, and Sexton *AJAE* 2022: Examine smallholder conversion in the context of production of a **domestic staple**, e.g., rice, maize

• The papers differ considerably because price is endogenous in MLS and domestic consumer welfare is an issue
Conceptual framework 1: model of farm production

• Assume constant returns to scale. Smallholder farms incur no penalty due to inefficient scale
  • CRS Cobb-Douglas production function with inputs land, labor, “capital,” where capital is a composite for all market-purchased inputs

• Smallholders maximize a household utility function subject to the production function and constraints on income, household labor, and capital availability
Conceptual framework 2: Commercial farming alternative

• Assume institutions are available to support the endogenous consolidation of farmland
  • Smallholders have secure property rights to rent or sell their land
  • Smallholders can also sell their labor to commercial farming operations
  • Land rental rates and labor wage rates are determined through competitive factor markets
  • Consolidation emerges “bottom up” through market processes, not “top down” as in the failed experiments to create “mega farms”

• Critical questions: (1) Is smallholder household welfare higher under active farming of their plots or as sellers of land and labor inputs? (2) What is urban consumer welfare under the two farming systems? (Only relevant in the domestic staple case)
Conceptual framework 3: Comparison of smallholder and commercial farm systems

• Smallholder farms may have a labor efficiency advantage relative to commercial operations based on the empirical literature.

• Smallholder farms obtain a lower selling price relative to commercial operations based on the empirical literature.

• Smallholder farms are credit constrained to an extent defined by the empirical literature. Credit constraints prevent efficient use of market inputs.
Reminder of some basic production economics

• Commercial farms’ demands for inputs (labor, land) is determined by their value marginal product (VMP)

\[ VMP_i = w_i = P \cdot MP_i, \quad i = \text{land, labor, capital} \]

• Inputs are typically complements, so \( \frac{\partial MP_i}{\partial x_j} > 0 \)
  
  • For example, more efficient application of capital inputs raises labor’s and land’s marginal productivities
Simulation model parameterization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Value</th>
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<tbody>
<tr>
<td>$\sigma_S$</td>
<td>Smallholder farm share of the retail value</td>
<td>0.51</td>
</tr>
<tr>
<td>$\sigma_L$</td>
<td>Large farm share of the retail value</td>
<td>$\sigma_S / \sigma$</td>
</tr>
<tr>
<td>$\sigma = \sigma_S / \sigma_L$</td>
<td>Smallholder relative farm share</td>
<td>(0.69, 0.96)</td>
</tr>
<tr>
<td>$\Omega$</td>
<td>Large farm labor efficiency</td>
<td>(0.79, 1.0)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Smallholder credit constraint</td>
<td>(1.70, 8.78)</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>Output elasticity of capital</td>
<td>0.19</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Output elasticity of labor</td>
<td>0.24</td>
</tr>
<tr>
<td>$\varepsilon_p$</td>
<td>Demand elasticity for the staple food</td>
<td>-1.0</td>
</tr>
<tr>
<td>$\varepsilon_Y$</td>
<td>Income elasticity for the staple food</td>
<td>0.73</td>
</tr>
<tr>
<td>$\xi$</td>
<td>Expenditure share on the staple food</td>
<td>0.33</td>
</tr>
</tbody>
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Simulation results: Domestic staple case
Welfare impacts: Urban, rural, total

- Simulations are conducted under various parameter values
  - Parameter values drawn randomly from uniform distributions indicated by the literature
  - 10,000 draws
- Measure changes in rural, urban, and social welfares
- Draw distributions of percentage changes
- Overall welfare rises in 93% of simulations
- Staple output increases an average 20.5%
Simulation results: Export commodity
Baseline results

- Assume low capital output elasticity \( \varepsilon = 0.19 \)

- \( R(\sigma, \Omega, \gamma, \varepsilon) = \frac{\pi_L^*}{\pi_S^*} = (\sigma \Omega \gamma)^{\frac{1}{1-\varepsilon}} \frac{1-\varepsilon}{\gamma-\varepsilon} \)

- Hyperplane is defined by \( R = 1 \)

- \( \sigma \geq 1 \); price premium earned by commercial farms

- Assume small-country exporter-no price impacts due to output changes

- Domestic consumer welfare is not a consideration in this case
Results for higher capital intensity

- Results are for $\varepsilon = 0.32$.
- Higher capital intensity magnifies commercial farms advantage from no credit constraint.
Impacts of commercial farm conversion on farm output

- $R' = \frac{Q_L}{Q_S} = \frac{1}{\Omega^{1-\varepsilon}} (\sigma \gamma)^{1-\varepsilon} \frac{\varepsilon}{\sigma \gamma}$.

- $R'$ increases in $\sigma$, $\Omega$, and $\gamma$.

- Hyperplane depicts $R' = 1$
Win-Win: Higher Farm Output and Farmer Income
Conclusions

• We have studied endogenous conversion to commercial-sized farms through market processes wherein smallholders sell land and labor inputs to commercial farms

• Domestic staple case:
  • Significant output expansion—+20% in baseline
  • Urban consumer welfare rises significantly
  • Farm income falls in most cases due to adverse price effects
  • Sum of urban and rural welfare is almost always higher in the commercial farm case

• Export commodity case
  • Smallholder income and output are higher in the commercial farm scenario in most simulations
More Conclusions

• If anything, our results err on the side of conservatism in simulating a labor-efficiency advantage to small farms and not considering economies of scale in farm production

• Society at large can ill afford to indulge and subsidize inefficient small-farm production amidst looming challenges to expand food production in response to growing food demand, especially among LMIC countries

• “Band-aids” aren’t likely to solve the problem

• Resources presently expended to support smallholder agriculture would be better spent supporting institution building in LMICs that would secure property rights and facilitate transition to commercial farming systems