

November 2009

**Agricultural Technology, Rural Transportation Infrastructure,
and Economic Growth in Africa**

**Douglas Gollin
Williams College
International Growth Centre**

**African Economic Conference
Addis Ababa**

Background

- **Large fractions of Africa's population live in rural areas and work in agriculture.**
- **Agricultural sector appears to have low productivity, relative to non-agriculture.**
- **Poverty remains concentrated in rural areas (Ravallion et al., 2007).**

Questions

- **What role can a low-productivity sector play in generating growth and reducing poverty?**
- **What role can improved agricultural technologies play in stimulating development?**
- **What are the interactions between agricultural technology and rural transportation infrastructure?**

Agriculture in Africa – Some Simple Facts

- **Agriculture accounts for very large shares of employment and output.**
- **Over 50 percent of the continent's labor force works primarily in agriculture.**
- **But only about 15 percent of GDP comes from agriculture.**

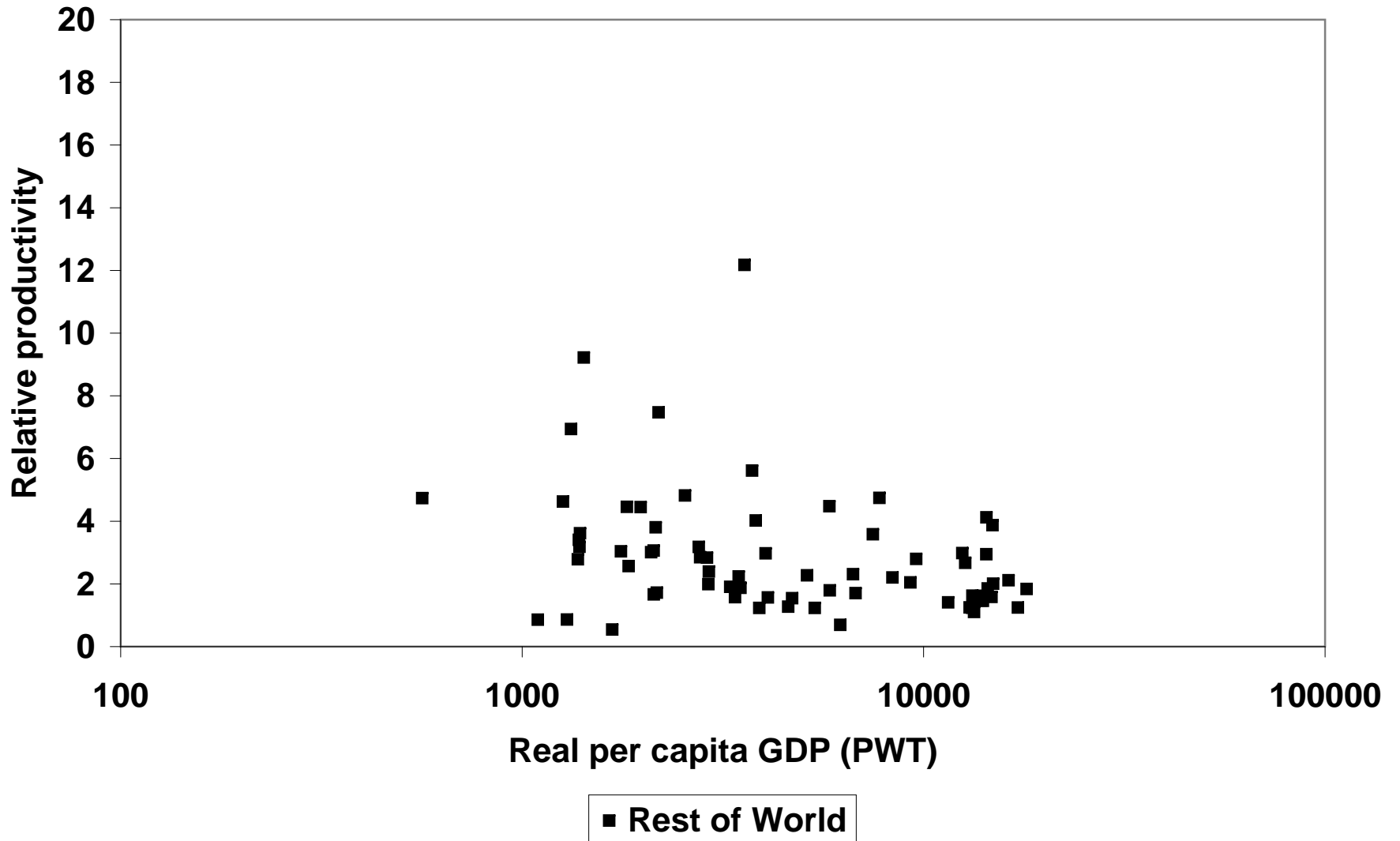
Some simple arithmetic

- ⇒ Output per worker is higher in non-agriculture than in agriculture (by a factor of six for all of Africa).**
- ⇒ Sectoral productivity differences are large!**

Agricultural productivity and income levels

- **Poor countries have low productivity levels in both agriculture and non-agriculture.**
- **African countries have particularly low levels of relative agricultural productivity** $\left(\frac{Y_A}{N_A} / \frac{Y_{NA}}{N_{NA}} \right)$
- **Africa looks quite different from the rest of the developing world in this measure.**

Sectoral relative productivity



Many possible explanations for low agricultural productivity

- **Geography / Climate**
- **Policies**
- **Institutions**
- **Technology**
- **Infrastructure**

⇒ **This paper will focus on the last two – and in particular on their interaction.**

Agricultural technology in Africa

- **Colonial powers invested relatively little in food staples; instead focused on export commodities.**
 - **Efforts to adapt agricultural technologies from other areas of the tropics, rather than to do research directly in Africa.**
 - **Unlike tropical Asia and LAC, little applicability of earlier research done in temperate zone countries of the North – with the possible exception of hybrid maize, which was deliberately ignored.**
- ⇒ **Low levels of technology at independence; little research capacity; little international investment until past 20 years.**

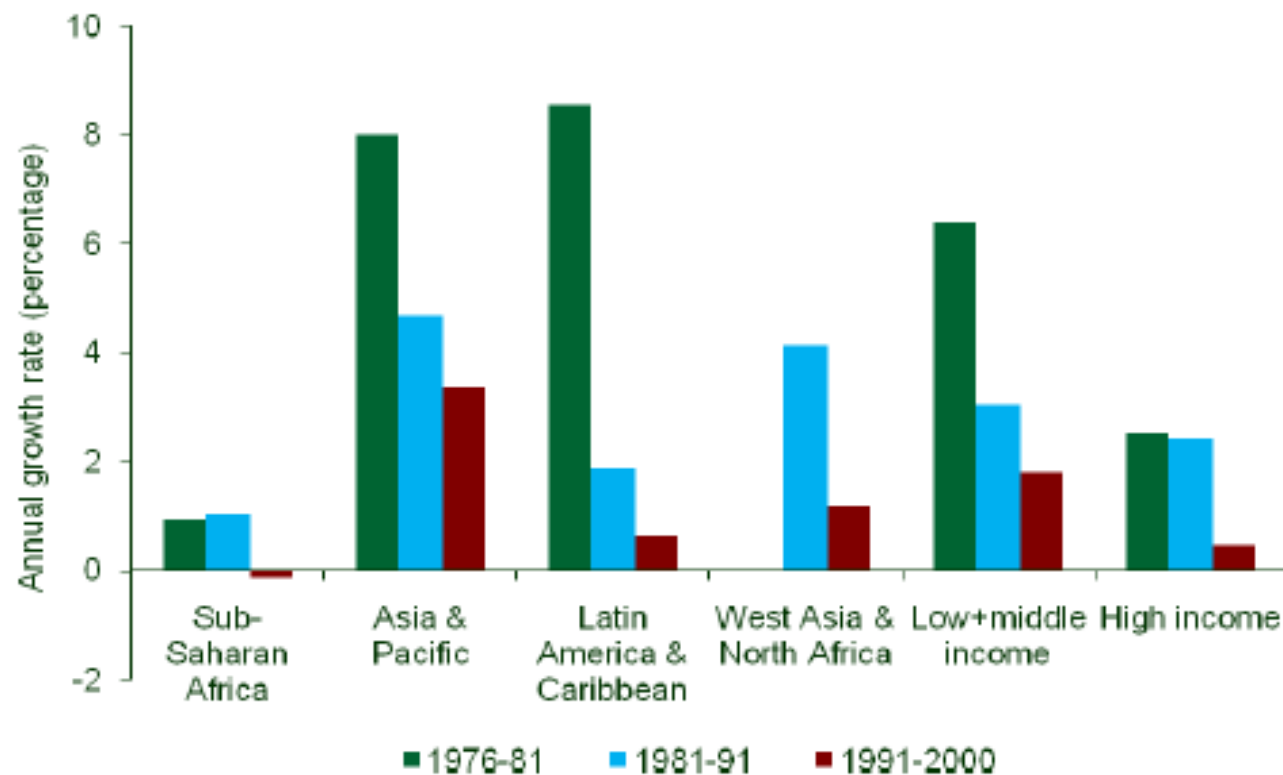
ASTI Indicators

Table 3—African public agricultural R&D spending in a global context

Region	Spending share in global total (percent)		Annual growth rate (percent)		Spending as a share of AgGDP (percent)	
	1981	2000	1981–91	1991–2000	1981	2000
Sub-Saharan Africa	7.9	6.3	1.25	0.82	0.84	0.72
Asia–Pacific	20.0	32.7	4.33	3.92	0.36	0.41
Latin America and the Caribbean	12.5	10.7	1.13	1.98	0.88	1.15
West Asia and North Africa	5.0	6.0	4.12	1.87	0.61	0.66
Developing-country subtotal	45.4	55.7	3.04	2.88	0.52	0.53
Developed-country subtotal	54.6	44.3	2.63	1.19	1.41	2.36
Total	100	100	2.46	0.75	0.79	0.80

Source: Pardey et al. (2006).

FIGURE 1. Growth rates in public agricultural research expenditures, 1981–2000



Sources: Calculated by authors based on ASTI datasets, MOST (various years), OECD (various years), and Pardey et al. (2006); 1976–81 growth rates are from Pardey and Beintema (2001).

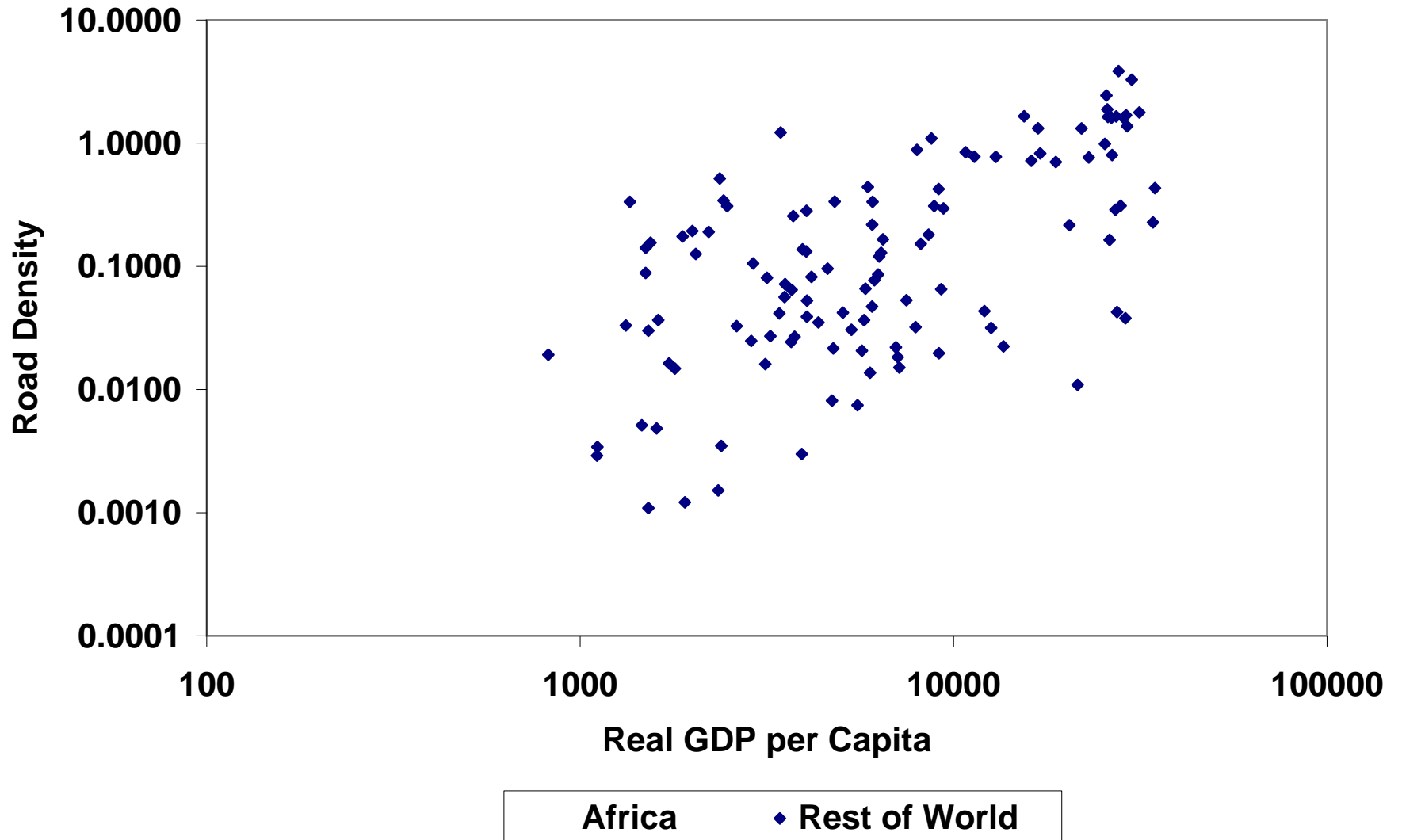
Rural transportation infrastructure in Africa

- **Fewer roads (and worse) than in any other part of the world.**
- **Road density (measured as paved roads per km²) is half that of Latin America and one-third that of Asia.**

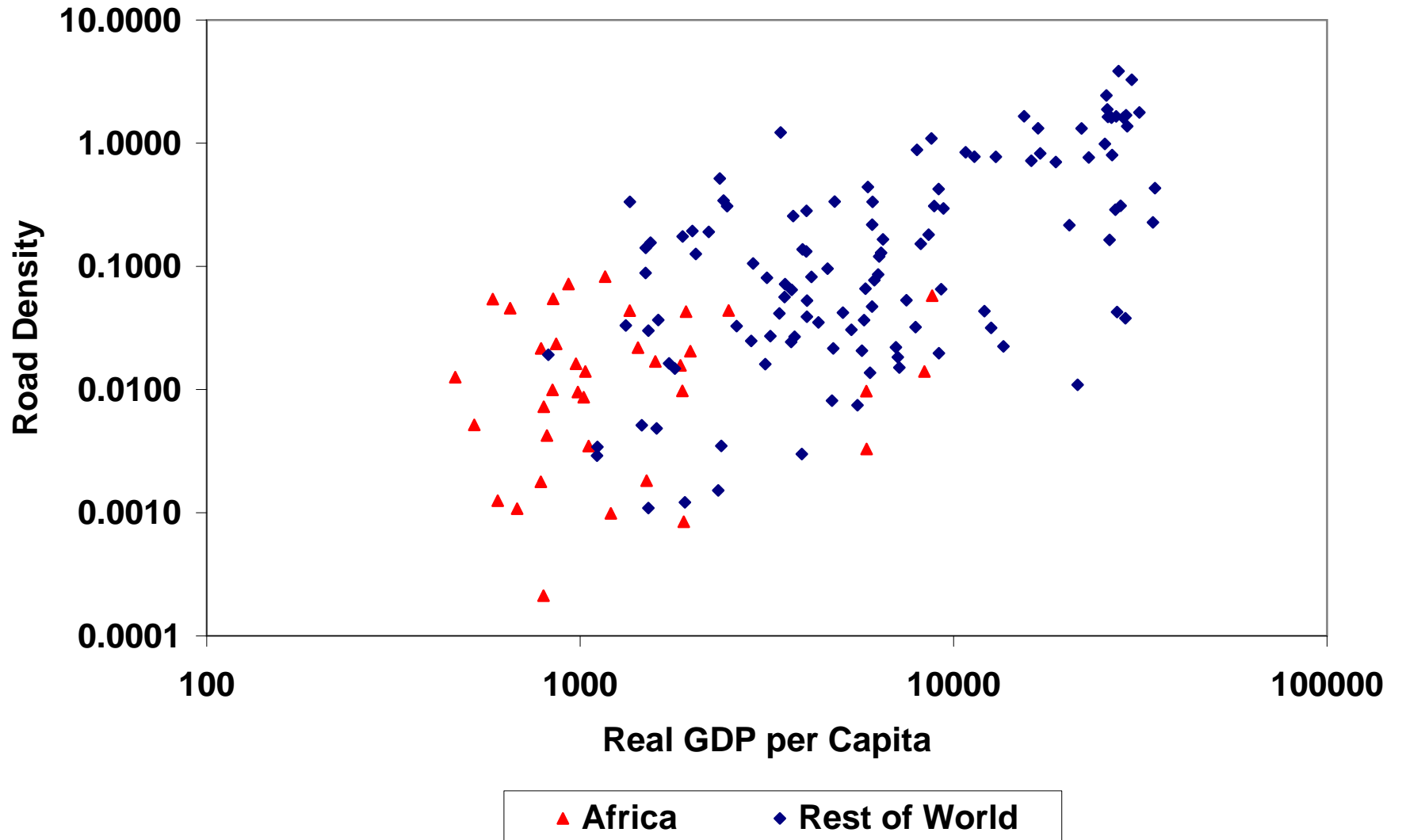
Remoteness

- **In sub-Saharan Africa, only 20 percent of population lives within one hour of a market center (population > 5,000)**
- **In DR Congo, Tanzania, Ethiopia, Rwanda, more than half the population lives at least five hours from the nearest market center.**
- **Uganda: 30 percent of communities surveyed in 2005/06 National Household Survey did not have vehicular access even in the dry season.**
- **Uganda in 2000 had roughly the same density of paved roads per km² as the UK in AD 350!**

Road Density and Income Levels



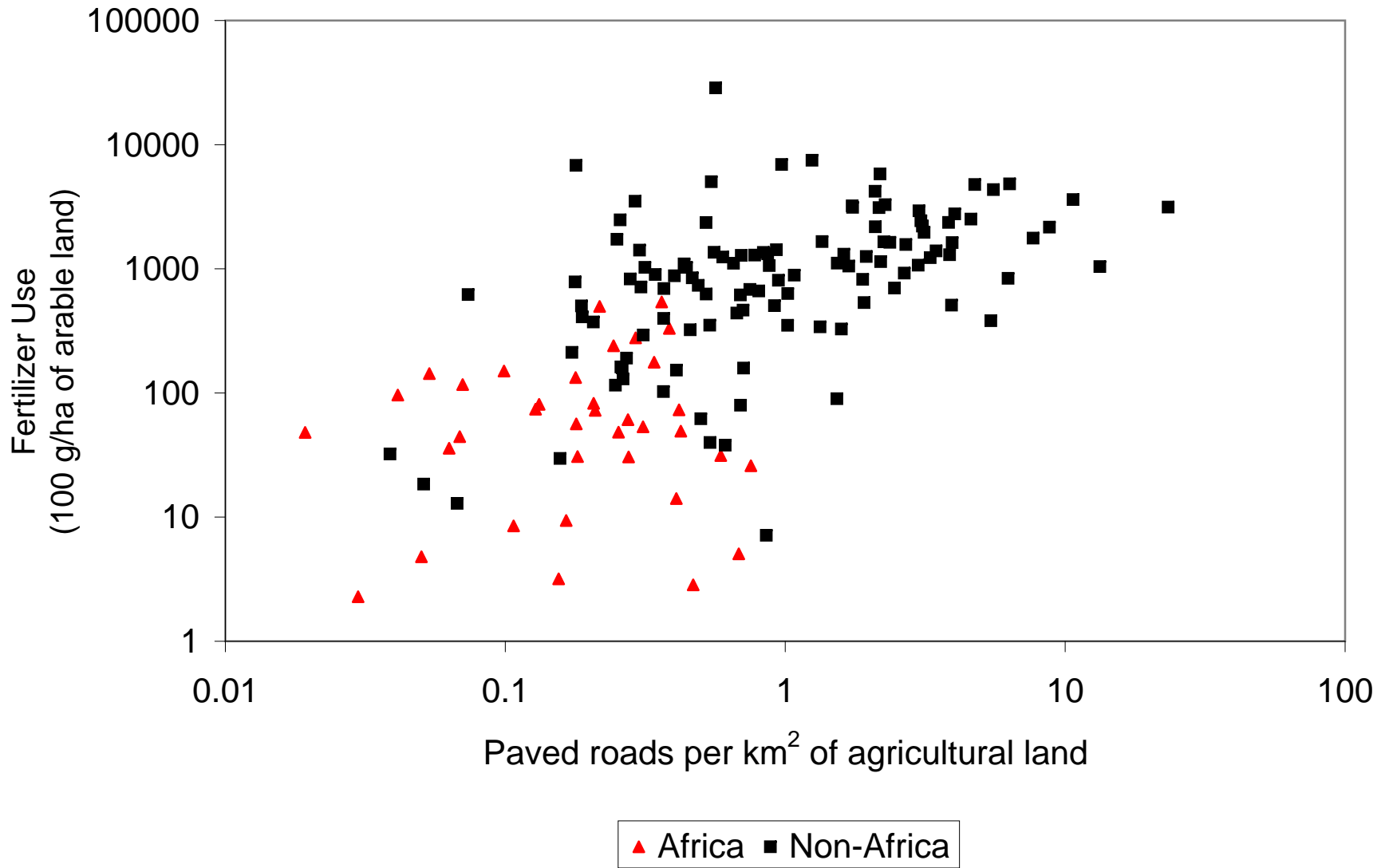
Road Density and Income Levels



Transportation costs and remoteness matter for agriculture

- **Purchased inputs become more expensive.**
- **Prices received by farmers are lower.**
- **Poor transportation networks can also reduce competition in transport sector and among middlemen.**

Fertilizer Use and Road Density



Model

- **Consider a model with both intermediate inputs (manufactured goods used in agriculture) and iceberg transportation costs to move goods from either sector to the other.**
- **Utility:**

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

- **Production**

Output in the agricultural sector is given by a CES function of land L , intermediates x and labor (n_a):

$$a = A_a [(1 - \theta_x - \theta_n)L^\varepsilon + \theta_x x^\varepsilon + \theta_n n_a^\varepsilon]^\frac{1}{\varepsilon}$$

Manufacturing output is given by:

$$m = A_m n_m$$

Other assumptions

- **Iceberg transport costs: a fraction q of output is lost to move goods (of either type) across locations.**
- **Assume costless movement of people and equalization of wages...**
- **Closed economy with non-homothetic preferences. (This assumption is key.)**

Feasibility is determined by the two constraints:

$$n_a a_a + (1 - n_a) \frac{a_m}{(1 - q)} = A_a F(1, x, n_a)$$

$$(1 - n_a) m_m + n_a \frac{m_a}{(1 - q)} + \frac{x}{(1 - q)} = A_m (1 - n_a)$$

Parameters

$\theta_x = .2$	Intermediate goods share in CES function
$\theta_n = .4$	Labor share in CES function
	\Rightarrow Land share = 0.4
$\alpha = 0.20$	Asymptotic expenditure share on agricultural goods
$\bar{m} = 0$	Utility parameter for non-agricultural good
$\bar{a} = 0.25$	Utility parameter for agricultural good; set so that 80% of workforce is in agriculture
$q = 0.5$	Iceberg transport cost

Benchmark results

Allocations in the Benchmark Equilibrium

n_a / Pop	a_m	a_a	m_m	m_a	x
.800	.454	.458	.045	.023	.077

Comparative statics

- 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 the three channels

Scenario	n_a / Pop	a_m	a_a	m_m	m_a	x	Δ
Benchmark	.800	.454	.458	.045	.023	.077	-
$A_a = 1.1$	.736	.460	.469	.103	.052	.081	.330
$A_m = 1.1$	.787	.455	.460	.063	.031	.086	.045
$q = 0.45$	.747	.457	.463	.080	.044	.095	.173
$A_a = 1.1, q = 0.45$	.681	.463	.474	.143	.079	.097	.769

Observations

- **All three channels, viewed separately, lead to declines in agriculture's share of workforce.**
- **The biggest declines come from improvements in agricultural productivity.**
- **A 10% reduction in transport costs has a similar effect to a 10% increase in agricultural TFP, but welfare effect is smaller.**
- **Overall, welfare effects are large.**
- **When we improve agricultural TFP and transportation simultaneously, the effect on labor is approximately additive, but the welfare effect is more than additive.**

Development Paths

Table 9: Development Paths

Scenario	n_a / Pop	a_m	a_a	m_m	m_a	x	Δ
Benchmark	.800	.454	.458	.045	.023	.077	-
$A_a = A_m = 2.0$	.344	.525	.599	1.01	.500	.150	10.45
$A_a = A_m = 2.0,$ $q = 0.25$	.229	.614	.668	1.31	.980	.176	17.14

- **Doubling both agricultural and non-agricultural TFP would have large impacts on allocations and welfare.**
- **Combining this with a halving of transport costs would have a much larger welfare effect.**

Key assumptions of the model

- **These results depend on three key assumptions:**
 - **Food is a good with no effective substitutes.**
 - **Income elasticities of food are high for low levels of income, but then fall as incomes rise.**
 - **For many (most?) countries, food cannot feasibly be imported in sufficient quantities to displace domestic production.**
- **With these assumptions, countries need to produce their own food; increases in agricultural productivity will be essential for releasing labor to other sectors.**
- * **High transportation costs can leave people "stuck" in agriculture.**

Conclusions

- **The case for investing in agriculture – and particularly in food production – seems strong, at least in those countries with large populations away from the coast.**
- **Investments in agriculture are probably complementary with investments in infrastructure that will reduce transaction costs.**
- **Large-scale farms and smallholders both probably have a role to play.**

Conclusions, cont.

- **Non-food agriculture also has a role, especially as a source of materials for agro-industry (e.g., cotton, oilseeds, sugar) and as a source of export earnings.**
- **Because food accounts for large shares of the expenditure of the poor, improvements in food production are likely to have particularly large impacts on the well-being of the poor.**
- **Farmers may not benefit much as producers, if increased agricultural productivity results in lower prices. But they may still benefit as consumers.**

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.**



Additional slides

Are these assumptions reasonable?

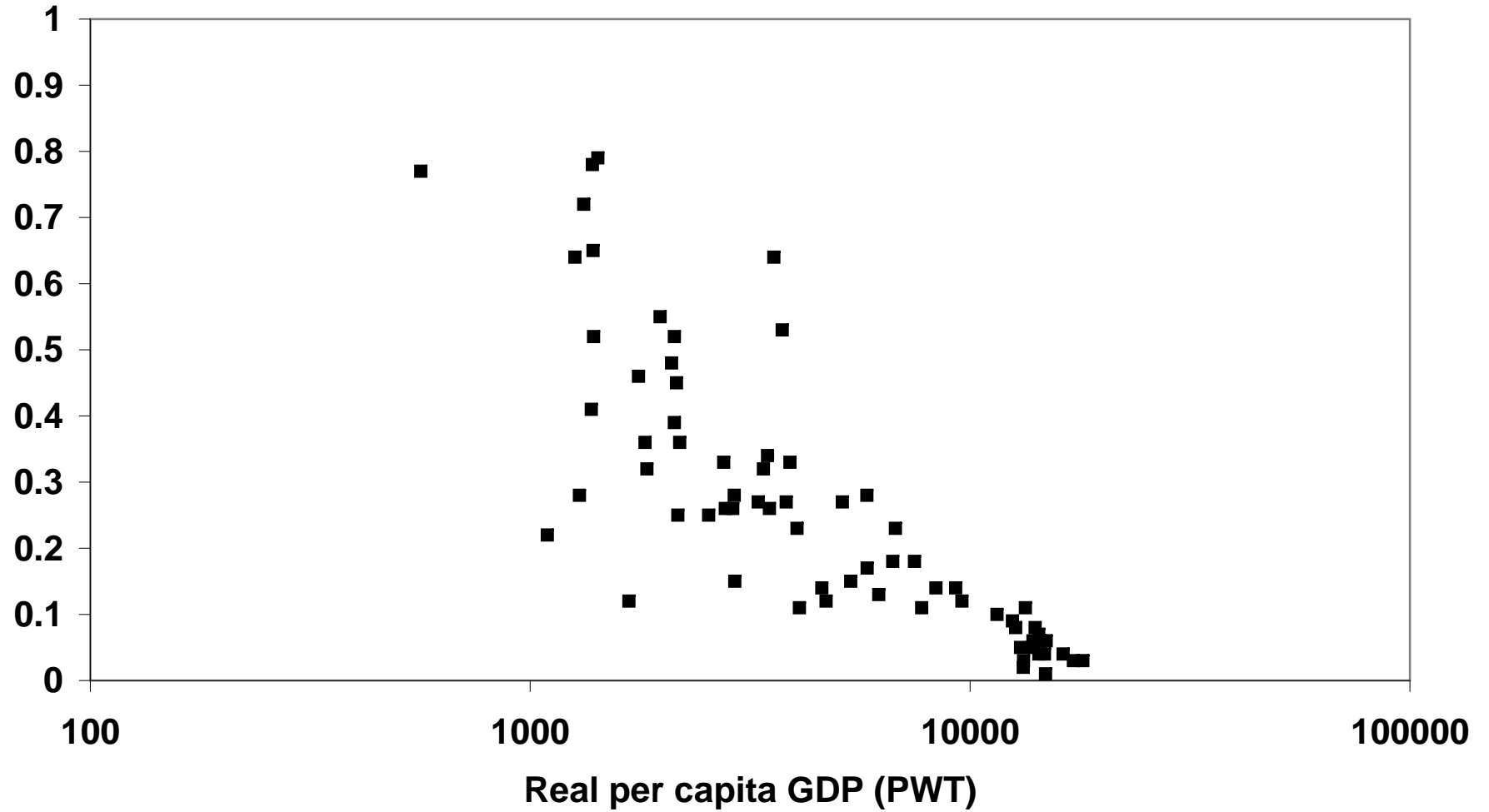
- **Food as an aggregate category has no clear substitute; people must eat. (But not all agriculture produces food, and people can eat a wide variety of foods.)**
- **Budget shares of food do fall as incomes rise, and income elasticities of demand for calories fall faster. (People substitute into higher quality and higher taste categories of food.)**
- **Food imports vary by commodity and country.**

Food balance sheet data

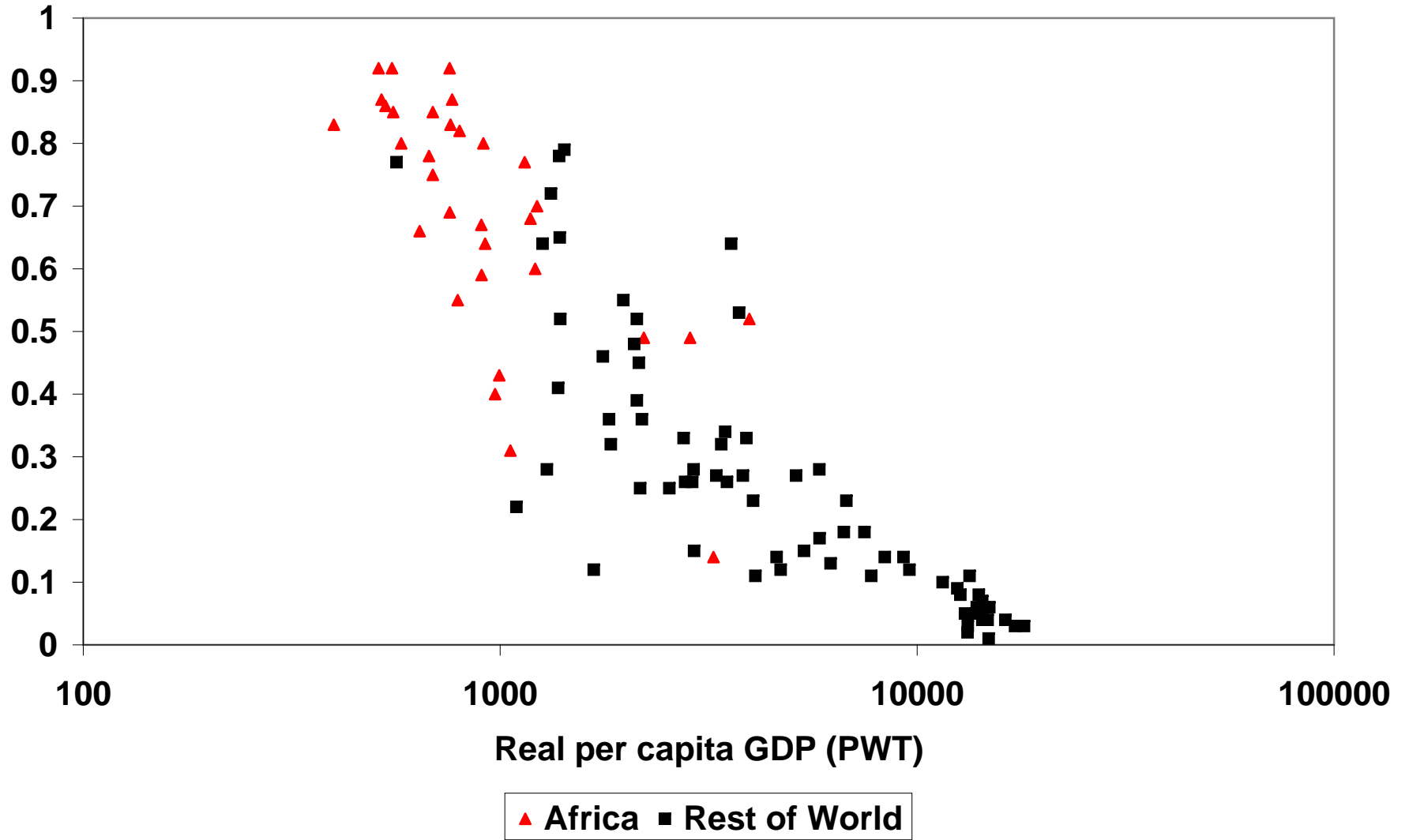
- **Sub-Saharan Africa imports 18 percent of its total grain consumption, 20 percent of its vegetable oils, 10 percent of its dairy consumption, and 50 percent of its animal fats.**
 - **However, lots of food consumption is essentially not imported: especially roots and tubers, vegetables, most meat.**
 - **Import share of total calorie consumption: 10%.**
 - **Uganda: 2%.**
- ⇒ **Some countries are effectively quite closed to food trade; others are not.**

- **Need for specific country studies that ask whether the case for agriculture applies.**
 - **How much food is imported at present?**
 - **How much of the population lives far from coasts?**
 - **How large are transportation costs, especially farm to market?**
 - **How feasible is it to import food?**
 - **Can the poor be reached through imported food?**
 - **How much export growth would be needed, at current prices, to pay for larger food imports?**

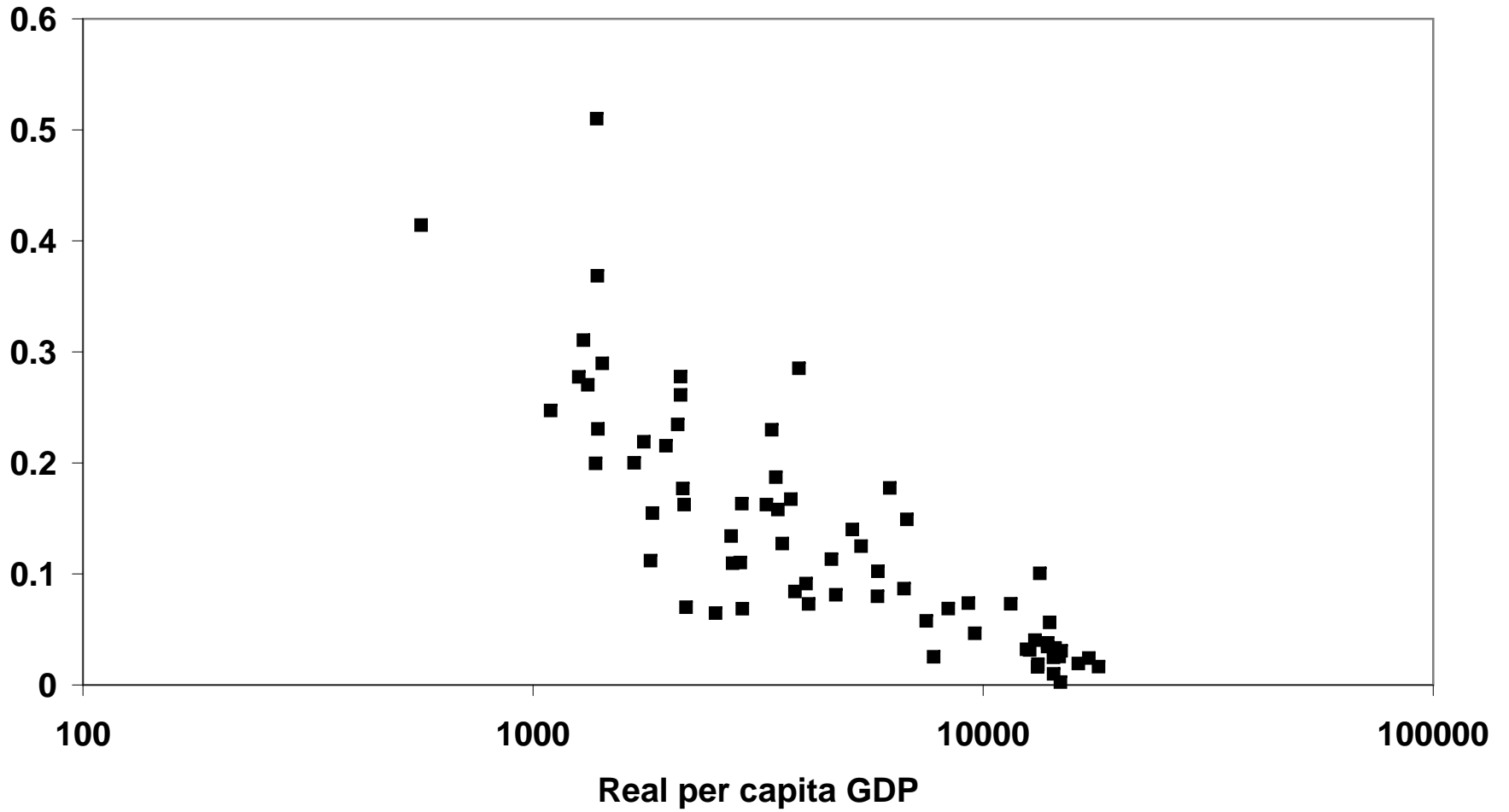
Labor force in agriculture



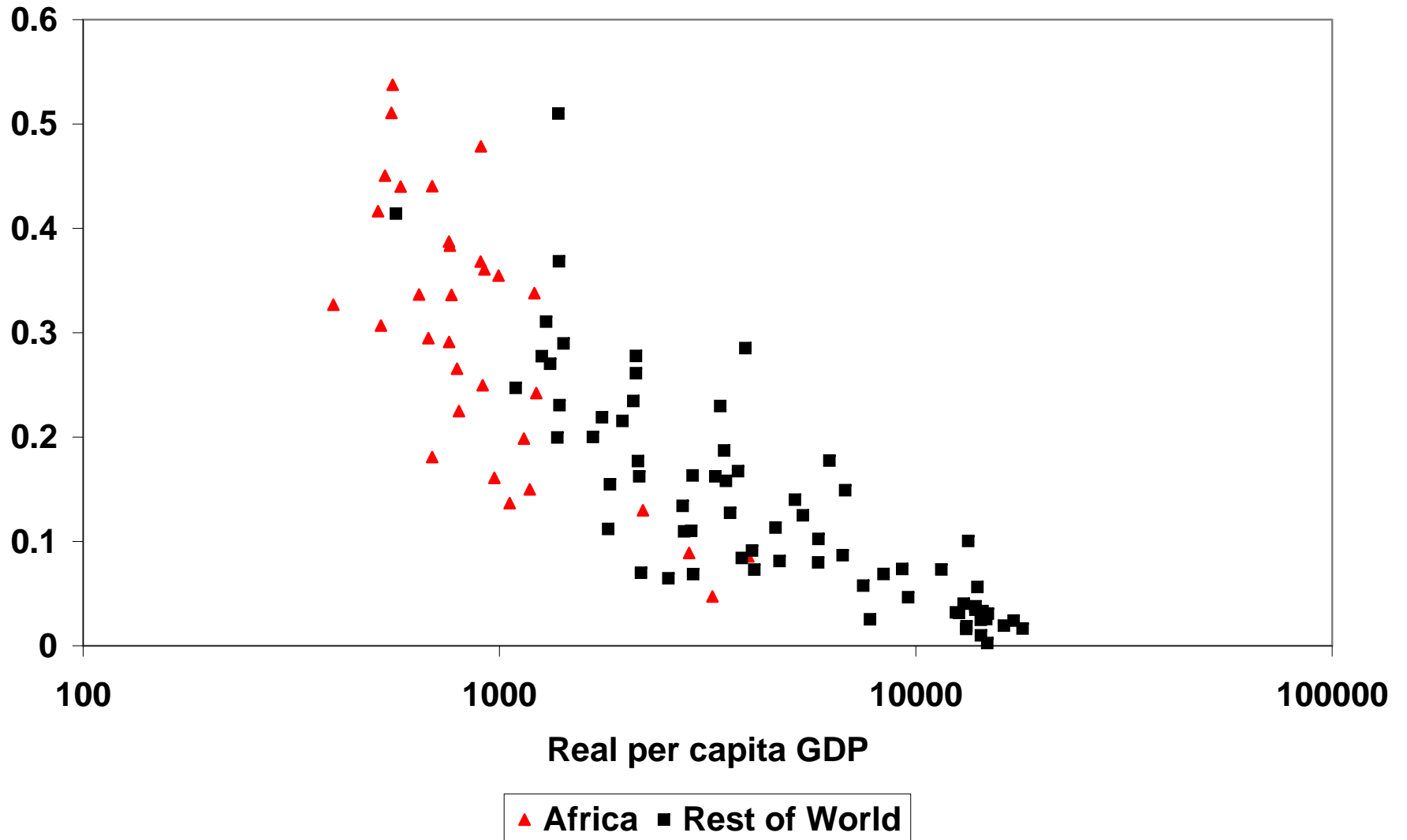
Labor force in agriculture



Share of GDP in agriculture



Share of GDP in agriculture



Geography and Climate

- **Much of Africa has difficult climatic conditions for agriculture; soils are also poor.**
- **But... Our measure of productivity is output per worker, not output per unit land...**
- **Many parts of the world with equally unpromising natural conditions are very productive in agriculture (e.g., western United States).**
- **Some tropical countries have highly productive agricultural sectors.**

African agricultural policy: an unhappy history

- **In the early years post independence, many governments promoted industrialization at the expense of agriculture.**
 - **Price response was thought to be limited, so governments set prices low.**
 - **Overvaluation of exchange rates and support for industry also harmed agriculture indirectly.**
- **Liberalization in the 1980s and 1990s removed the worst price distortions, but “getting prices right” was not enough.**
- **Some recent investments and donor interest, but most governments in Africa continue to give low priority to agriculture.**

Agricultural institutions

- **Complex traditional systems of land tenure and rural property rights.**
 - **Little or no effective contract enforcement in agriculture, except through informal mechanisms.**
 - **Poor security in many places.**
 - **Thin (and occasionally non-competitive) markets for inputs, outputs, labor, and capital.**
- ⇒ **Not necessarily much different from other parts of the world at similar points in their development trajectory.**