



Road Network Upgrading And Overland Trade Expansion In Sub-Saharan Africa

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Infrastructure Consortium for Africa Meeting – Berlin – January 18, 2007

Study motivation

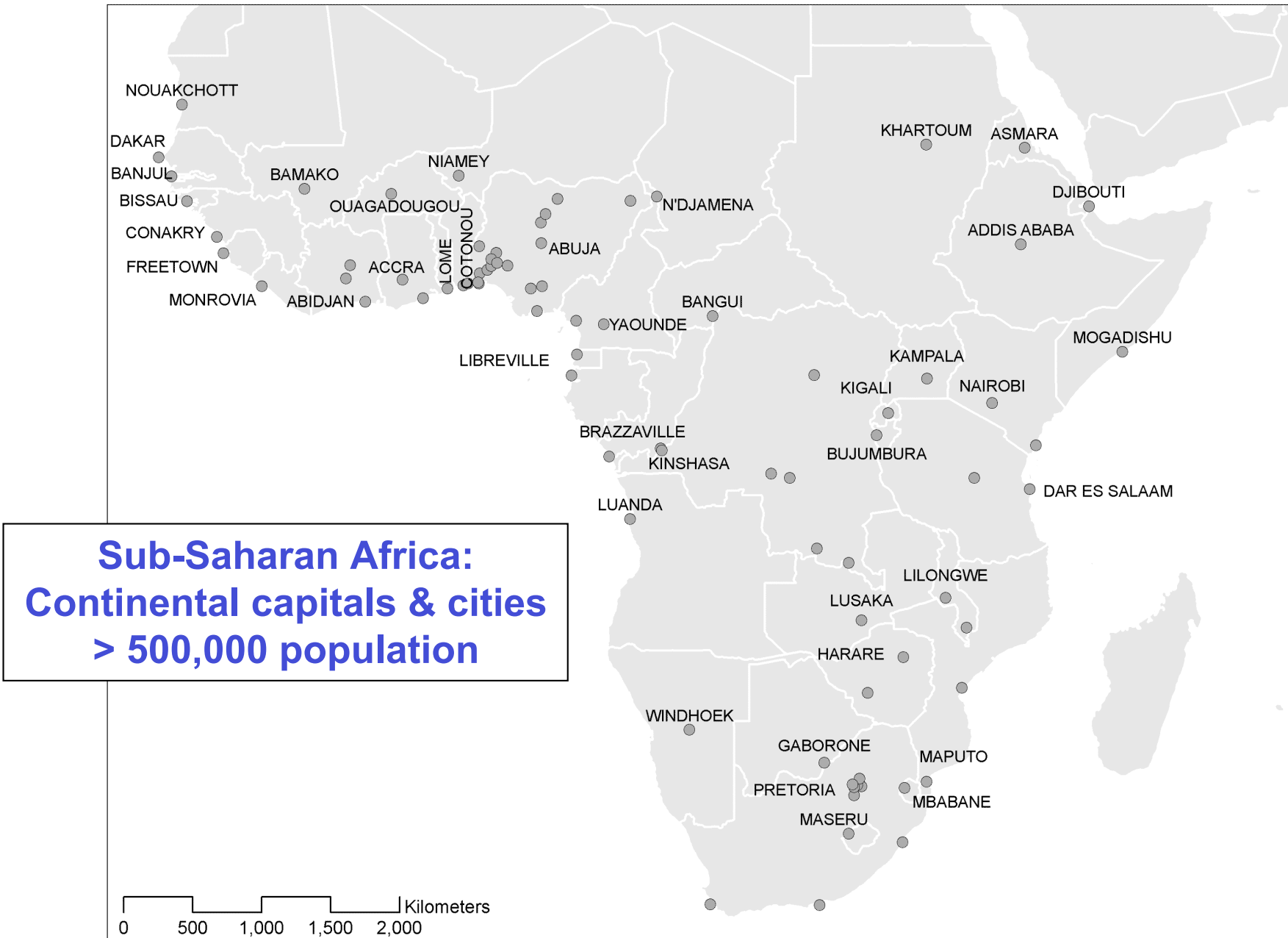
- Most trade and infrastructure studies look at external trade
(move commodities out to world markets)
- This study asks how to promote intra-African trade

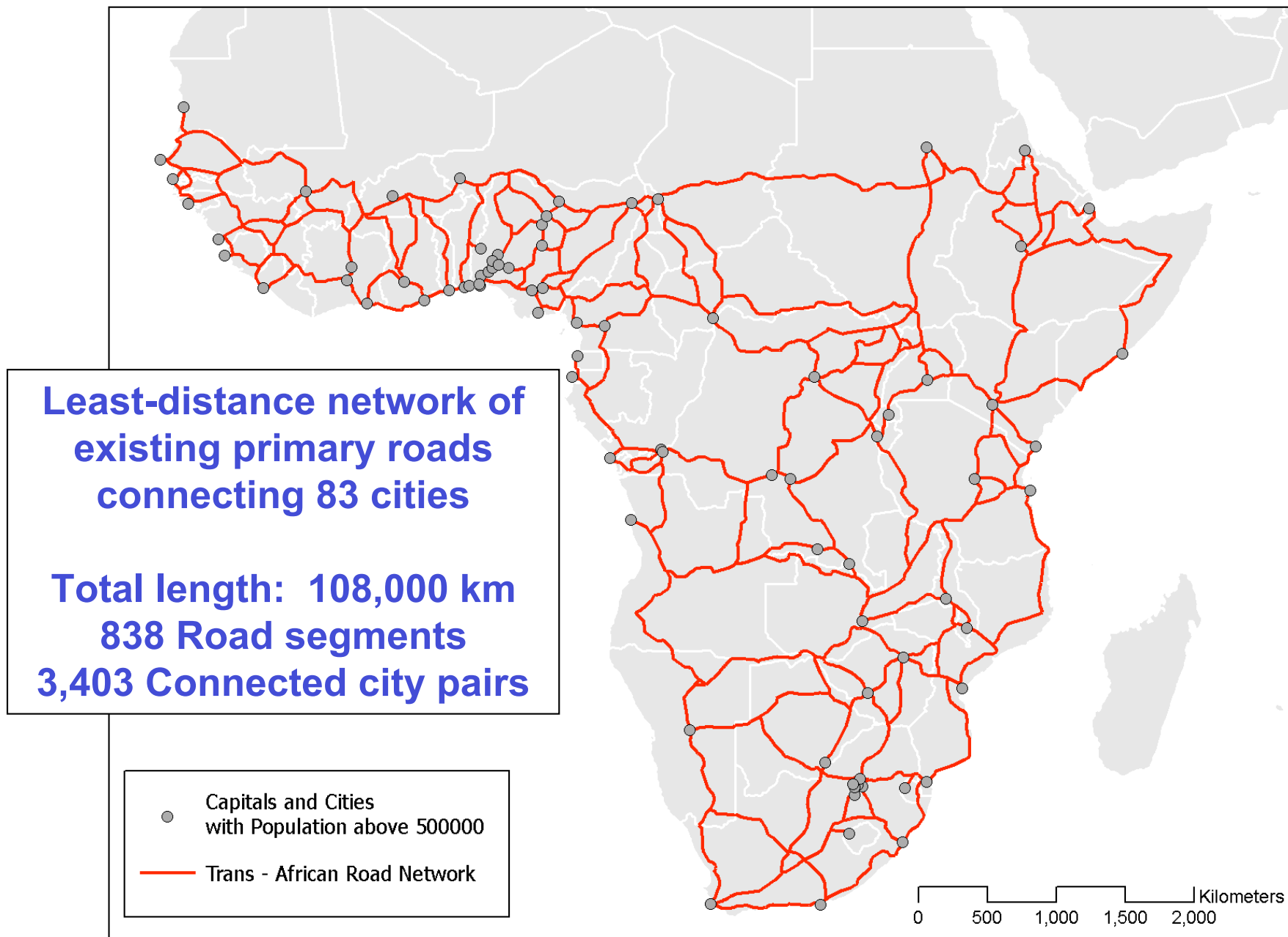
Policy research questions

- By how much would intra-African trade increase with a major upgrading of the main continental highway network?
- How much would upgrading and annual maintenance of such a system cost?

Analysis

- Develop a spatially explicit model of pan-African highways
- Estimate benefits and costs based on a full network trade model connecting all major cities in continental sub-Saharan Africa
- Combines use of geographic information systems and econometric techniques





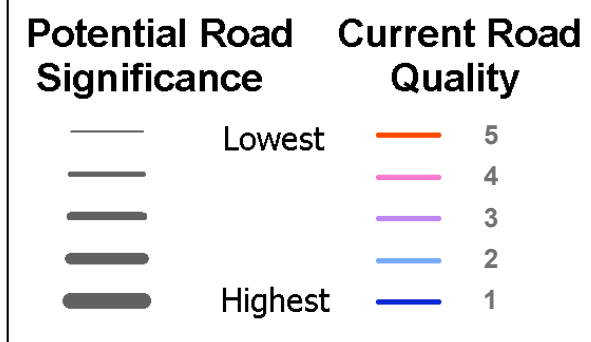
The Proposed Pan-African Highway Corridors



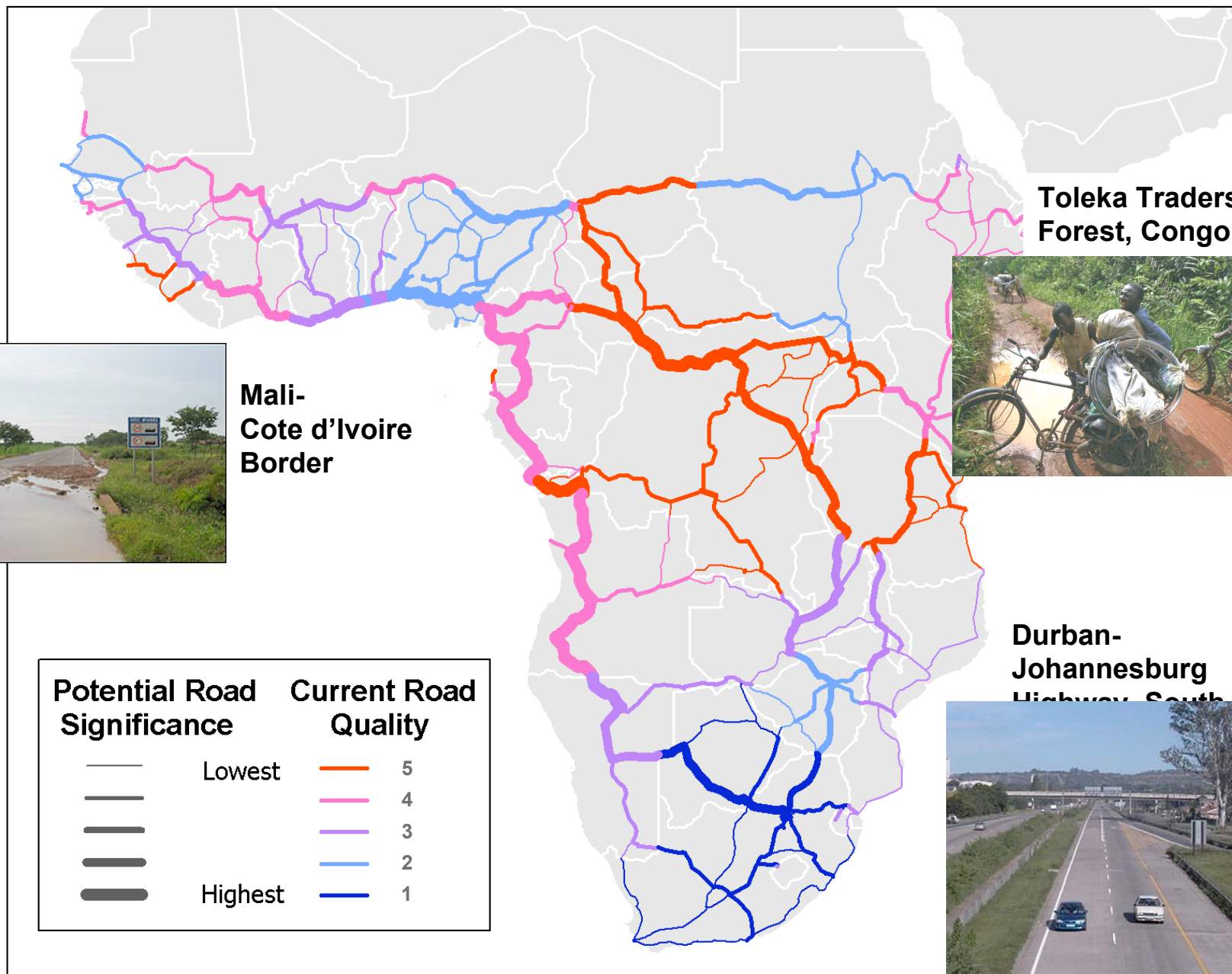
Gravity trade model

- Standard tool in trade economics
(and in transport sector analysis)
- More trade between larger economies
- Less trade between distant economies
- But: *quality* of transport links also matters,
as do institutional factors such as trade
agreements

Estimated road network quality and importance of links



Road significance: number of times segment is used when connecting each city with all other cities



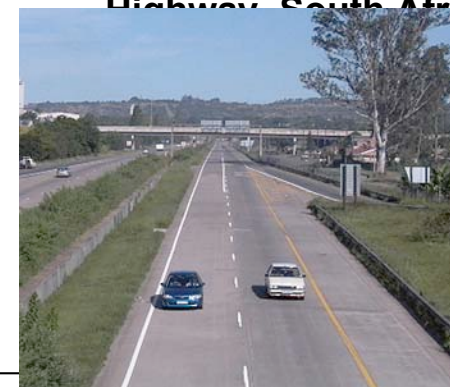
Toleka Traders, Ituri Forest, Congo D.R.



Mali-Cote d'Ivoire Border



Durban-Johannesburg Highway, South Africa



Estimating trade flows: Econometric analysis via gravity modeling

Data Source: IMF Directions of Trade, 2000-2003
merchandise imports/exports

Sample Size: 1128 Observations

All parameters are highly significant

$$\hat{T}_{ij} = K \frac{A_{ij}^{2.74} E_i^{1.71} M_j^{1.44} q_{ij}^{1.93}}{d_{ij}^{2.10}}$$

A_{ij} = Membership in WAEMU, CEMAC or EAC

E_i = Exporter economic scale

M_j = Importer economic scale

q_{ij} = Quality index for the network road link

d_{ij} = Network road distance

Estimating trade flows: Econometric analysis via gravity modeling

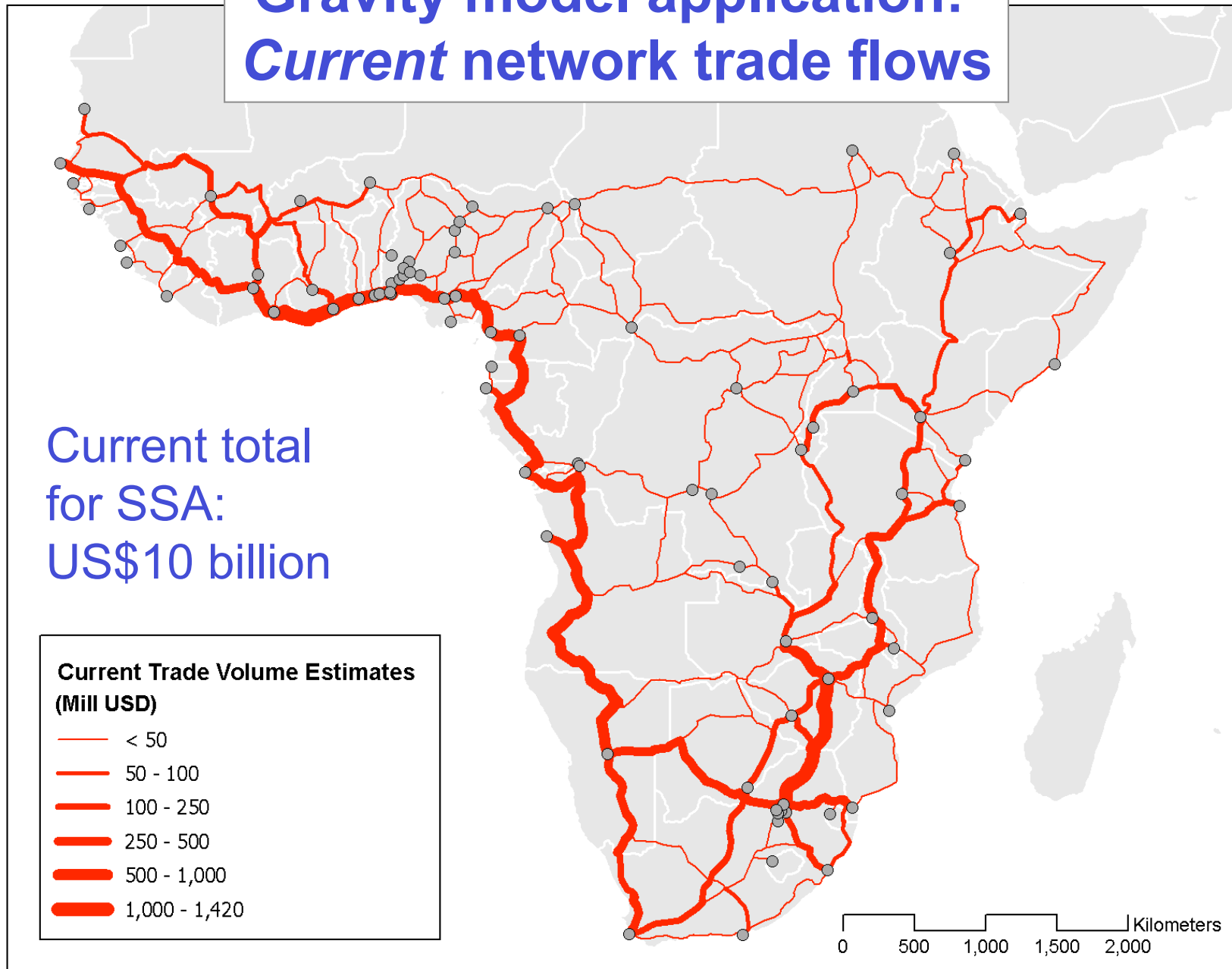
- Downscale **country-to-country trade estimates** to generate **city-to-city flows** along the least-cost path through the highway network
- This yields estimates of current trade volumes on each road link
- We can then predict future trade volume after road upgrading

Gravity model application: *Current network trade flows*

Current total
for SSA:
US\$10 billion

Current Trade Volume Estimates (Mill USD)

- < 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1,000
- 1,000 - 1,420

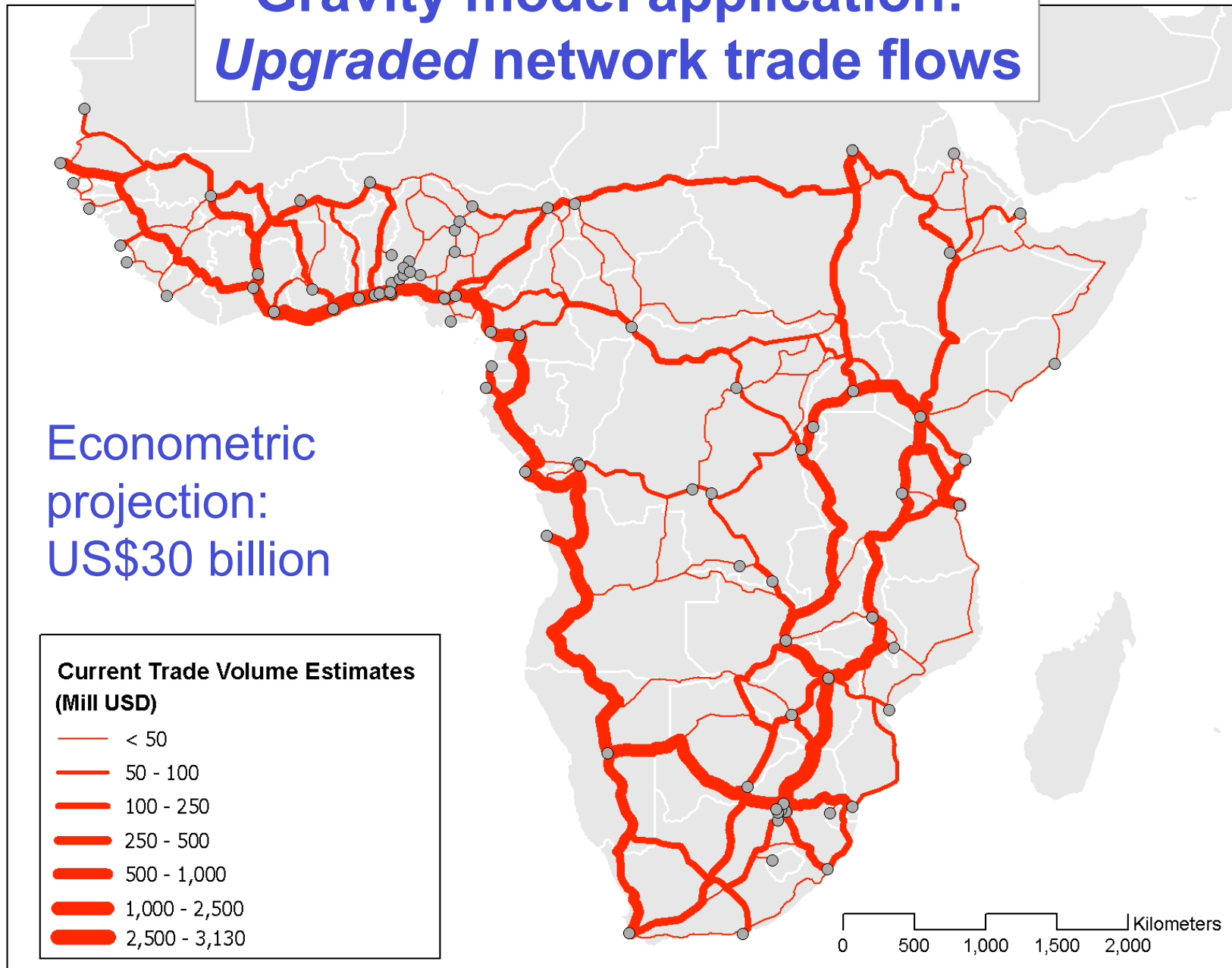


Gravity model application: *Upgraded network trade flows*

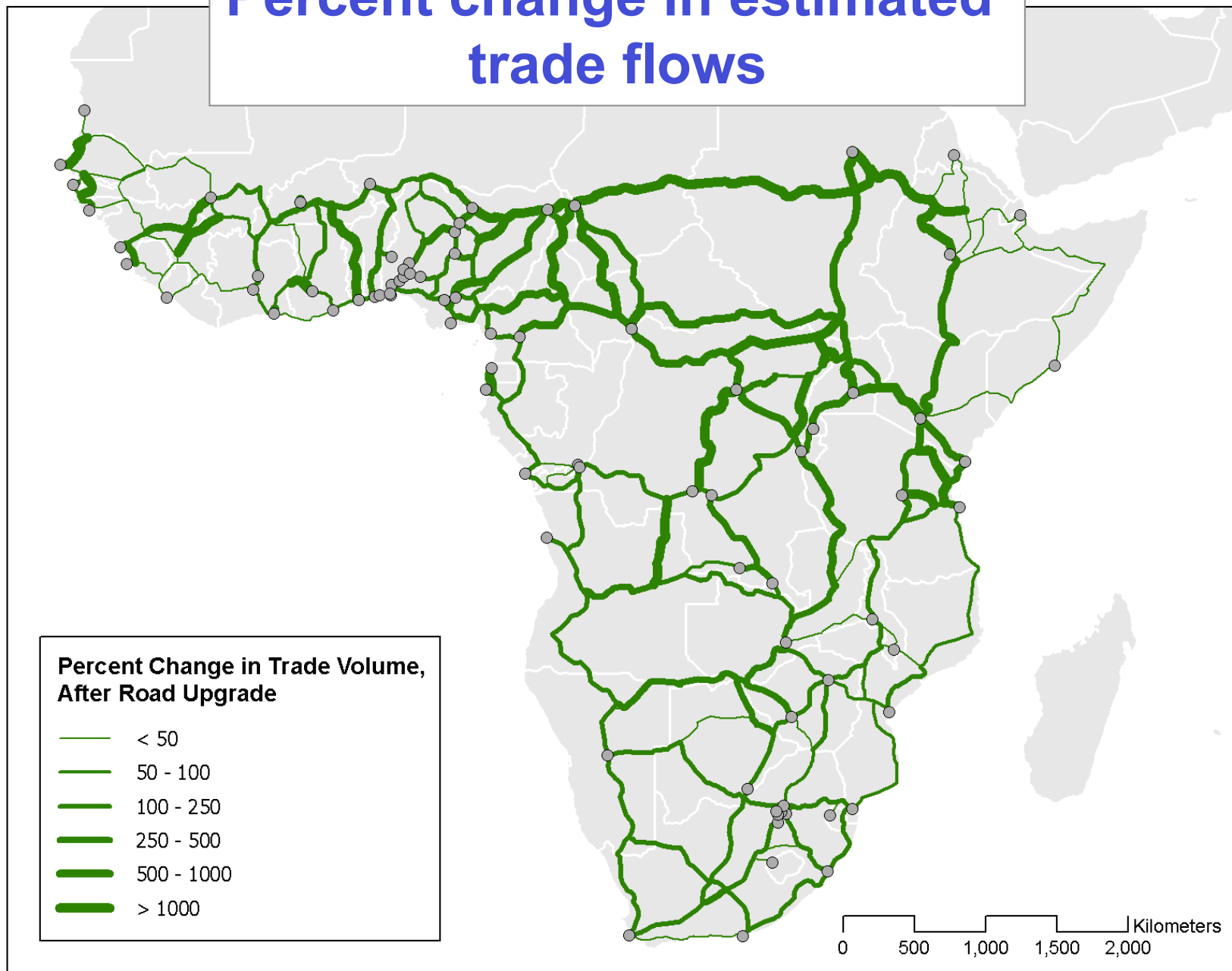
Econometric
projection:
US\$30 billion

Current Trade Volume Estimates (Mill USD)

- < 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 3,130



Percent change in estimated trade flows



Gravity model application: Network trade flows

Program: Network upgrade to class **2**

Econometric projection: Annual trade (US\$billion)

Current

Upgraded

10.1



29.8

55.5 [+1 Std. Error]

16.4 [-1 Std. Error]

Almost half of increase is *between* major regions
(West, Central, East, Southern, South Africa)

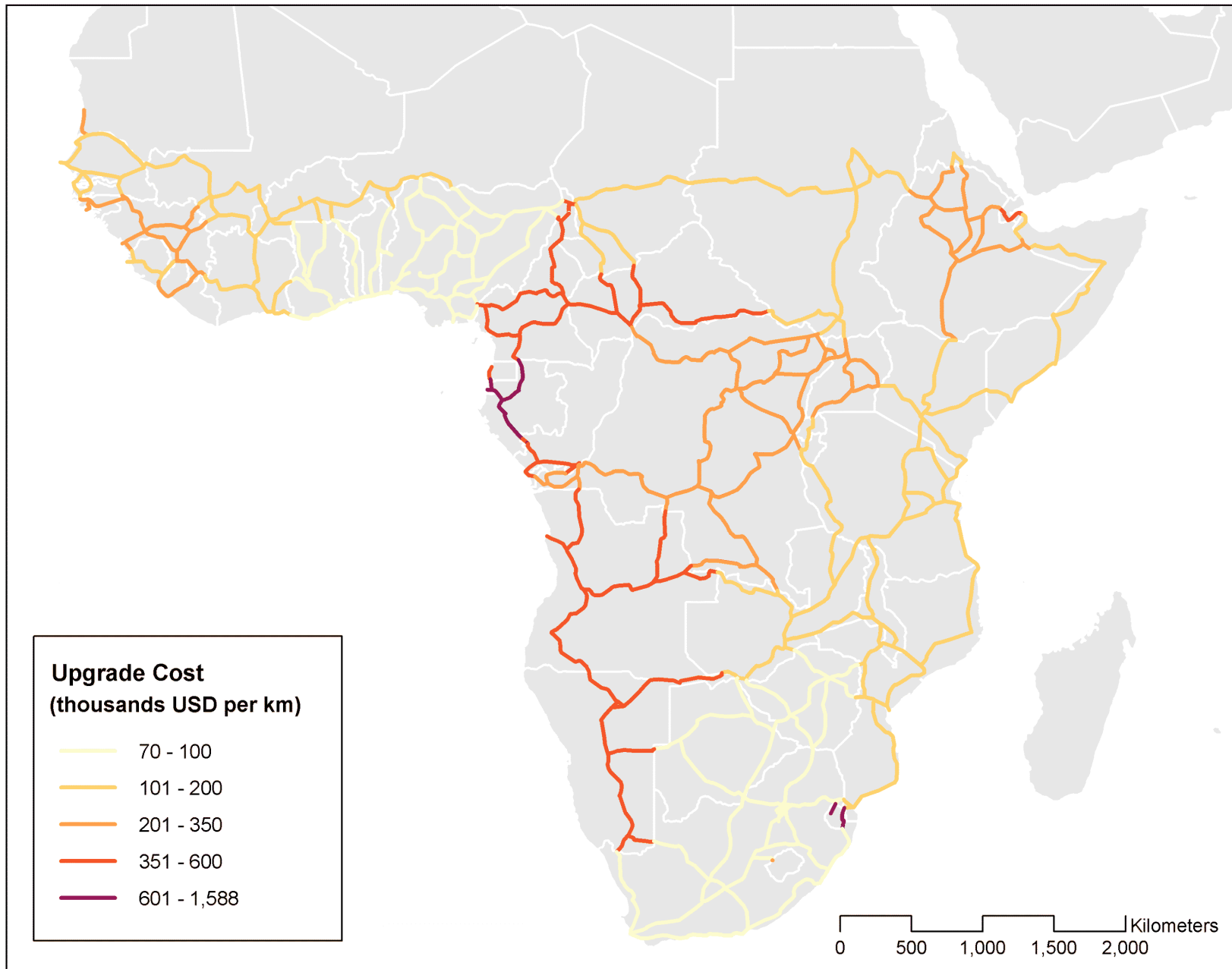
Costs

**Econometric estimation of
upgrading and maintenance costs**

Estimation of upgrading and maintenance costs

- Data Source: World Bank ROCKS Database (unit costs of 470 road improvement projects in Sub-Saharan Africa)
- Estimate country specific unit cost functions based on
 - Existing road condition
 - Wage rates
 - Governance
 - Rainfall intensity
 - Project types

Projection from estimated cost function



Program: Network upgrade to class **2**

Econometric projection: Upgrade cost (US\$billion)

	<u>Upgrade</u>	<u>Annual maintenance</u>
20.7	$\left[\begin{array}{l} 28.4 \text{ [+1 Std. Error]} \\ 15.6 \text{ [-1 Std. Error]} \end{array} \right]$	$\left[\begin{array}{l} 1.2 \text{ [+1 Std. Error]} \\ 0.7 \text{ [-1 Std. Error]} \end{array} \right]$

Network upgrade program: 5-Year upgrade; 10-Year operation

Trade Category	Annual Trade Growth (\$Bill.)	Upgrade Cost Category	Upgrade Cost (\$Billion)	Maint. Cost Category	Maint. Cost (\$Bill.)	Total Trade Growth (\$Bill.)	Total Cost (\$Bill.)	Net (\$Bill.)
Low	6.2	High	28.4	High	1.2	77.5	43.4	34.1
Low	6.2	Benchmark	20.7	Benchmark	0.9	77.5	32.0	45.6
Low	6.2	Low	15.6	Low	0.7	77.5	24.4	53.2
Benchmark	19.7	High	28.4	High	1.2	246.25	43.4	202.9
Benchmark	19.7	Bench mark	20.7	Benchmark	0.9	246.25	32.0	214.3
Benchmark	19.7	Low	15.6	Low	0.7	246.25	24.4	221.9
High	45.3	High	28.4	High	1.2	566.25	43.4	522.9
High	45.3	Benchmark	20.7	Benchmark	0.9	566.25	32.0	534.3
High	45.3	Low	15.6	Low	0.7	566.25	24.4	541.9

Benchmark 15 year scenario suggests almost \$ 250 billion
of additional intra-African trade at a cost of \$ 32 billion

Trade expansion vs. welfare gain

- Value of increased trade does not equal welfare gain
- *But:* most studies show a link between trade and growth, and between growth and poverty reduction
 - e.g., Frankel and Romer, *AER* (1999):
1% increase in trade share increases incomes by 0.5 - 2%
- *Also:* Additional benefits from increased intra-country trade, external trade, multipliers & spillovers

Summary

- Upgrading could bring a \$215 billion “surplus” over 15 years
- Results reflect *network* benefits
 - Upgrades in one country may benefit neighbors more than country itself
 - Requires a regional perspective (and financing arrangements!)
- Road quality improvements need to be accompanied by removal of non-physical trade barriers

Implementation issues

- Beneficiary estimation
 - Possibly tremendous employment benefits from labor intensive construction methods
 - 8.4 million person years employment for upgrading
 - 365,000 permanent jobs for maintenance
 - These estimates are based on other labor intensive infrastructure projects

Thank you!

For a copy of the working paper or presentation, email
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