Agricultural Productivity, Economic Growth, and Food Security

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Agriculture for Development – Revisited
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Outline

1. Background
2. Impact assessment
3. The model
4. Conclusions
Agriculture is a large sector in most poor countries, both in terms of employment and output.

The agricultural sector has strong linkages to other sectors:

- As a source of supply for a unique consumption good
- As a source of demand for non-agricultural products
- As a potential source of labor and other productive resources (land, capital)

These linkages make it important to think about agriculture in general equilibrium.
Agricultural productivity $\Rightarrow$ Macroeconomic outcomes

Many channels of connection

- Agricultural performance affects GDP levels and growth rates
- Agricultural production often has big impacts on inflation rates
- Governments may earn large shares of revenue from agricultural exports (e.g., export taxes in many African countries)
- Poverty alleviation and inequality
Macroeconomy $\Rightarrow$ Agriculture

- Demand for products
- Overall demand for labor
- Exchange rates
- Macro and monetary stability
Outline

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2. Impact assessment for agricultural interventions

- Many agricultural interventions are targeted to the level of farms or communities
  - New crop varieties
  - Input subsidies
  - Rural roads and infrastructure
  - Etc.
Benefits spill over
Are we looking in the right place?

- Evaluations often focus on the impact of these interventions on farm income or living standards.
- These interventions may create some benefits at the farm level.
- But benefits may instead be transmitted through markets to others.
  - Consumers may benefit through lower prices.
  - Processors may benefit through more consistent supply or lower costs.
  - Firms in other sectors may demand more labor and drive up wage rates.
- Micro evaluations that do not consider general equilibrium effects may give misleading results.
Background
Impact assessment
The model
Conclusions

Example: Agricultural development and structural transformation

- Based on Gollin and Rogerson (2010), in a paper on Uganda.
- Consider general equilibrium effects of programs and policies that generate agricultural “development”.
- These interventions cause the share of agriculture in GDP and employment to fall.
- Naive evaluation techniques might fail to recognize agriculture’s role.
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Close in spirit to Eswaran and Kotwal (1993).
Also related to work on transportation and growth in Herrendorf, Schmitz, and Teixeira (2006, 2008); Adamopoulos (2005).
Most similar to models of structural transformation in Gollin, Parente, and Rogerson (2004, 2007).
Consider a closed developing economy with two sectors: an agricultural sector that produces food and an urban sector that produces non-agricultural goods.

Non-agricultural goods can be consumed or used as inputs into the production process in either sector.

Non-agricultural goods are produced in the city.

Food can be produced in either of two rural regions: an area “close” to the city or an area that is more “remote”.

There are (high) transportation and transaction costs that make it expensive to move manufactured goods from the city to rural areas and (symmetrically) make it costly to move food from rural areas to the city.
Schematic Representation

Remote Agriculture  
Region 2  
Cost $q_2$  
$m$

Near Agriculture  
Region 1

City Manufacturing  
Region 0  
Cost $q_1$  
$m$

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Agriculture and Growth
In equilibrium, people will inhabit all three regions.

Those in the remote rural area will produce less for the market than those in the close rural area.

The urban population is limited by the ability of the agricultural sector to produce “marketable surplus;” low agricultural productivity implies small urban populations.

High transportation costs will make it costly to move goods across regions.
Log linear preferences with non-homotheticities:

\[ \alpha \log(a - \bar{a}) + (1 - \alpha) \log(m + \bar{m}) \]
Three-Region Model
Technologies

- Agricultural technology:
  \[ a_j = A_a F(l_j, x_j, n_{aj}) = A_{aj} l_j^{1-\theta_x-\theta_n} x_j^{\theta_x} n_j^{\theta_n} \]
- Manufacturing technology: \( m = A_m n_m. \)
Three-Region Model

Endowments

- $l_1 = 0.1$
- $l_2 = 0.9$
- Labor is allocated endogenously.
Feasibility Conditions

\[
n_0 m_0 + n_1 \frac{m_1 + x_1}{1 - q_1} + n_2 \frac{m_2 + x_2}{(1 - q_1)(1 - q_2)} = A_m n_0
\]

\[
n_0 \frac{a_0}{(1 - q_1)} + n_1 a_1 + n_2 (1 - q_2) a_2 = A_a^1 \left( 1 - \theta x - \theta n \right) x_1^\theta n_1^\theta + (1 - q_2) A_a^2 \left( 1 - \theta x - \theta n \right) x_2^\theta
\]
Equilibrium Allocations

- For interior solution:
  \[ m_0 + \bar{m} = \frac{m_1 + \bar{m}}{1 - q_1} = \frac{m_2 + \bar{m}}{1 - q_1(1 - q_2)} \]
  \[ \frac{a_0 - \bar{a}}{(1 - q_1)} = a_1 - \bar{a} = (1 - q_2)(a_2 - \bar{a}) \]

- Corner solutions are plausible under some specifications. We solve for them and check for them computationally.
Choose parameter values to match a few stylized observations from Uganda.

- $A_a = A_m = 1$
- $\theta_x = .2, \theta_n = .4$
- $\alpha = .20$
- $\bar{m} = 0$
- $\bar{a} \Rightarrow n_1 + n_2 = 0.80$
- $q_1 = 0.1, q_2 = 0.6$
Benchmark Allocations

Consumption Allocations: Three Region Model

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- Individuals in the “near” agricultural region consume bundles quite similar to urban residents.
  - Sell almost half (45%) of agricultural output.

- Individuals in the “remote” agricultural region seem to be in quasi-subsistence:
  - Consume only one-third as much $m$ as urban residents.
  - Sell only one third (34%) of own agricultural output.
### Agriculture Production: Three Region Model

<table>
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<tr>
<th>$l_1/n_1$</th>
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- Labor intensity is greater in near region.
- Far greater use of intermediates in near region.
- Output per unit of land (yield) is 40% higher in the near region.
- Differences in output per worker are not large.
Comparative Statics

Consider three scenarios:

- 10% increase in agricultural TFP
- 10% increase in manufacturing TFP
- 10% reduction in transport cost

Welfare comparison: Ask how by what fraction the benchmark consumption bundle would need to be increased in order to yield the same utility as each scenario.
### Equilibrium Scenarios

#### Experiments in the Three Region Model: Consumption Allocations

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<tr>
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## Manufacturing Consumption in Equilibrium

### Experiments in the Three Region Model: Manufacturing Consumption

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Impact assessment
The perils of overlooking GE effects

- In all of these scenarios, 80-90 percent of welfare gains come from sectoral reallocation of people, in the sense that increasing consumption allocations alone would generate only 10-20% of the welfare gains.

- Impact assessment techniques that focus on “within” measures of welfare gains will give misleading (low) estimates of impact.

- Similar in spirit to Lewis model, in which growth consists of moving people from a low productivity sector to a higher productivity sector.
Consider the scenario in which agricultural TFP rises by 10%.

Our welfare measure suggests that this generates as much improvement in well-being as a 32% increase in all consumption allocations.

But suppose we do what is common in the agricultural economics literature on impact assessment studies: we will calculate increases in crop yields.
Sectoral impacts in agriculture

- At a national level, yield increases by 7.7% (for a population-weighted sample) or 8.3% (for an area-weighted sample). Both are smaller in percentage terms than the TFP increases.
- Agricultural output increases by 8.6%.
- We do not calculate prices, but shadow prices fall in the model economy. The value of agricultural output rises only very slightly.
- But the big effect is that 6.3% of the people move from rural to urban areas, while another 1.9% move from quasi-subsistence to commercial agriculture.
Consider the scenario in which transportation costs fall by 10%.

Our welfare measure suggests that this generates as much improvement in well-being as a 35% increase in all consumption allocations.

Suppose this policy is examined for its impact on rural households.
Impacts on rural households

- At a national level, yield increases by 1.4% (for a population-weighted sample) or 2.3% (for an area-weighted sample).
- Agricultural output increases by 0.44%;
- Prices received by farmers may rise, but if we use market prices for food, the decline in transport cost is likely to lead to significant decreases in market prices. Rural incomes rise very slightly or perhaps fall.
- Rural consumption rises – but nominal prices have fallen, so an expenditure survey may not capture this adequately.
- The big effect is that 20% of the total population is able to move out of subsistence agriculture.
Need a general equilibrium model to think properly about these impacts.

In evaluating economy-wide changes (e.g., Green Revolution, any kind of national-level interventions), ignoring the GE effects may lead to serious errors.

Surveys that track migration and sectoral movements will do a better job than studies that focus only on rural or agricultural households.
Need to be careful with attribution of benefits:

- Big gains occur through rural-to-urban migration.
- This movement may be driven powerfully by investments in agriculture.
- Empirical finding that rural-to-urban migrants achieve the biggest welfare gains will tell us nothing about the causal mechanisms; possibly this reallocation is best achieved through investments in agriculture.
Outline

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5. Conclusions and Questions

- We need to remember that in many developing countries, agricultural interventions have impacts that spill out from the sector. Will a macro perspective change our assessments of which interventions are successful?
- What government investments and policies can help to reduce the costs of change?
Taking okro to market