Roads, Agriculture, and Economic Development in Africa: The Case of Uganda

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Background

- **Large fractions of Uganda's population live in rural areas (85%) and work in agriculture (73%).**

- **Agricultural sector appears to have low productivity, relative to non-agriculture. Agriculture accounts for 20% of GDP, suggesting that output per worker in non-agriculture is greater by a factor of 12!**

- **Poverty is relatively concentrated in rural areas (93%).**

- **Poverty rates are much higher among rural households (34%) than urban households (14%).**

Agriculture

- **Within rural Uganda, most individuals work in agriculture, although non-farm enterprises are also important.**

- **Farms primarily produce staple foods on small plots.**

  - ➢ **Major crops are cooking bananas, cassava, maize, beans.**
  - ➢ **Each of these is grown by approx. 75-85% of agricultural households.**
  - ➢ **These four crops together account for 55% of crop area.**
  - ➢ **Cash crops (coffee, tea, sugar, cotton) together account for less than 8% of cropped area.**

Large-scale and smallholder agriculture

- A large-farm sector is found in tea, cotton, and sugar.
  - ➢ Approximately 400 registered enterprises employing 28,000 workers.

- Smallholder farms account for almost all of agricultural employment and output.
  - ➢ Approximately 4.2 million agricultural households employing approximately 8 million workers.

Semi-subsistence farming

- Most farms produce similar food crops on very small scale.

- Large fractions of output are consumed at home.
  - Banana (68%)
  - Cassava (77%)
  - Maize (48%)
  - Beans (84%)

- Households trade small amounts of their output, often selling in local markets to buy non-agricultural consumption goods and intermediate inputs: salt, soap, kerosene; farm tools and chemicals.

Puzzles:

- **Why are so many people concentrated in a sector where they are so (relatively) unproductive?**

- **Within the sector, why is there so little specialization; *i.e.*, why do so many people live in semi-subsistence?**

Possible explanations

- **Low agricultural productivity: farms cannot produce enough surplus to support large urban populations.**

- **Low non-agricultural productivity: non-agricultural consumption goods and manufactured inputs are prohibitively expensive, so rural households do not seek to trade.**

- **High transportation costs: make food expensive in cities, limiting the size of urban populations; also make non-agricultural goods expensive in rural areas, reducing demand.**

- **Population growth: more workers must produce food to meet the additional demand.**

Evidence: Low agricultural productivity

- **Maize yields only 30% of world average; 40% of yield in Brazil.**

- **Other crops show similar yield deficits relative to countries with similar agroecologies.**

Crop yields, Uganda and Brazil
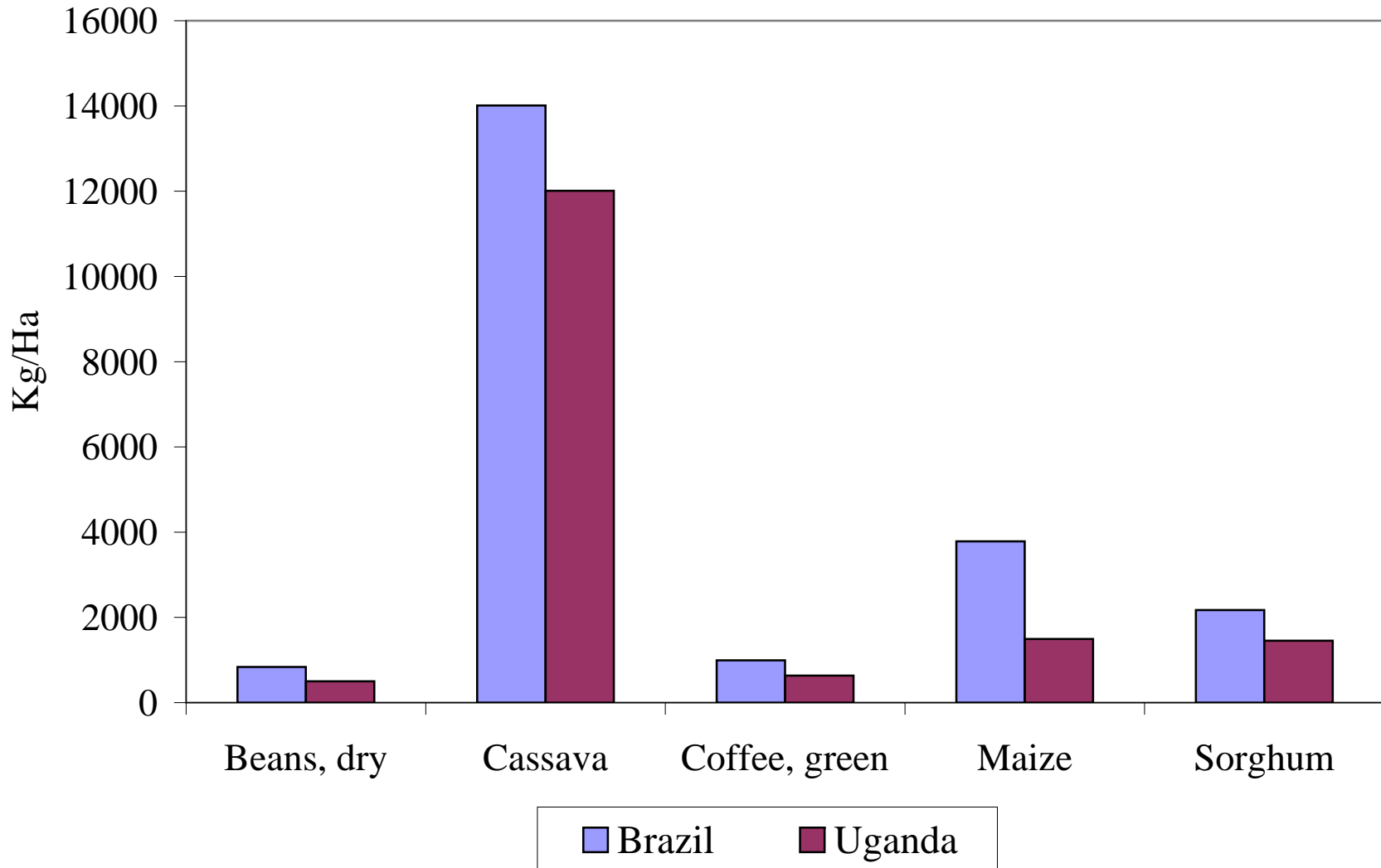
Evidence: Low non-agricultural productivity

- **Average productivity is higher than in agriculture, but it is still low by world standards.**

- **Uganda exports very limited quantities of non-agricultural goods: some minerals (gold, cobalt, petroleum); soap; hand tools; and electric current.**

Evidence: Remoteness and transportation

- **Rural households are frequently remote:**

  - ➢ **Three-quarters live more than two hours from a market center.**
  - ➢ **One-quarter live more than five hours from a market center.**

- **Average distance to a health clinic was 7 km (including in cities); 77 percent of people report that they walk to get to clinics.**

Transportation

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- **Measured transport costs are very high, and price wedges between different markets appear to be extremely high.**

- **The cost of moving 100 kg of agricultural goods 100 km was as high as $5.43 (trucking matoke from Mbarara to Lira), compared with $0.573 for corn in the US.**

- **Uganda's paved road density in 2003 was 16,300 km in an area of 200,000 km^2.**

- **By contrast, Britain at the time the Romans left (AD 350) had 12-15,000 km of roads in an area of 240,000 km^2.**

Evidence: Population growth

- **Uganda's population growth rate of 3.2% is one of the fastest in the world.**

- **Population grows by 10% every three years…**

Specific questions

- **How would the economy respond to each of the following?**

  - ➢ **Improvements in agricultural productivity**
  - ➢ **Improvements in non-agricultural productivity**
  - ➢ **Reductions in transportation costs**
  - ➢ **Population growth**

- **How would they alter the allocation of workers across sectors?**
- **How would they affect the prevalence of semi-subsistence agriculture?**
- **How would they affect welfare?**

Modeling strategy

- To answer these questions, we need a general equilibrium model with at least two sectors and with explicit transportation costs.

- We also need to distinguish between agriculture that is "semi-subsistence" and more commercially oriented agriculture.

Related literature

- **Close in spirit to Eswaran and Kotwal (1993).**

- **Some similarities to 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)**

GPR model

- **Dynamic model of structural transformation.**

- **Closed economy; resources are locked in agriculture until countries can satiate their demand for agriculture.**

- **Movement out of agriculture depends on increases in agricultural productivity. Improvements in non-agricultural productivity also matter.**

$\Rightarrow$ **The subsistence requirement can substantially slow down the process of structural transformation and the rate of economic growth.**

A new model

- **Consider a model with three regions: a city, a "close" rural area, and a "remote" rural area.**
- **Non-agricultural ("manufactured") goods are produced in the urban area; food is produced in both rural areas.**
- **Agriculture uses intermediate inputs from the manufacturing sector.**
- **There are iceberg transportation costs associated with moving any goods from one region to another.**
- **There are many identical families, each of which allocates its members across the three regions to maximize aggregate (family) welfare.**

Utility:

- **Preferences are non-homothetic, with food consumption particularly valued at low levels of income.**

$$\alpha \log(a - \overline{a}) + (1 - \alpha) \log(m + \overline{m})$$

Production

- **Output in each agricultural region $i \in \{1,2\}$ is given by a CES production function defined over land L, intermediates x and labor:**

$$Y_{ai} = A_a F(L_i, x_i, n_i) = A_a [(1 - \theta_x - \theta_n)L_i^\varepsilon + \theta_x x_i^\varepsilon + \theta_n n_i^\varepsilon]^{\frac{1}{\varepsilon}}$$

- **Manufacturing output is given by:**

$$m = A_m n_m$$

Transportation

- **Iceberg transport costs:**

  ➢ **A fraction q_1 of output is lost to move goods (of either type) between the city and the "close" rural area.**
  ➢ **A fraction q_2 is lost to move goods between the "close" and "remote" rural areas.**

- **Assume costless movement of people…**

Feasibility is determined by the following constraints:

$$\frac{a_0}{(1-q_1)} + n_1 a_1 + n_2 \frac{a_2}{(1-q_2)} = Y_{a1} + \frac{Y_{a2}}{(1-q_2)}$$

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

$$n_0 + n_1 + n_2 = N$$

Parameters

$\theta_x = .2$ **Intermediate goods share in CES function**

$\theta_n = .4$ **Labor share in CES function**

$\Rightarrow$ **Land share = 0.4**

$\varepsilon = 0.40$ **Elasticity of substitution in production**

$\alpha = 0.20$ **Asymptotic expenditure share on food**

$\overline{m} = 0$ **Utility parameter for non-agricultural good**

$\overline{a} = 0.25$ **Utility parameter for agricultural good; set so that 80% of workforce is in agriculture**

$q_1 = 0.10$ **Transport cost from city to "close" rural area**

$q_2 = 0.60$ **Transport cost from "close" to "remote"**

$L_1 = 0.10$ **Land endowment in "close" rural area**

$L_2 = 0.90$ **Land endowment in "remote" rural area**

Benchmark results

	Population Shares			Use of intermediate inputs	
	Urban	Close	Remote	Close	Remote
Benchmark	0.197	0.096	0.707	0.018	0.046

Comparative statics and welfare comparisons

- **Define welfare measure:**

    Consider the benchmark consumption bundle. What proportionate change in this consumption bundle would be needed to achieve the same utility level as the benchmark?

Comparison of different channels

Scenario	Population Shares			Intermediate Input Use in Agriculture		Welfare Gain
	Urban	Close	Remote	Close	Remote	
Benchmark	0.197	0.096	0.707	0.018	0.046	-
$A_a = 1.1$	0.260	0.115	0.625	0.023	0.050	0.32
$A_m = 1.1$	0.210	0.105	0.685	0.021	0.051	0.06
L1 expands from 0.1 to 0.2	0.280	0.216	0.504	0.049	0.047	0.35
Transport costs fall 10%	0.259	0.098	0.643	0.022	0.063	0.26
Population increases 10%	0.190	0.099	0.812	0.017	0.047	-0.02

Observations

- **All three channels, viewed separately, lead to declines in agriculture's share of workforce.**

- **The biggest declines come from improvements in agricultural productivity and from increases in the fraction of land that has good access to the city.**

- **A 10% reduction in transport costs has a similar effect to a 10% increase in agricultural TFP, but welfare effect is smaller.**

- **Increase in population actually increases *proportion* of the population in agriculture – not just total number.**

- **Overall, welfare effects are large.**

Interactions

Scenario	Population Shares			Intermediate Input Use in Agriculture		Welfare Gain
	Urban	Close	Remote	Close	Remote	
Benchmark	0.197	0.096	0.707	0.018	0.046	-
A_a, A_m, and q	0.340	0.124	0.536	0.032	0.074	1.07
A_a and q	0.320	0.114	0.566	0.026	0.065	0.82

- **Increasing agricultural productivity and improving transportation simultaneously has a larger welfare impact than the sum of the two separately.**

Conclusions

- **In an effectively closed economy, with agricultural goods exhibiting low income elasticities of demand (beyond some range of income), improvements in agricultural productivity necessarily matter.**

- **Agricultural productivity increases will release labor (and potentially other resources) to other sectors.**

- **High transportation costs will tend to keep people "stuck" in rural areas.**

Caveats

- **Lots of things missing from the model…**

- **If transportation improvements involve road construction, keep in mind that:**

  - ➢ **Road building is expensive.**
  - ➢ **Environmental impacts of roads may be large.**
  - ➢ **Political and social costs may be substantial.**