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

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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
Sub-Saharan Africa: Continental capitals & cities > 500,000 population
Least-distance network of existing primary roads connecting 83 cities

Total length: 108,000 km
838 Road segments
3,403 Connected city pairs
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
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
Econometric projection: US$30 billion

Gravity model application: *Upgraded* network trade flows
Percent change in estimated trade flows

Percent Change in Trade Volume, After Road Upgrade

- < 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1000
- > 1000

Kilometers

0 500 1,000 1,500 2,000
Gravity model application: Network trade flows

Program: Network upgrade to class 2

Econometric projection: Annual trade (US$ billion)

<table>
<thead>
<tr>
<th>Current</th>
<th>Upgraded</th>
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<tbody>
<tr>
<td>10.1</td>
<td>29.8</td>
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</table>

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

55.5 [+1 Std. Error]

16.4 [-1 Std. Error]
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
**Program: Network upgrade to class 2**

**Econometric projection: Upgrade cost (US$ billion)**

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<tr>
<th></th>
<th>Upgrade</th>
<th>Annual maintenance</th>
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<td><strong>Annual maintenance</strong></td>
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Network upgrade program:  
5-Year upgrade; 10-Year operation

<table>
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<tr>
<th>Trade Category</th>
<th>Annual Trade Growth ($Bill.)</th>
<th>Upgrade Cost Category</th>
<th>Upgrade Cost ($Billion)</th>
<th>Maint. Cost Category</th>
<th>Maint. Cost ($Bill.)</th>
<th>Total Trade Growth ($Bill.)</th>
<th>Total Cost ($Bill.)</th>
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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 udeichmann@worldbank.org