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Adaptation to land constraints: Is Africa different?

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1. Introduction

- ❑ Some 215 years ago, Malthus argued that pop. growth cyclically outstrips agricultural productivity
- ❑ In much of the world, economic history has not been kind to Malthus, because of “induced innovations”:
 1. Endogenous reductions in fertility (Becker)
 2. Endogenous intensification of agriculture (Boserup)
 3. Policy-induced, scientific intensification of agric. (GR)
 4. Migration out of agriculture
- ❑ But what about Africa? Famines are not a thing of the past, and there is still huge dependency on food aid



1. Introduction

- ❑ Structurally, there are 6 inter-related reasons to be concerned about the specter of Malthus in Africa:
 1. Very poor, and poverty still heavily rural
 2. Low inherent agric. potential (incl. low irrigation)
 3. Mixed success with agric. intensification
 4. Climate change: secular changes, and more shocks
 5. Rapid population growth (double by 2050) and small and shrinking farm sizes
 6. Very limited success with industrialization



1. Introduction

- ❑ This paper is mainly concerned with farm size evolution: trends, patterns, and adaptive behaviors
- ❑ Framework based on decomposing growth in farm income:

$$\Delta \ln \frac{\text{Output}}{\text{Pop.}} = \Delta \ln \frac{\text{Land}}{\text{Pop.}} + \Delta \ln \frac{\text{Output}}{\text{Land}}$$

Growth in rural population is the sum of fertility & net migration:

$$= \Delta \ln \frac{\text{Output}}{\text{Land}} + \Delta \ln \text{Land} - \Delta \ln \text{fertility} - \Delta \ln \text{migration}$$

Shrinking farm sizes

The diagram illustrates the relationship between farm size and population growth components. A central box labeled "Shrinking farm sizes" has four arrows pointing to the terms in the equation above: "Output/Land", "Land", "fertility", and "migration".



1. Introduction

- ❑ Our overarching objective is to assess international experience in these 4 adaptations to land pressures
- ❑ There is a large literature exploring Boserup's hypothesis, as well as policy-induced intensification
- ❑ There is much smaller literature on land expansion
- ❑ There is essentially no literature on farm sizes & fertility rates
- ❑ And there is some indirect literature on farms sizes, rural nonfarm activity and migration
- ❑ For each of these adaptations, we also ask whether Africa is different, and why?



1. Introduction

- ❑ In terms of data and methods, we make use of:
 1. FAOSTAT ag production and land data;
 2. Census (FAO) and survey data on farm size distributions
 3. DHS data on rural fertility rates & occupations
 4. Some WB data on remittances
- ❑ We combine these data in an unusually rich data set on agricultural and rural development
- ❑ (though we also acknowledge that some of the numbers are fairly speculative)



- ❑ On methods, our approach is necessarily exploratory
- ❑ Establishing causation is an under-recognized problem with Boserup's theory
- ❑ Problems of simultaneity, omitted variables, selection biases, parameter heterogeneity. Some examples:
 1. Agroecological (AE) factors & market access jointly determine settlement patterns and intensification
 2. Boserupian intensification depends on AE potential
 3. Unsuccessful intensification encourages out-migration
 4. Policies promote intensification, discourages out-migration
- ❑ IV rarely plausible in cross-country setting, but we do make an effort to add as many controls as possible



2. Land expansion

- ❑ If farm sizes are shrinking, why not expand land use?
- ❑ Africa is typically thought of as land abundant, but this neglects the heterogeneity within Africa

Region	Period	Hectares per agric. worker (FAO)	Hectares per holding (censuses)	Used land as % of potentially cultivable land
Africa - high density ^b (n=5)	1970s	0.84	1.99	32.7
	2000s	0.58	1.23	43.8
Africa - low density ^b (n=11)	1970s	1.65	2.65	17.2
	2000s	1.37	2.82	24.7
South Asia (n=5)	1970s	0.78	2.01	129.5
	2000s	0.55	1.19	135.9
China & S.E. Asia (n=4)	1970s	0.80	2.08	71.2
	2000s	0.68	1.58	83.0



2. Land expansion

- ❑ Several important facts & mysteries emerge from census, FAO and FAO-IIASA data:
 1. Farm sizes are shrinking in high-density Africa.
 2. Some high-density countries still have unused land, but smallholders face major constraints to using that land (e.g. Ethiopia, Madagascar).
 3. Even in countries with unused land (e.g. Ethiopia), there are major constraints to using new lands: different agronomics, disease burdens, infrastructure
 4. Farm sizes are unchanged (on average) in low density Africa, but still very small on average

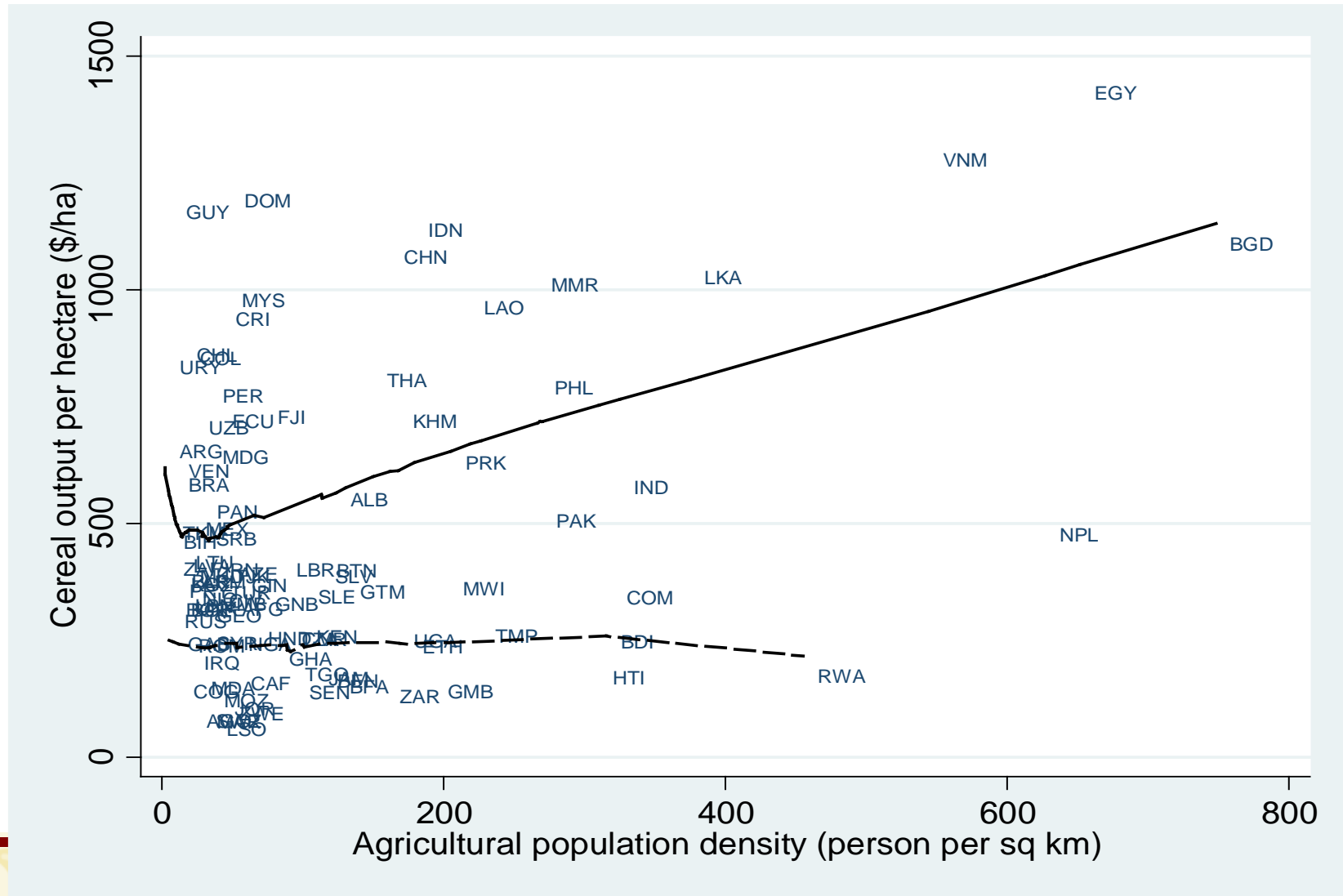


3. Agricultural intensification

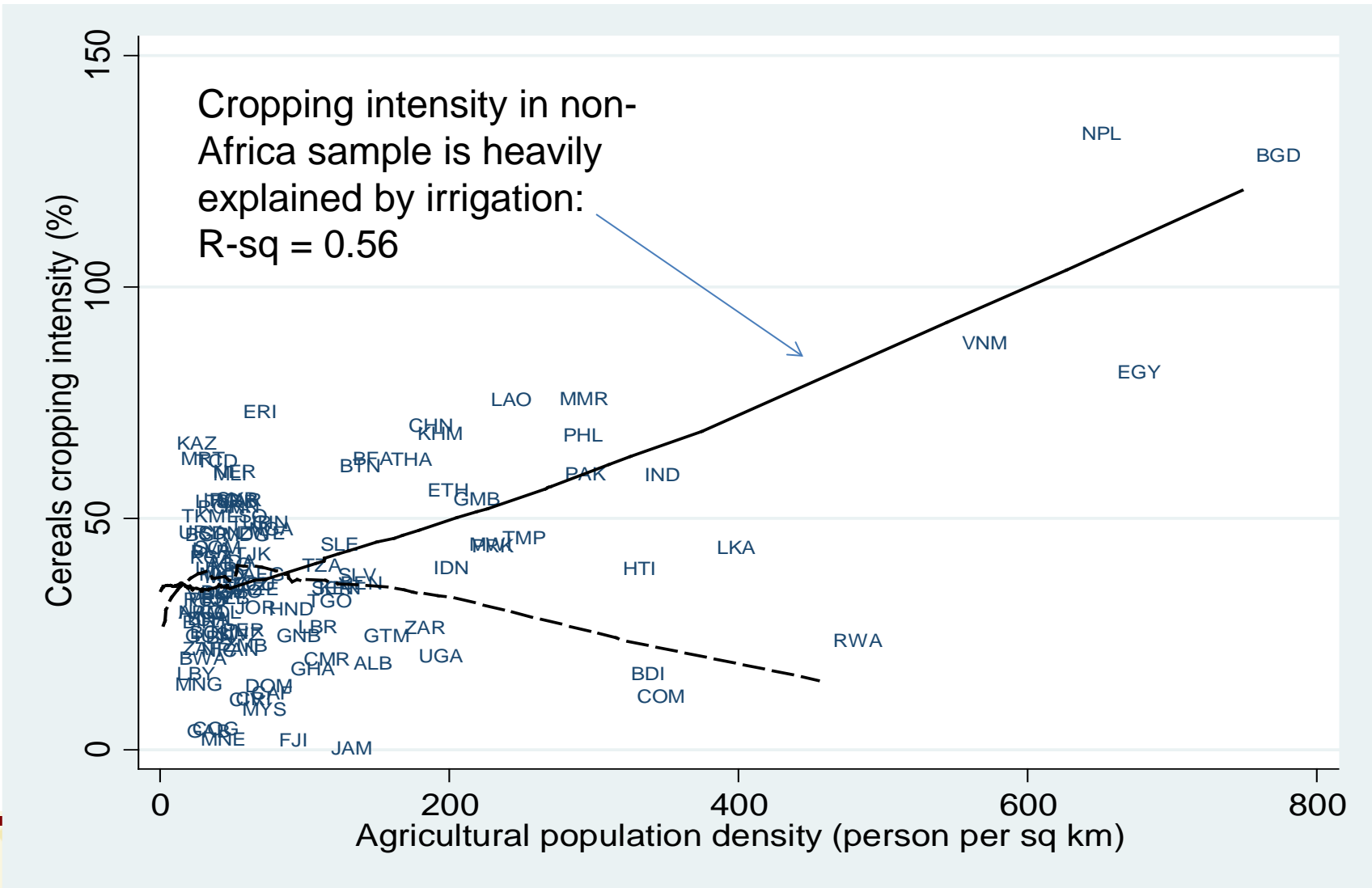
- ❑ In the framework above, the most welfare-relevant indicator of intensification is just output per hectare
- ❑ Boserup focused more on cropping intensity, and the ag-econ profession & CGIAR looks a lot at yields
- ❑ But switching to high value crops is obviously also a potentially important adaptation, especially in SSA.
- ❑ So I'm going to show you a series of graphs, and then some more formal econometric tests.
- ❑ Note that I also decompose agricultural output per hectare into cereal yields, cereal cropping intensity and high value non-cereals



3. Agricultural intensification



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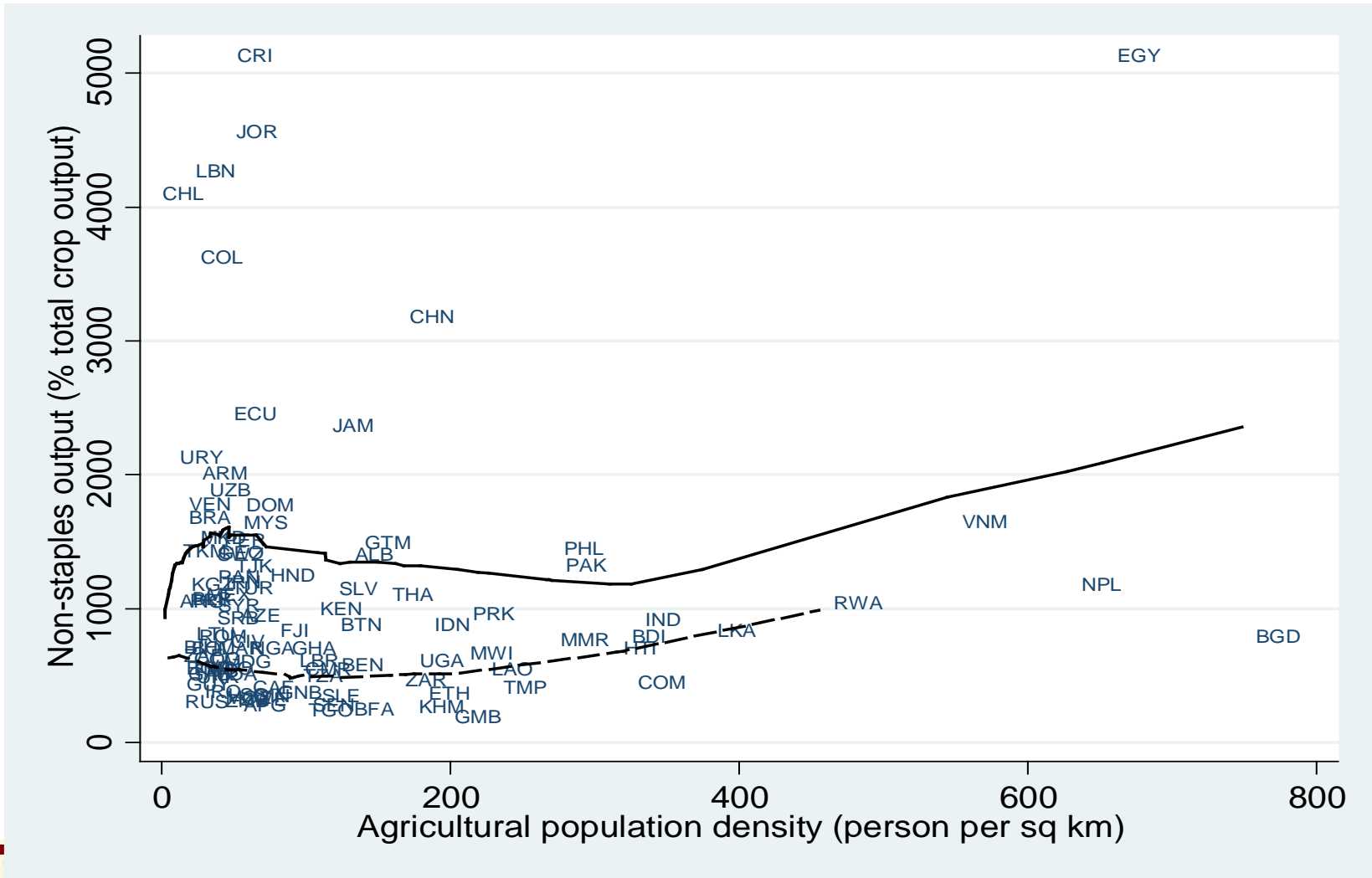


Table 4. Log-log estimates of agricultural value per hectare and its three components

Regression No.	R1	R2	R3	R4
Dep. var.	Agric. output per ha	Cereal output per ha	Cereal crop intensity	Non-cereal output per ha
Population density	0.33***	0.18***	0.20***	0.28***
Density*Africa	-0.11**	-0.23***	-0.01	-0.01
Road density	0.14***	0.09**	-0.03	0.19***
Number of ports	0.14***	0.21***	0.03	0.15***
Urban agglom (%)	0.29***	-0.09	0.31***	0.31***
Regional fixed effects?	Yes	Yes	Yes	Yes
Sign of SSA dummies?	+ in E.Africa	Zero	Neg.	+ in E.Africa
AE controls	Yes	Yes	Yes	Yes
No. Obs	243	243	243	243
R-square	0.8	0.74	0.67	0.79



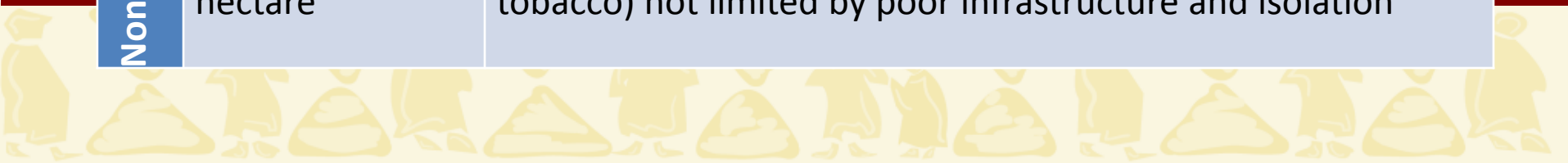
Table 5. Log-log estimates of specific agricultural inputs

Regression No.	R1	R2	R3	R4
Dep. var.	Fertilizers per hectare	Cattle/oxen per hectare	Irrigation per hectare	Capital per hectare
Population density	0.76***	0.42***	0.59***	0.24***
Density*Africa	-0.32**	0.15*	-0.47***	-0.10***
Road density	-0.08	0.31***	0.04	0.07**
Number of ports	0.50***	0.07	0.24***	0.12***
Urban agglom (%)	0.38	0.03	0.24**	-0.03
Regional fixed effects	Yes	Yes	Yes	Yes
Sign of SSA dummies?	Zero	Neg.	Zero	Zero
AE controls	Yes	Yes	Yes	Yes
No. Obs	0.73	0.77	0.92	0.77
R-square	0.69	0.74	0.91	0.73



Table 7. Potential explanations of Africa's agricultural intensification trajectory

	Stylized facts	Potential explanations
Low productivity of cereals sector	Low fertilizer application	Agronomic constraints (e.g. low soil fertility) Poor management practices, low human capital High transport costs (see regression 1 in Table 4); Low rates of subsidization (structural adjustment)
	Low adoption of improved varieties	More varied agroecological conditions and crop mix Lower returns because of limited use of other inputs (e.g. irrigation); Lower investment in R&D
	Low use of plough/ tractors	Tsetse fly in humid tropics Feed/land constraints in some densely populated areas
	Low rates of irrigation	Hydrological constraints; High costs of implementation and maintenance; Poor access to markets limits benefits
Noncereals	High non-cereal output per hectare	Agroecological suitability; Colonial introduction of cash crops; Non-perishable cash crops (cotton, coffee, cocoa, tea, tobacco) not limited by poor infrastructure and isolation



3. Reducing rural fertility rates

Figure 3. Rural fertility rates and rural population density

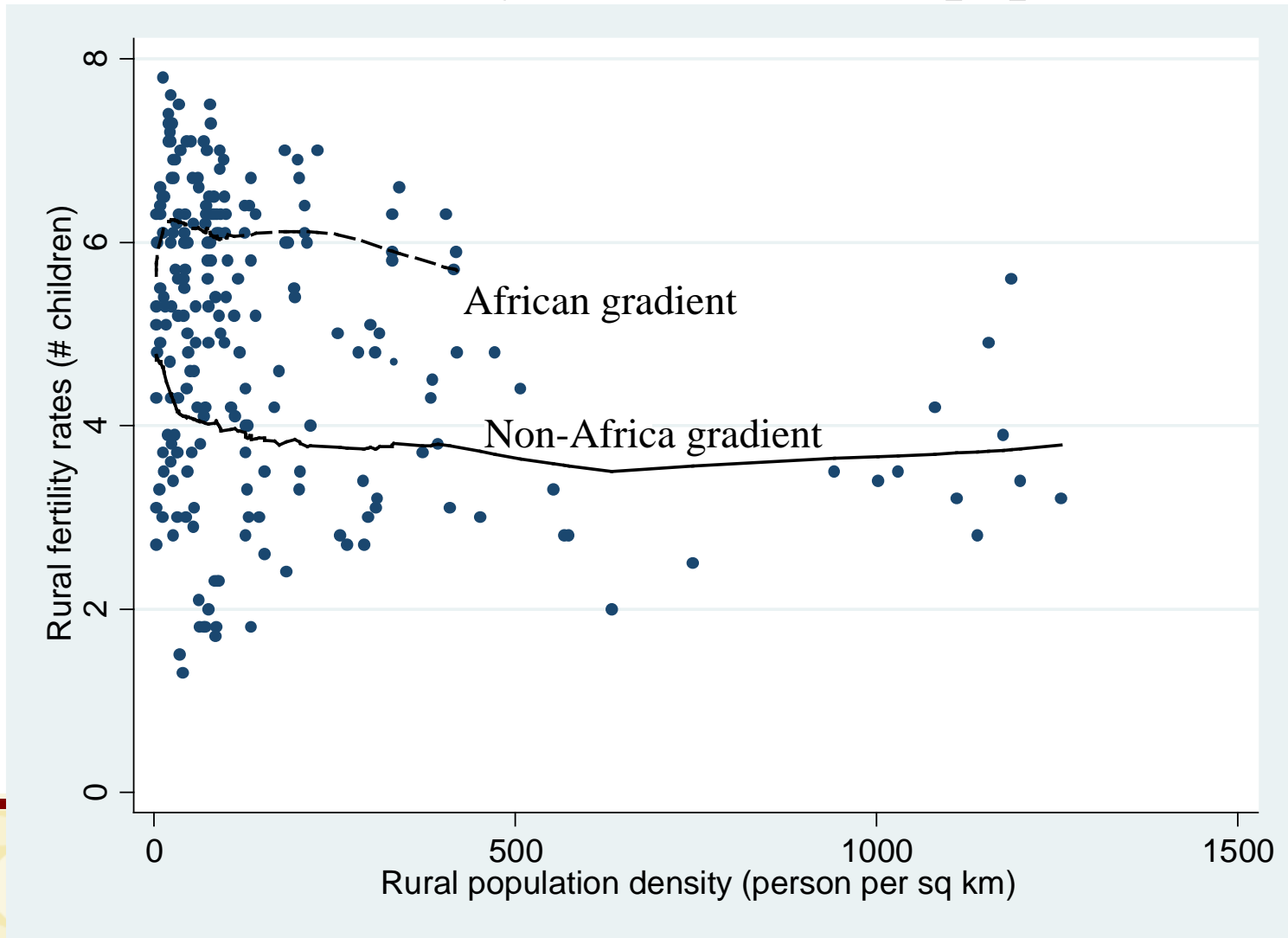


Figure 4. Desired rural fertility & population density

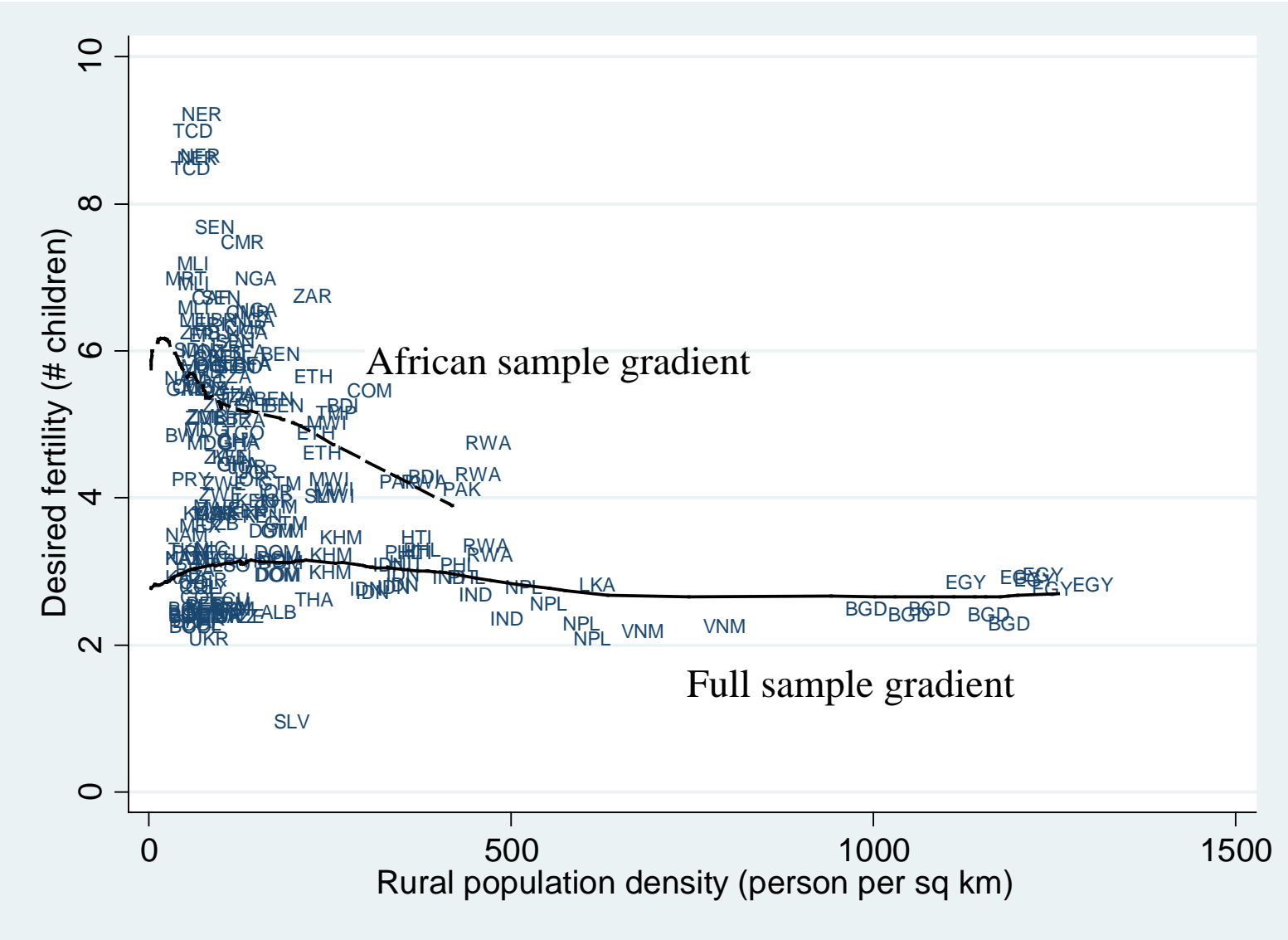
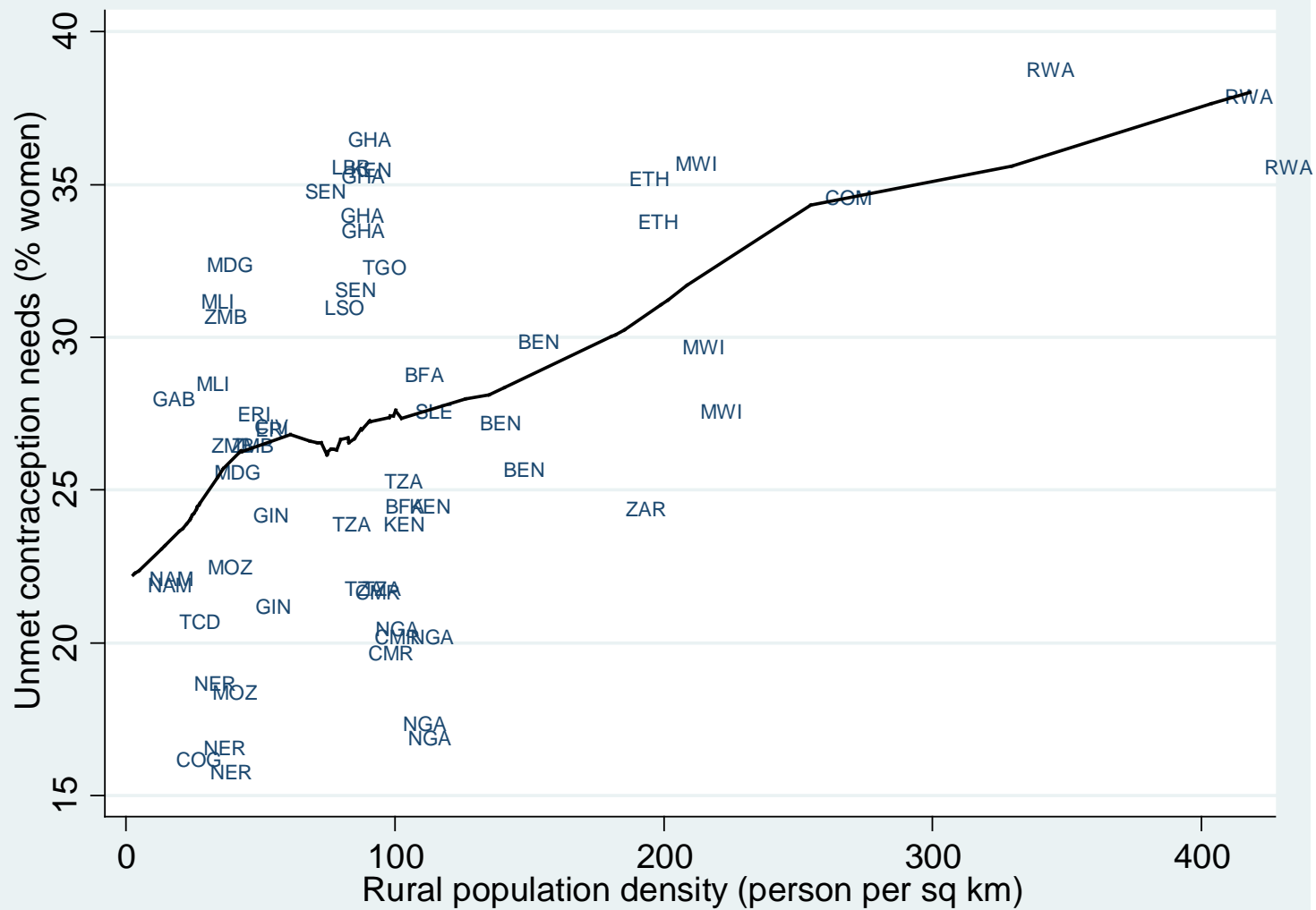


Figure 5. Unmet contraception needs (%) and rural population density in Africa



Sources



Table 8. Elasticities between rural fertility indicators & rural population density

Regression number	1	2	3	4
Dependent variable	Actual fertility	Actual fertility	Desired fertility	Desired fertility
Model	Linear	Log-log	Linear	Log-log
	b/se	b/se	b/se	b/se
Pop density (per 100 m ²)	-0.14***	-0.09***	-0.11***	0.00
Density*Africa	0.05	0.09***	-0.34***	-0.07***
Female sec. education (%)	-0.02***	-0.05***	-0.01**	-0.08***
Ag. output per worker, log	-0.58***	-0.13***	0.01	0.06***
Africa dummy	1.25***	-0.15	2.13***	0.67***
Number of observations	165	165	164	164
R-square	0.75	0.76	0.77	0.81



4. Nonfarm diversification

- ❑ Much neglected in 1980s literature on Boserup
- ❑ Subsequent literature on both RNFE and migration & remittances shows that RNF income is big
- ❑ But not much specific literature looking at pop density
- ❑ On RNF activity, often suggested there is a U-shaped relationship between farm size and RNFE: landless poor are pushed into RNFE, rich are pulled in
- ❑ Very difficult to look at rural-urban migration
- ❑ Int. remittances have boomed in last 10 years, particularly in densely population South Asia – now 22% of rural income in Bangladesh



Table 9. Speculative estimates of rural nonfarm employment shares for men and women in the 2000s

<u>High density Africa</u>			<u>Low density Africa</u>			<u>Other LDCs</u>		
Country	W	M	Country	W	M	Country	W	M
Benin	50.4	23.7	Burkina Faso	12.9	8.1	BGD	53.4	44.5
Congo (DRC)	14.0	23.5	Chad	13.7	9.6	Bolivia	71.4	25.9
Ethiopia	34.3	9.7	Cote d'Ivoire	31.7	22.1	Cambodia	36.0	
Kenya	47.1	37.3	Ghana	50.1	26.6	Egypt	69.4	
Madagascar	17.8	15.3	Mali	44.6	16.0	Guatemala	79.1	
Malawi	41.5	36.0	Mozambique	5.2	23.0	Haiti	24.0	19.0
Nigeria	65.5	37.0	Niger	60.2	35.8	India	22.4	
Rwanda	7.3	14.2	Senegal	63.7	37.1	Indonesia	59.2	39.5
Sierra Leone	25.2	20.1	Tanzania	7.2	10.5	Nepal	90.5	34.2
Uganda	15.5	20.3	Zambia	30.1	19.5	Philippines	16.2	42.6



Table 11. Elasticities between RNF employment indicators and rural population density for women and men

Regression No.	R1	R2	R3	R4	R5	R6
Sample	Women	Women	Women	Men	Men	Men
Population density	0.47	0.09	0.15	-0.33	-0.32	-0.31
Density*Africa	-0.19**	-0.22**	-0.15*	0.03	-0.02	-0.02
Africa dummy	-0.25	0.1	0.04	-0.43	0.09	0.09
Sec. educ. by gender		0.03	0.11		0.35***	0.35***
Road density		0.14*	0.15**		0.17*	0.17*
Electricity		0.20**	-0.07		0.09	0.09
Ag. Output/worker, log			0.46***			0.01
No. Obs.	162	122	95	74	74	74
R-square	0.2	0.53	0.24	0.55	0.55	0.55



Figure 6. National remittances earnings (% GDP) and rural population density

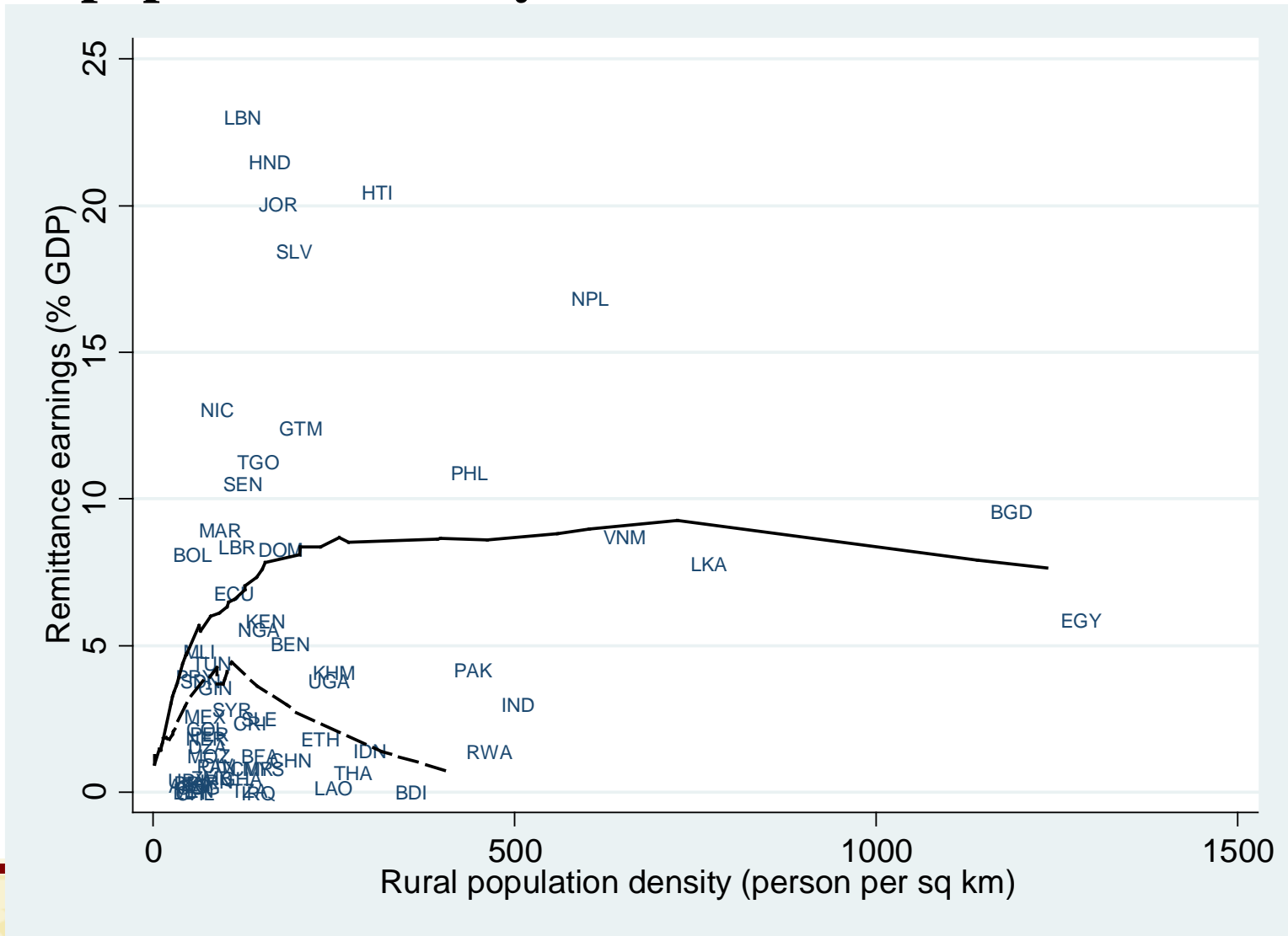


Table 11. Estimating elasticities between national remittance earnings (% GDP) and population density

Estimator	OLS	Robust	OLS	Robust
Structure	Levels (logs)	First difference	Levels (logs)	First difference
Density variable	Agricultural	Agricultural	Rural	Rural
Population density	0.25***	0.97**	0.31***	1.17***
Population density* Africa	0.05	-0.94	0.04	-1.22**
Total population	-0.24***	-1.31**	-0.23***	-0.82
Lagged remittances		-0.21***		-0.24***
Lagged population density		0.06		0.06
West Africa dummy	-0.67*		-0.49	
Central Africa dummy	-1.55***		-1.40***	
East Africa dummy	-0.90**		-0.74*	
Southern Africa dummy	0.14		0.24	
1977-87 dummy	0.15		0.12	
1987-97 dummy	0.33*	-0.09	0.28*	-0.06
1997-2007 dummy	0.79***	0.19	0.72***	0.24*
Number of observations	231	147	231	159
R-square	0.39	147	0.4	0.22

5. Conclusions

- ❑ Land pressures are severe in much of Africa, esp. high density SSA, where **small farms are getting smaller, and will continue to get smaller as pop. grows**
- ❑ Yet history shows that rural people are generally adept at adapting to mounting land pressures.
- ❑ Ag intensification is only part of the adaptation
- ❑ The question we posed is whether Africa is different
- ❑ In many ways, the answer is yes . . .



5. Conclusions

- ❑ **Adaptation 1 - Agricultural Intensification**
- ❑ **Africa has intensified agriculture**, but largely through high value non-perishable crops (HVCs)
- ❑ Much less historical success with cereals, and much less potential given limited potential for irrigation
- ❑ *Should we shift emphasis of research and development strategies from cereals to HVCs?*
- ❑ CGIAR, for example, barely looks at cash crops like coffee, tea, cotton, cocoa, tobacco (even though cash buys food!)



5. Conclusions

- ❑ **Adaptation 2 - Reducing fertility rates**
- ❑ Higher densities (smaller farms) appear to lead to a desired reduction in fertility in Africa
- ❑ But desired reductions are not met by access to contraceptive technologies
- ❑ High-density East Africa now shows mixed policies
- ❑ Ethiopia & Rwanda are investing in family planning (*), but Museveni (Uganda) has resisted family planning (population growth is “a great resource”)
- ❑ Asian experience suggests FP yields high returns



5. Conclusions

- ❑ **Adaptation 3 – Nonfarm diversification**
- ❑ Weak evidence, but evidence that is there suggests that nonfarm sector doesn't just grow without engines like education, infrastructure, agriculture (also true for African cities?)
- ❑ Boom in overseas migration and remittances is new, and unexpected.
- ❑ 20 years ago, BGD and Pakistan were regarded as too big to benefit from remittances. Not true now.
- ❑ Why isn't Africa getting more remittances?



5. Conclusions

- ❑ Finally, we ask whether the results we find warrant a re-think in the way high density countries pursue rural development
- ❑ Are SSA countries thinking through the implications of rural pop. growth for farm sizes and rural welfare?
- ❑ Do SSA countries need rural development strategies that are more integrated with respect to smallholder intensification, commercial farms, family planning, migration and rural nonfarm development?
- ❑ What are the costs of not doing so?





