Agricultural Productivity and Structural Change

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Outline

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1. Introduction

- This morning's theme: understanding agriculture is complicated – more complicated than we used to think!
- Spatial effects are important; heterogeneity is important.
- This presentation: macro spillovers can be important...
- To evaluate some agricultural interventions, we need to look beyond the farm.

Macro approach

- Consider general equilibrium effects of agricultural interventions or changes
- Need to understand the connections between agriculture and macro economy.
- Agricultural productivity is intimately related to structural changes – movements of labor, inputs, capital, etc., across sectors.

Why Look at Agriculture in General Equilibrium?

- Agriculture is a large sector in most developing 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.
- Some policies can be evaluated entirely with micro tools or experiments; others require careful thinking about economy-wide impacts, whatever the methodology.

Outline

2. Structural change

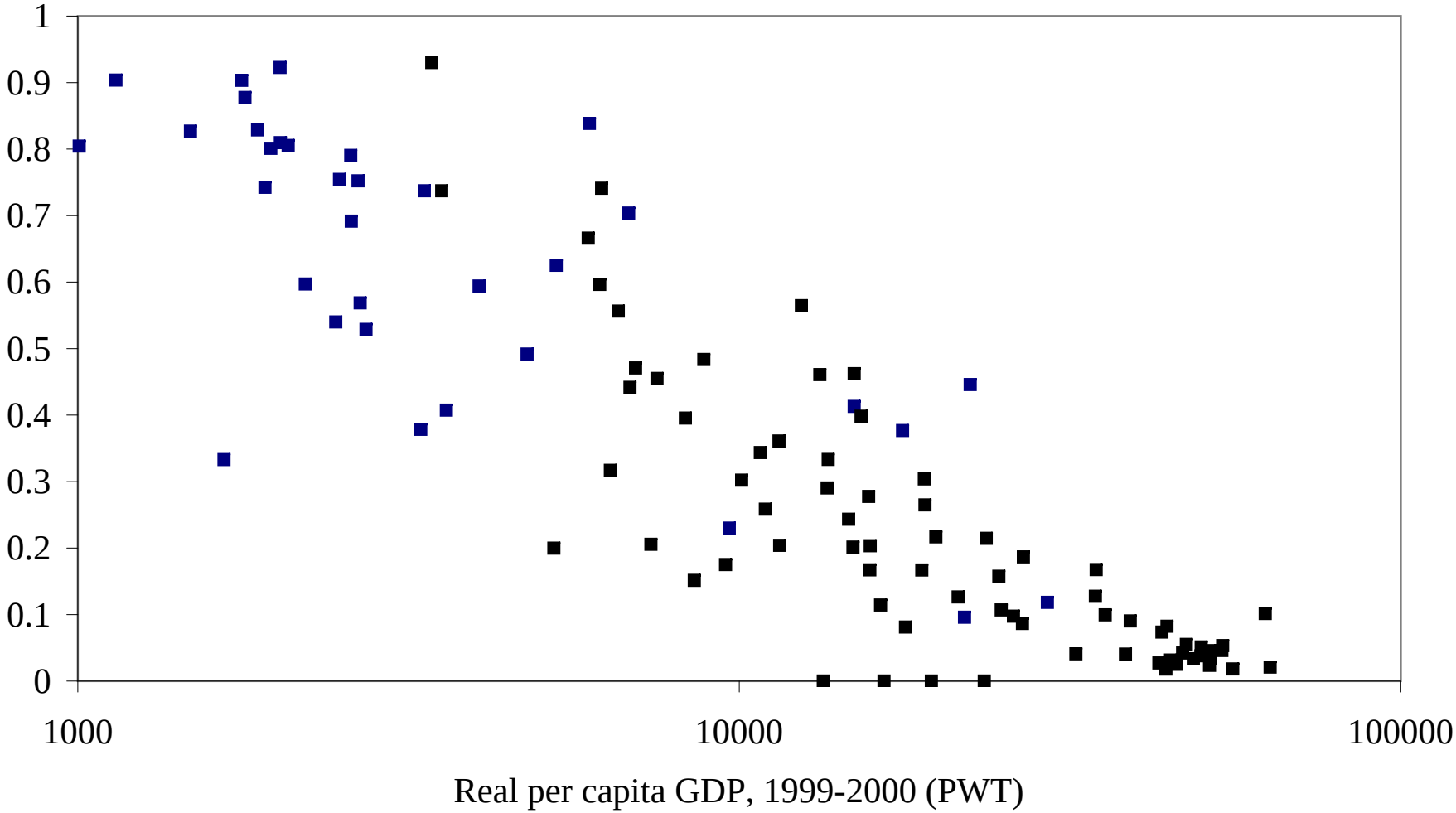
- What is structural change, and why should we care about it?
- What do we know about agriculture's role in structural change?
- Does agricultural productivity affect structural change?
- How might a macro view inform micro analyses?
- What are some of the questions motivated by macro literature?

Patterns of structural change

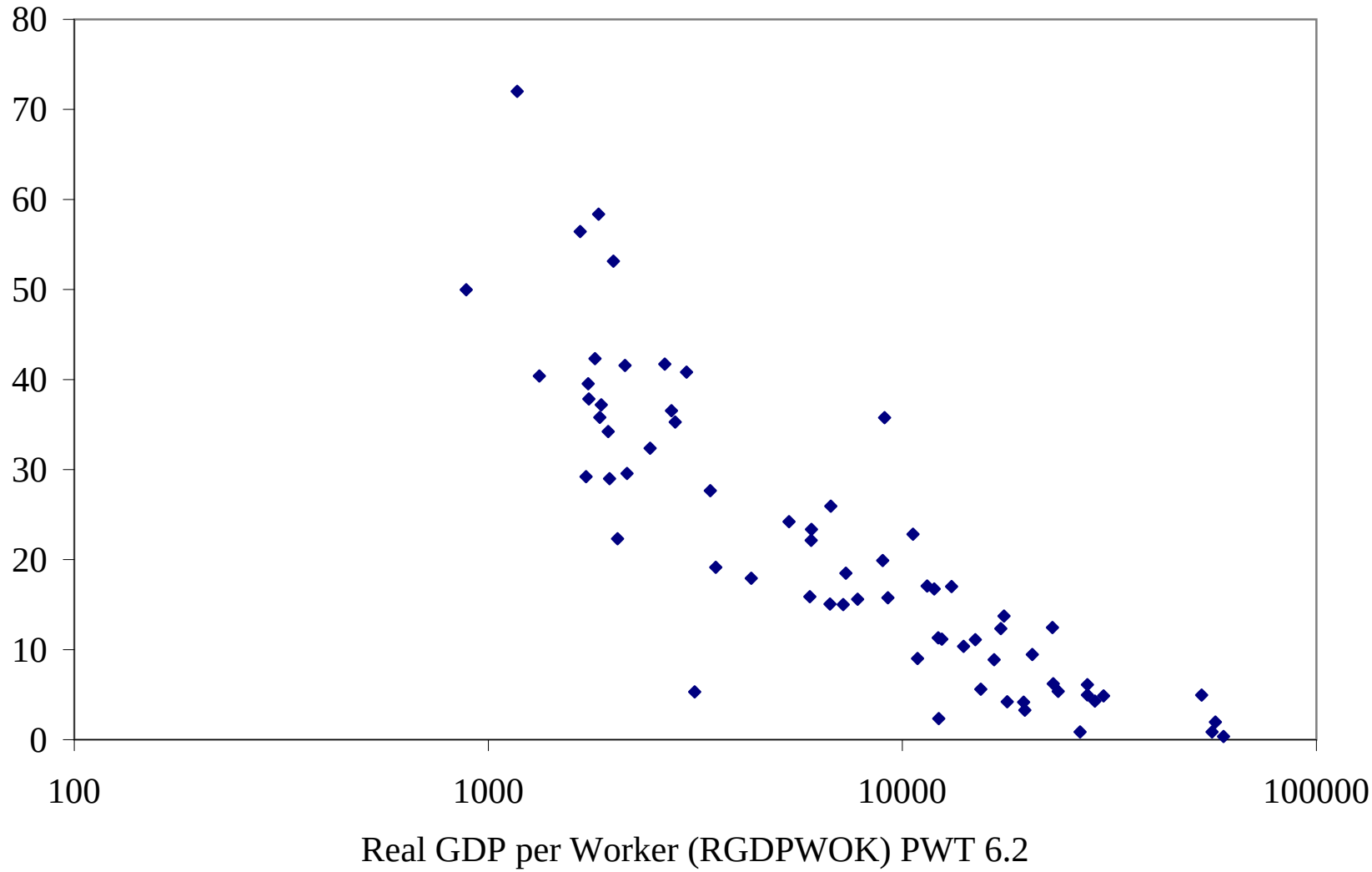
- Economic growth is accompanied by large changes in the sectoral composition of output and employment.
- Agriculture falls as a proportion of GDP and as a share of the economically active population.
- Movement of people from rural to urban areas.
- The pattern holds both in the cross-section and the time series.
- Transformation occurs at different speed in different countries; different starting points.

Agriculture Share of Workforce,Cross-Section Data, 2000

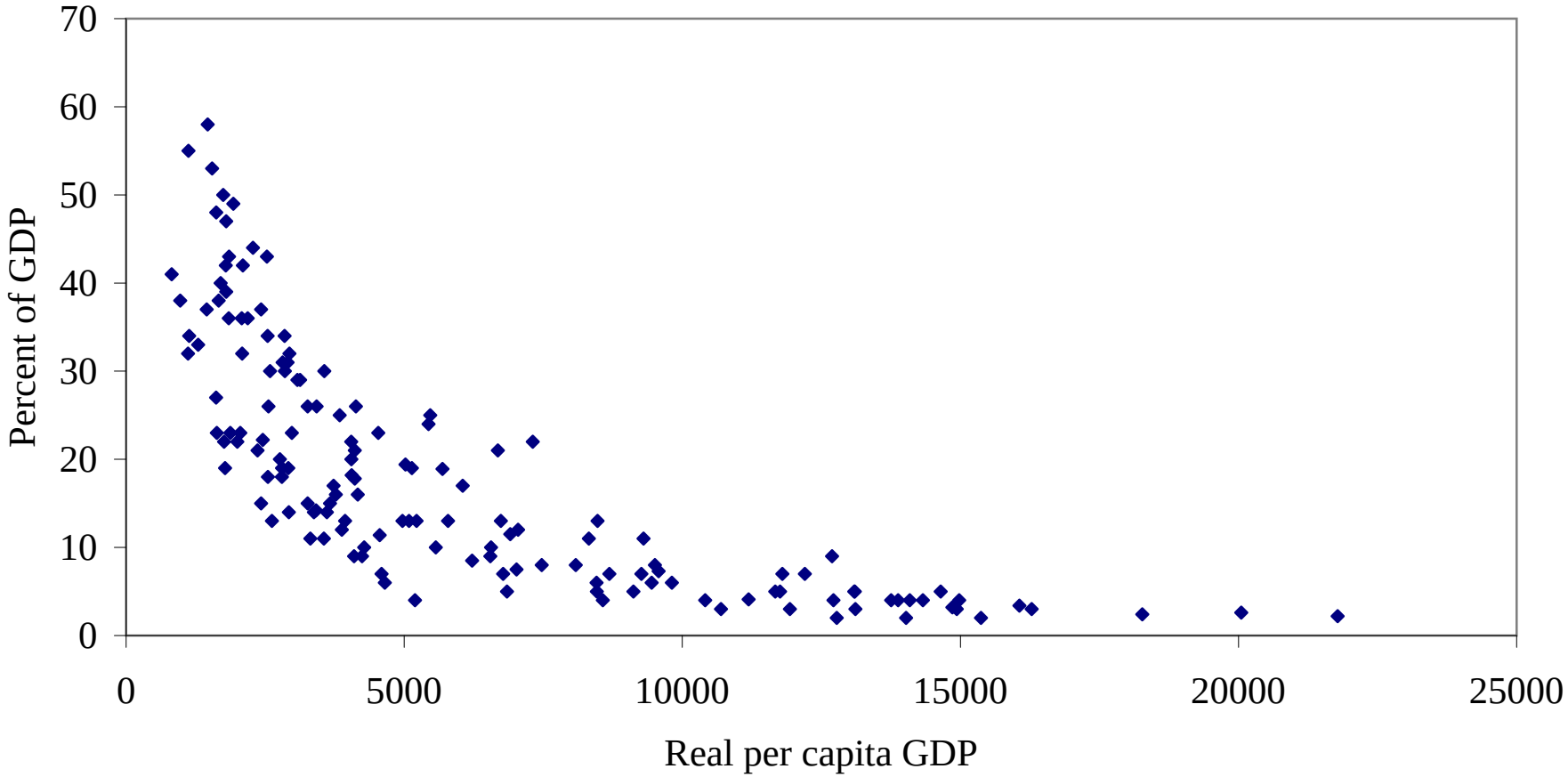
(Source: FAOSTAT)



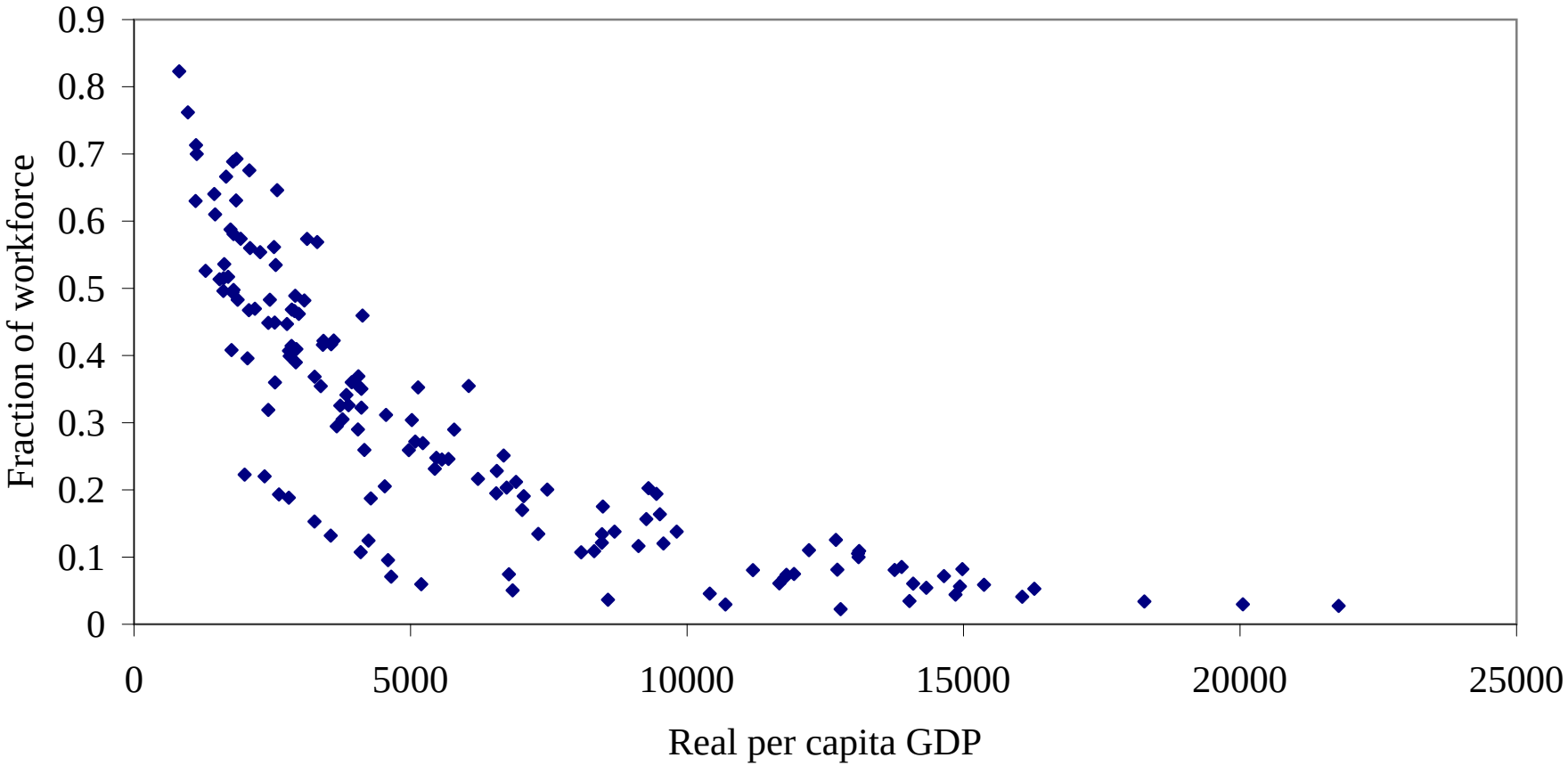
Agriculture's Share of GDP, Cross-Section Data, 2000



Share of agriculture in GDP, historical data for 15 industrial countries



Employment in agriculture as share of total employment, based on historical data for 15 industrial countries



Sources: Mitchell 1992, pp. 141-58; Kurian 1994, p. 78; Mitchell 1993, pp. 99-103; Mitchell 1995, pp. 95-103. Data on real per capita GDP are taken from Penn World

Agricultural productivity and structural change

- Does agricultural productivity growth drive structural change?
  - Old literature in agricultural economics (T.W. Schultz, Mellor, Gardiner, Kilby) argues that improvements in agricultural productivity drive structural change.
  - But theory and empirical evidence are somewhat ambiguous; agricultural productivity growth is neither necessary nor sufficient for structural change.
- If agricultural productivity growth does drive structural changes, do we care?

Why do we care about structural change?

- The decline of agriculture is one of many structural transformations that take place in the course of growth:
  - Decline of self-employment
  - Increases in average firm size
  - Growth of services
  - Changes in retailing and markets
  - Etc.
- Do these structural changes carry any welfare implications?
- Perhaps they are just intriguing curiosities...

Sectoral differences in living standards

- One reason why we might believe that there are welfare implications to the structural change out of agriculture is that there are big differences in measured living standards between urban and rural areas in most poor countries.
  - Poverty rates are systematically higher in rural areas; income/expenditure are lower; health and mortality indicators are almost always worse.
  - In this case, there may be important welfare benefits to interventions that produce structural changes.

Outline

3. 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 output, farm income, or rural 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.

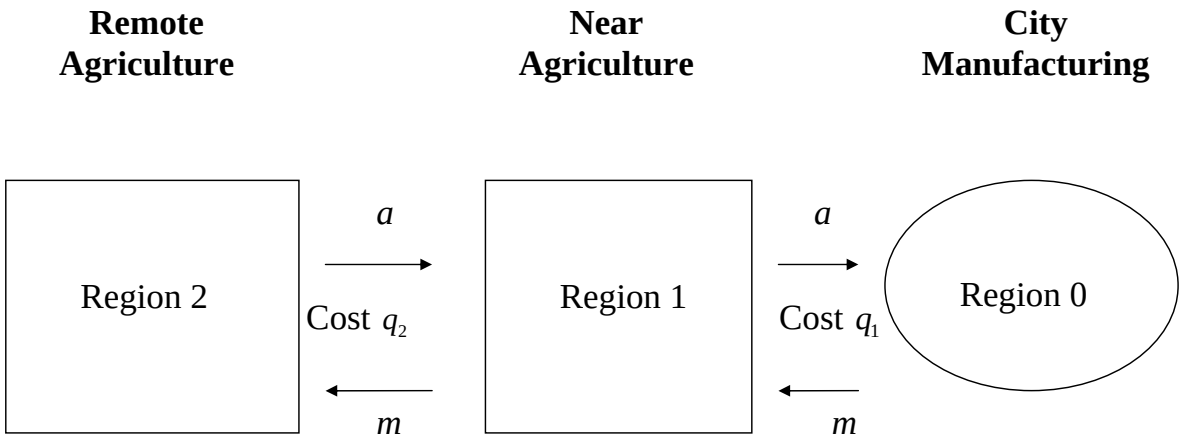
Example: Agricultural productivity and structural transformation

- Based on Gollin and Rogerson (2010), in a paper on Uganda, carried out in coordination with MISR with assistance of Wilberforce Kisamba Mugerwa.
  - Close in spirit to Eswaran and Kotwal (1993); Caselli and Coleman (2001); Vollrath (2004, 2008).
  - 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 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.

Model environment

- 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



Model environment, cont.

- 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.

Three-Region Model

Preferences

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

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

$$n_0 \frac{a_0}{(1 - q_1)} + n_1 a_1 + n_2 (1 - q_2) a_2 = A_a l_1^{1-\theta_x-\theta_n} x_1^{\theta_x} n_1^{\theta_n} + (1 - q_2) A_a l_2^{1-\theta_x-\theta_n} x_2^{\theta_x} n_2^{\theta_n}$$

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 (likely) under some specifications. We solve for them and check for them computationally.

Quantitative Experiment

Parameter Values

- Chosse 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

n_1	n_2	a_0	a_1	a_2	m_0	m_1	m_2
.096	.707	.409	.410	.425	.0516	.0464	.0186

- 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, Near and Far

Inputs and Intensity across Regions

Agriculture Production: Three Region Model

l_1/n_1	l_2/n_2	x_1/n_1	x_2/n_2	y_{a1}/n_1	y_{a2}/n_2	y_{a1}/l_1	y_{a2}/l_2
1.04	1.27	.187	.066	.73	.64	.70	.50

- 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

	n_0	n_1	n_2	a_0	a_1	a_2	Δ
Benchmark	.197	.096	.707	.409	.410	.425	–
$A_a = 1.1$	.260	.115	.625	.415	.417	.442	.32
$A_m = 1.1$	.210	.105	.685	.411	.412	.429	.06
$q = .9q$	.259	.098	.643	.413	.414	.431	.26
A_a, A_m, q	.340	.124	.536	.420	.422	.448	1.07
A_a , q	.320	.114	.566	.420	.421	.447	.82
$l_1 = .2$	.280	.216	.504	.414	.415	.438	.35
Pop 1.1	.089	.099	.812	.407	.407	.418	−.02

Manufacturing Consumption in Equilibrium

Experiments in the Three Region Model: Manufacturing Consumption

	m_0	m_1	m_2	Δ
Benchmark	.052	.046	.019	–
$A_a = 1.1$	.096	.087	.035	.32
$A_m = 1.1$	.065	.059	.024	.06
$q = .9q$	.085	.077	.036	.26
A_a, A_m, q	.16	.15	.068	1.07
A_a , q	.14	.13	.057	.82
$l_1 = .2$	.095	.085	.034	.35
Pop 1.1	.036	.032	.013	−.02

Agriculture in Equilibrium

Intensification and Input Use

Experiments in the Three Region Model: Agricultural Production

	y_{a1}/n_1	y_{a2}/n_2	y_{a1}/l_1	y_{a2}/l_2
Benchmark	.73	.64	.70	.50
$A_a = 1.1$	.75	.77	.86	.53
$A_m = 1.1$	.71	.66	.75	.51
$q = .9q$	.75	.72	.73	.51
A_a, A_m q	.77	.91	.95	.54
A_a,q	.77	.86	.88	.54
$l_1 = .2$	.72	.75	.78	.47
Pop 1.1	.71	.59	.70	.53

Agriculture in Equilibrium

Intensification and Input Use

Experiments in the Three Region Model: Agricultural Production

	l_1/n_1	l_2/n_2	x_1/n_1	x_2/n_2
Benchmark	1.04	1.27	.187	.066
$A_a = 1.1$	.87	1.44	.196	.080
$A_m = 1.1$	.95	1.31	.200	.075
$q = .9q$	1.02	1.40	.221	.097
A_a, A_m q	.81	1.68	.254	.137
A_a,q	.88	1.59	.225	.115
$l_1 = .2$	.92	1.59	.226	.094
Pop 1.1	1.02	1.11	.176	.058

Impact assessment

The perils of overlooking GE effects

- In all of these scenarios, we can decompose welfare gains into improvements in welfare within locations and movements of people across locations. The sectoral reallocations appear to account for most 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.

Agricultural TFP increase

The perils of overlooking GE effects

- 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 look at some alternative measures of impact, common in the micro literature.

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%.
- Agricultural consumption in rural households rises by 3.5%.
- We do not calculate prices, but shadow price of food must fall in the model economy. This means that the value of agricultural output rises by less than the quantity.
- 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.

Rural transportation infrastructure improvements

The perils of overlooking GE effects

- 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%; agricultural consumption of rural households increases 1.9%.
- Prices received by farmers may rise, but if we measure poorly and use urban prices for food, the decline in transport cost is likely to make it appear that prices have fallen! Rural incomes rise very slightly or perhaps fall.
- The big effect is that 20% of the total population is able to move out of subsistence agriculture.

Implications

- 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.

Attribution

- 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

4. Conclusions

- We need to remember that in many developing countries, agricultural interventions have impacts that spill out from the sector.
- For evaluation purposes, there are some interventions where we may need to take into account these spillovers:
  - Track migration out of agriculture
  - Measure improvement in urban living standards (e.g., reductions in food prices)
  - Look at changes in non-agricultural economy (e.g., agricultural service sector)
- When do we need to consider these effects?
  - Not for small-scale experimental interventions
  - For interventions that affect a large number of farmers or large fractions of production
- How do we characterize results of experiments or small-scale interventions?
  - Should not suggest that the farm-level benefits will hold at the aggregate level...
  - Should recognize that there may be many other important benefits that

Taking okro to market

Why Does the Structural Transformation Occur?

- It is not entirely clear why this pattern of structural change occurs.
- One explanation: fundamental non-homotheticities in preferences.
  - If the income elasticity of demand for food is less than one, we would expect to see richer countries with lower budget shares in agriculture.
  - But that does not necessarily correspond to either a declining income share or a declining employment share in agriculture; consider a world with a Leontief production technology for agriculture, with labor and land used in fixed proportions. With no technology change, and with food a normal good, growth will increase demand and labor used in agriculture will actually rise.
- An alternative explanation: differential rates of technological progress; rapid TFP growth in agriculture reduces the number of workers needed to meet food needs.
- Many other explanations possible...

Is the Transformation Necessary?

- If we believe that the transformation is necessary for growth, then we might also want to understand why it is taking place slower in some countries than in others, and why it has started so late.
  - Are there barriers or obstacles that might hinder the process?
  - Are there policies or public goods that might allow it to move faster?
  - Would it improve welfare to accelerate the transformation?