The Heterogeneous Effects of Transportation Infrastructure: Evidence from Sub-Sahara Africa

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WORK IN PROGRESS

January 2016

Research Questions

- ▶ **How has intercity road upgrading affected city growth in Sub-Saharan Africa?**

- ▶ **What are the implications for current/future road-building efforts?**

  - ▶ Almost 20% of World Bank lending on transport as of 2007, 68% of which on roads.
  - ▶ Large fraction of network still unpaved
  - ▶ Trans-African Highway network as coordinating mechanism: 55,000 km of planned highways (vs. 1,000 km of highways in c. 2012).
    - ▶ Abidjan-Lagos Motorway: $8 billion
    - ▶ LAPSSET Project in Kenya-Ethiopia-South Sudan: $22 billion
    - ▶ Gauteng-Maputo Development Corridor: $5 billion

What We Do

- ▶ Build a **new panel data set** on road surface, city population and market access for 39 Sub-Saharan African countries 1960-2010.
- ▶ Estimate the average effects of **market access** changes (as induced by road surface changes) on city growth.
  - ▶ market access is a measure summarizing a city's access to all other cities.
  - ▶ a doubling of market access induces a 5–18% increase in city population
  - ▶ effect spread up to 30 years after road upgrading
- ▶ Also investigate the **heterogeneous effects** of road changes:
  - ▶ Larger cities vs. smaller cities
  - ▶ Denser vs. less dense regions
  - ▶ Coast vs. inland
  - ▶ Close to largest city vs. hinterland

Related work

- ▶ Highway infrastructure impacts in China, USA, India, Brazil,
- ▶ Rail infrastructure impacts in China, USA, India, Ghana, Kenya
- ▶ Micro road surface/quality impacts in Sierra Leone (agricultural prices), Indonesia (manufacturing employment), Mexico (household wealth)
- ▶ Transport and trade costs in Africa - variation from other sources:
  - ▶ Fuel prices
  - ▶ inferred from price changes of very specific goods
- ▶ Our contributions:
  - ▶ Scale: 39 countries, 6 time slices over 50 years
  - ▶ Timing and heterogeneous effects.
  - ▶ Not just building highways: paving and improving (gravelling)

Outline

- ▶ Data

- ▶ Estimation

- ▶ Results

- ▶ Conclusion

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Data: Roads

GIS database of roads:

- ▶ *Michelin* paper road maps for 39 Sub-Saharan African countries from the early 1960s to date. Sources:
  - ▶ Government maps
  - ▶ Feedback from customers (large network of tire distributors and correspondents)

- ▶ Map ≈ every 3 years, so 833 country-years
- ▶ Surface of each road: *Highway*, *Paved*, *Improved* and *Dirt* (vs. Primary, secondary, tertiary)
- ▶ No city streets

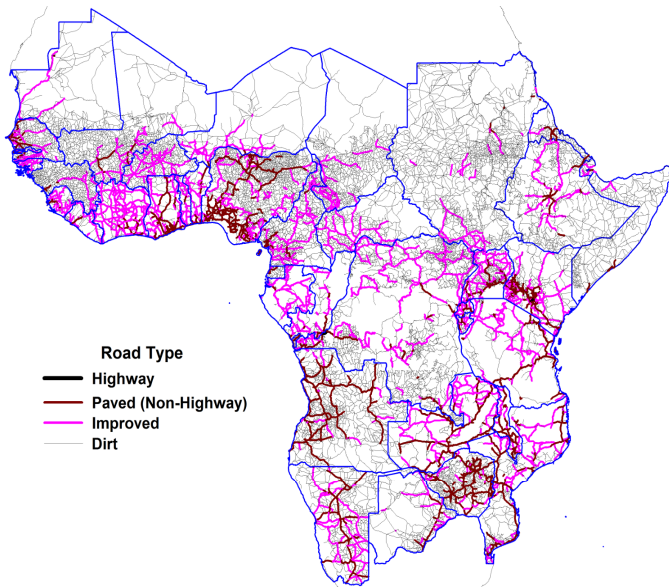# Michelin Road Map Countries and Years
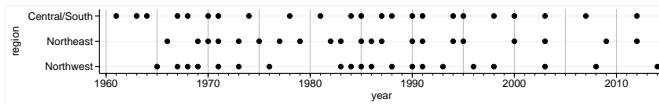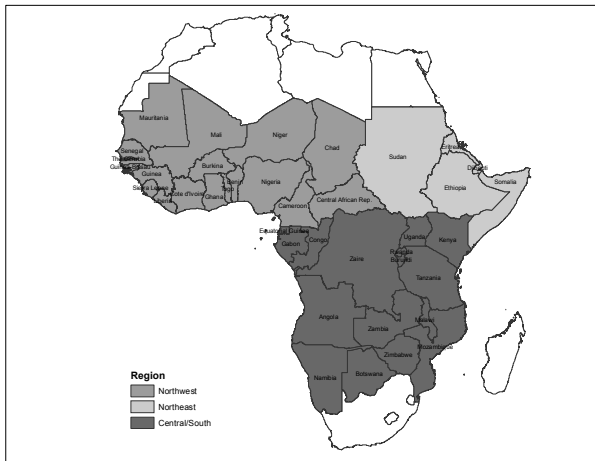
Michelin Road Map for Liberia in 1965

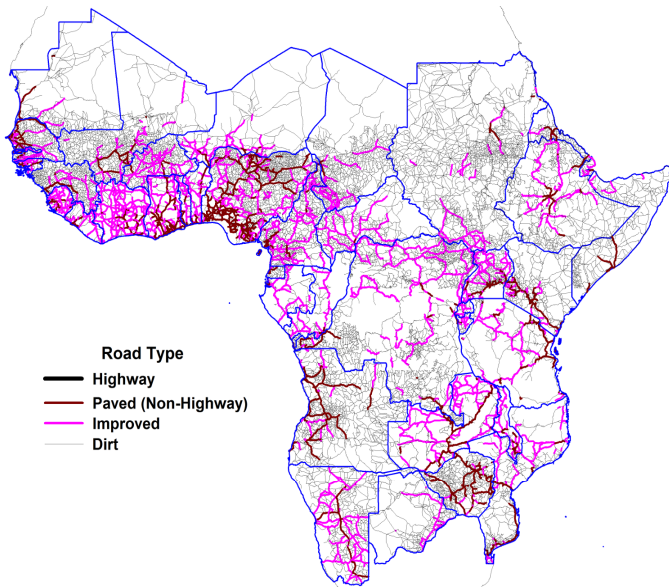Surfaces aggregated into 4 categories: *Highway*, *Paved*, *Improved* and *Dirt*
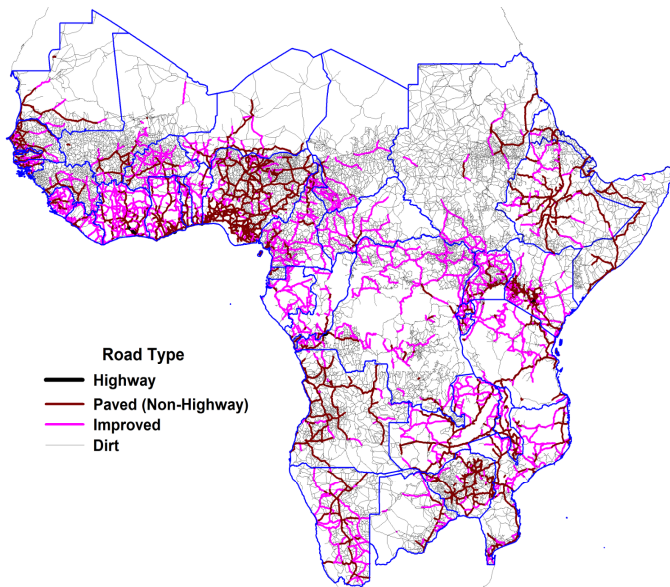
Four Road Surface Categories

Roads in 1960

Roads in 1970
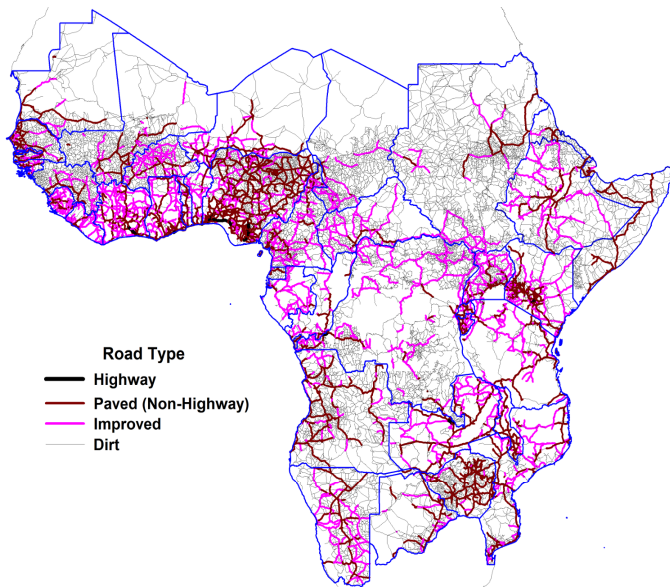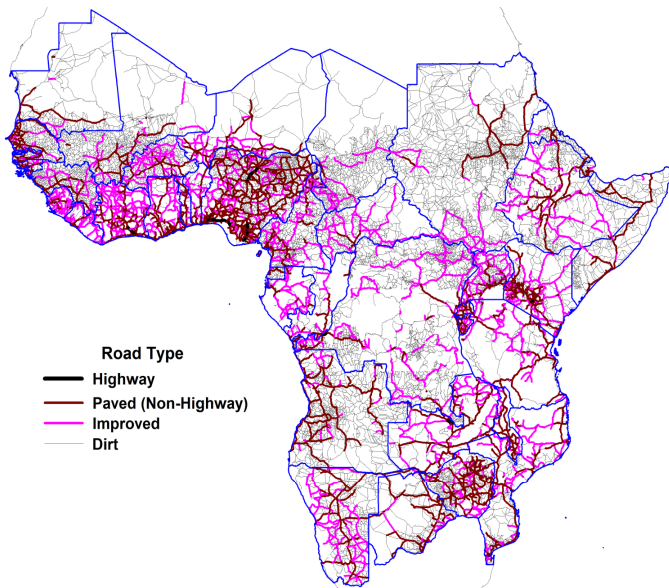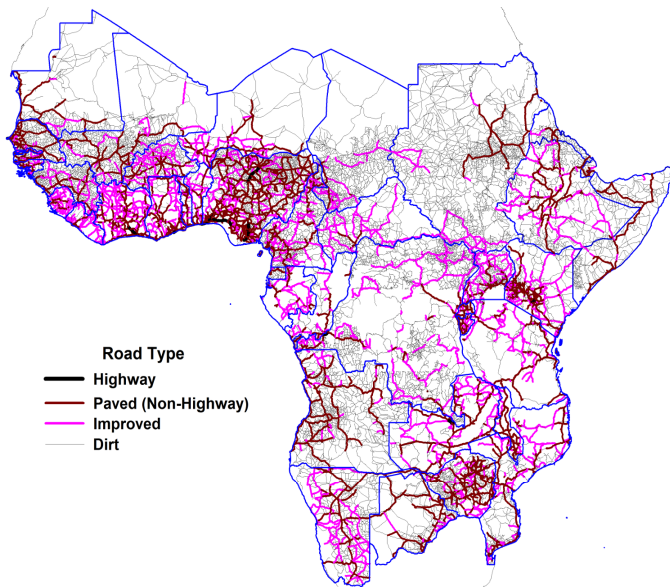

Road Type
— Highway
— Paved (Non-Highway)
— Improved
— Dirt

Roads in 1980

Road Type
— Highway
— Paved (Non-Highway)
— Improved
— Dirt

Roads in 1990

Roads in 2000

Road Type
— Highway
— Paved (Non-Highway)
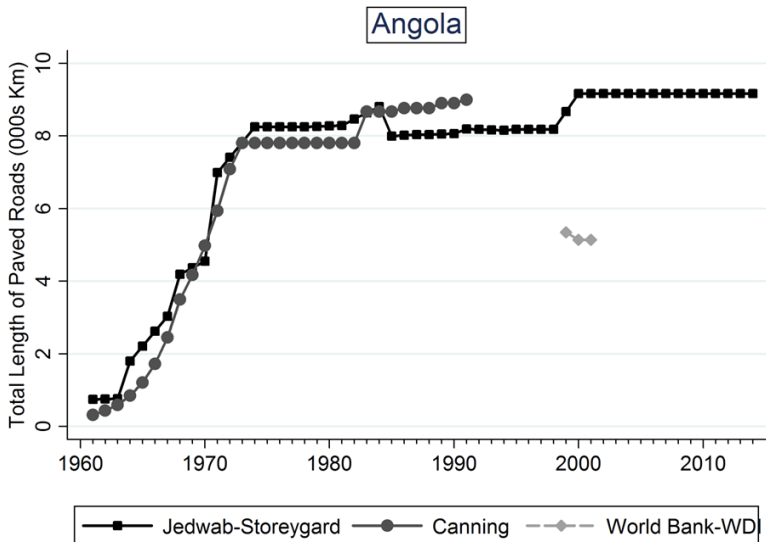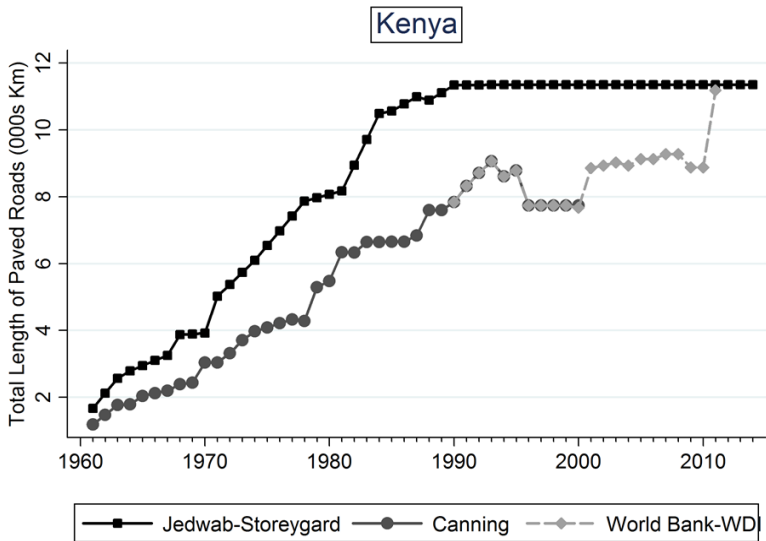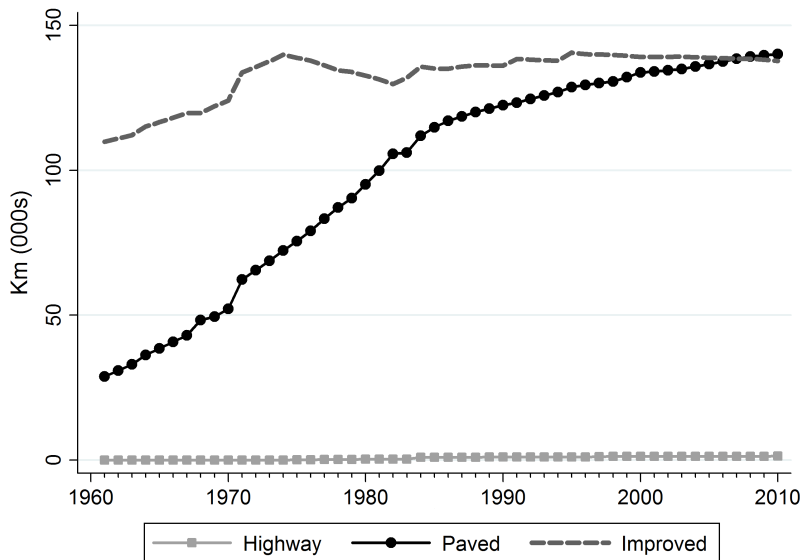— Improved
— Dirt

Roads in 2010

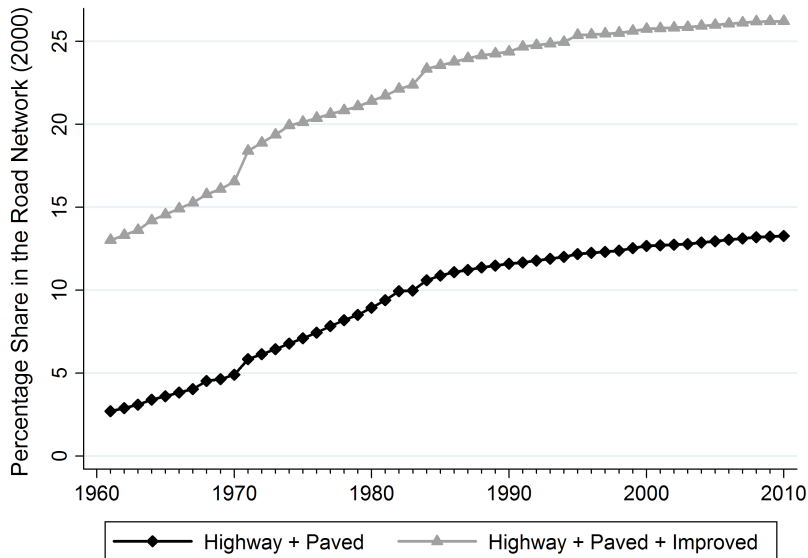# Road Length: Michelin vs. Canning (2008) vs. World Bank

Angola

Road Length: Michelin vs. Canning (2008) vs. World Bank

Road Length in Sub-Saharan Africa (39 Countries)

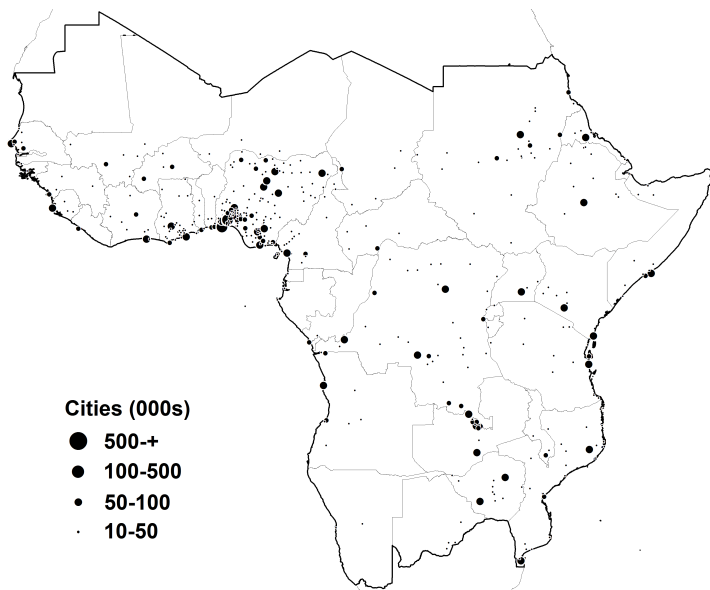# Percentage Share in the Road Network (39 Countries)

Data: Cities

GIS database of cities:

- ▶ Population of localities ever above 10,000 inh. for the same 39 countries in 1960, 1970, 1980, 1990, 2000 and 2010

- ▶ Proxy for local economic development in the absence of other data (no land prices, no systematic rural populations before c. 1990, no night lights before 1992).

- ▶ Sources: *Africapolis I* and *II* for 33 countries + *Population Census* data for 6 countries (similar methodology)

Cities ($\geq$ 10,000 Inh.) in 1960

Cities ($\geq$ 10,000 Inh.) in 1970

Cities (000s)
- **500-+**
- **100-500**
- **50-100**
- **10-50**
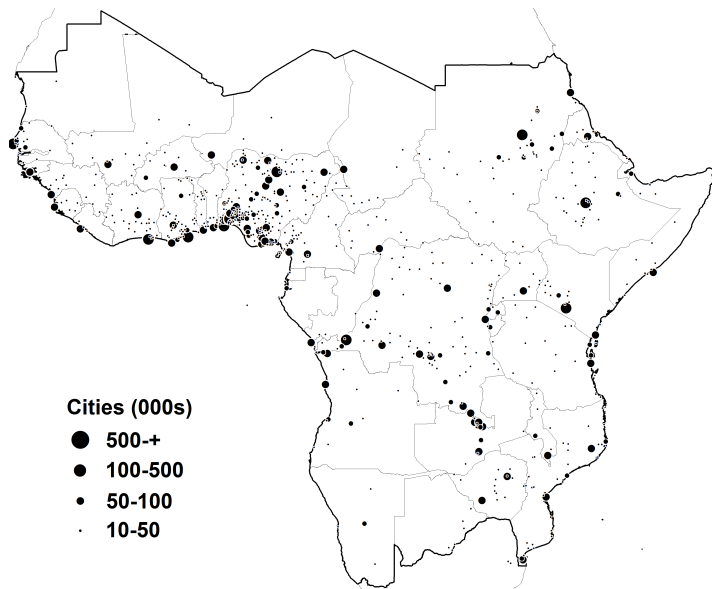
Cities (≥ 10,000 Inh.) in 1980

Cities (000s)
- 500-+
- 100-500
- 50-100
- 10-50
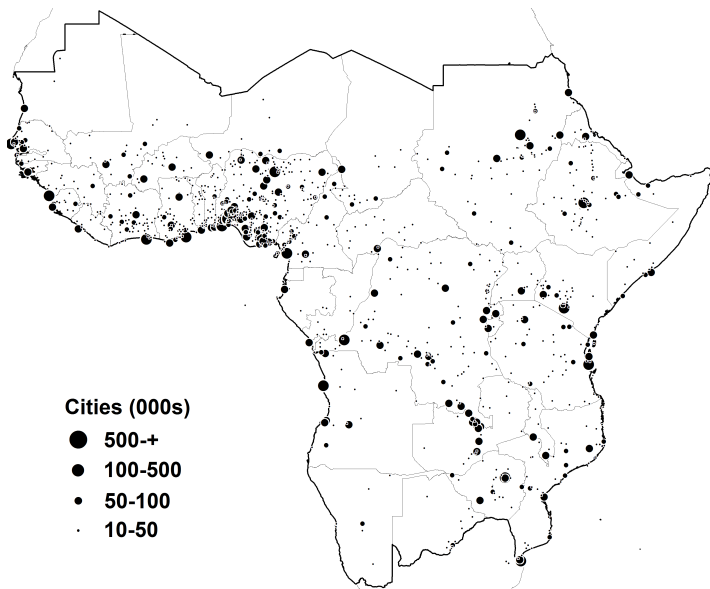
Cities (≥ 10,000 Inh.) in 1990

Cities (000s)
- ● 500-+
- ● 100-500
- • 50-100
- · 10-50
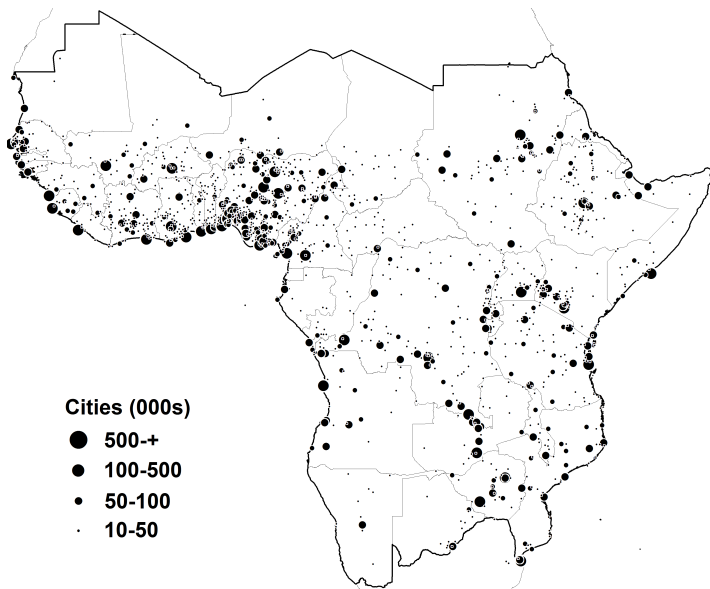
Cities (≥ 10,000 Inh.) in 2000

Cities (000s)
- ● **500-+**
- ● **100-500**
- · **50-100**
- · **10-50**

Cities (≥ 10,000 Inh.) in 2010
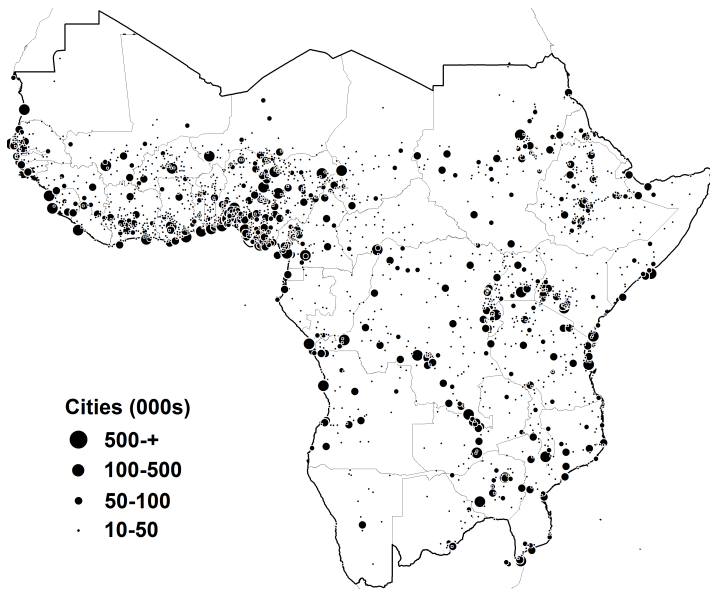
Cities (000s)
- 500-+
- 100-500
- 50-100
- 10-50
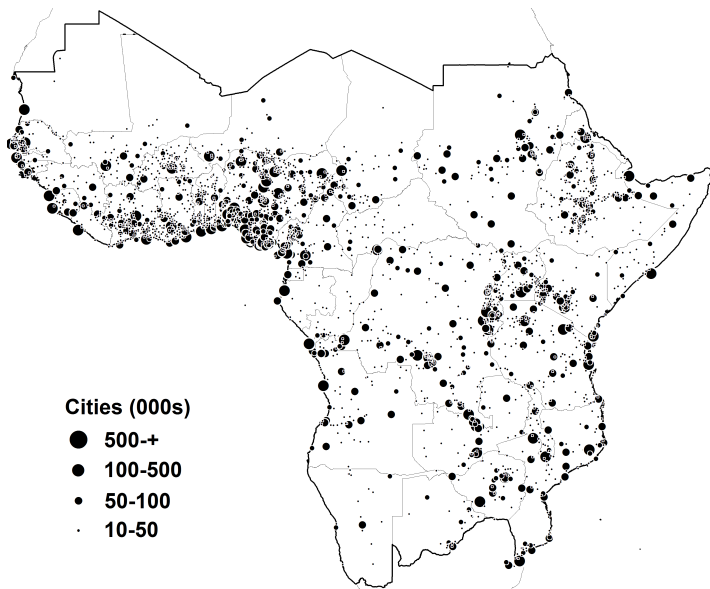
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Unit of analysis

▶ Grid squares: 0.1x0.1 degree (~11x11 km; computational constraints)

▶ Select the best (lowest-cost) road in the cell

▶ Sum of city populations within cell (98 of 2,879 populated cells have multiple cities)

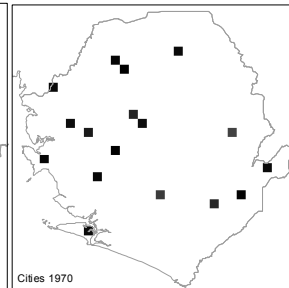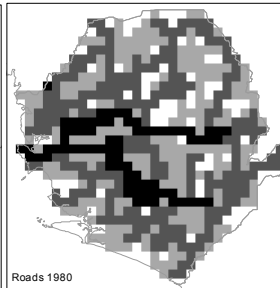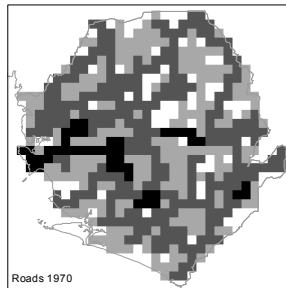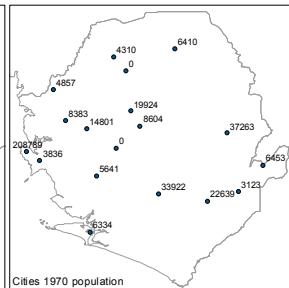# Sample

- ▶ Full sample: 5,906 city-years for 2,127 cities ($>$10,000 in at least two years)
  - ▶ 2010: 2,119
  - ▶ 2000: 1,514
  - ▶ 1990: 1,094
  - ▶ 1980:   746
  - ▶ 1970:   433
  - ▶ 4,725 city-years for 2,126 cities when including two lags

Defining Market Access

- ▶ We care about the effect of roads beyond the cities they pass through
- ▶ First cut: how many people can I reach within a two hour journey from e..g Central London?
- ▶ How many more can I reach if I build a new road or rail?
- ▶ **Market access** generalizes this for concentric rings of travel time:
    - ▶ weighted sum of all people outside the city
    - ▶ weights are inversely proportional to travel time (far places count less)
- ▶ Building/improving roads increases market access by reducing travel time
- ▶ Building roads to bigger cities increases market access more
- ▶ We don't consider congestion (lack of data, conceptual issues)

Example for Sierra Leone, 1970-1980

Example for Sierra Leone, 1970-1980

Shortest routes to Makeni, 1970

Shortest routes to Makeni, 1980

Shortest routes to Bo, 1980

MA 1970

MA 1980

Change in MA 1970-80 holding roads at 1970
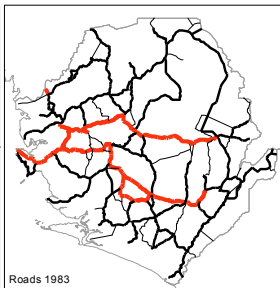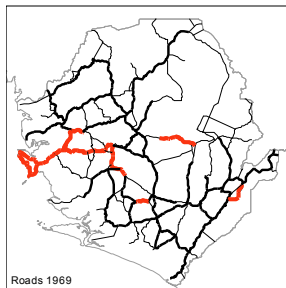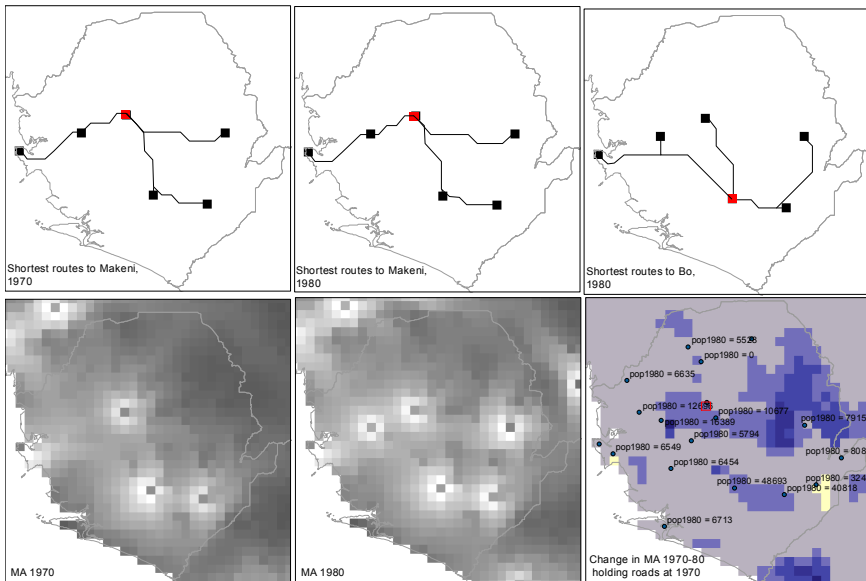
Change in market access due to road changes, 1960-2010

Change in market access 1960-2010
holding population at 1960 value
- -0.53 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.7
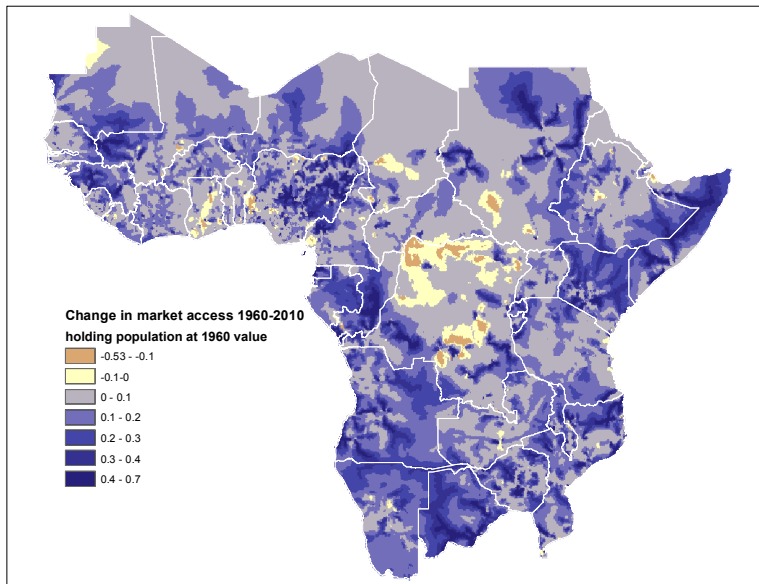
Problems with determining causal impacts of road building on city population using market access

- ▶ Reverse causality
    - ▶ Governments may build roads to places they expect to grow rapidly in the future
        - ▶ High growth misattributed to roads (overestimation)
    - ▶ Governments may build roads to places they expect to lag
        - ▶ Low growth misattributed to roads (underestimation)

- ▶ All cities in a region may grow rapidly together for a reason unrelated to roads
    - ▶ e..g. a local resource boom drives growth in my city and my neighbors
    - ▶ Neighbors' population increases my market access
    - ▶ But I don't grow *because of* my neighbors' growth

- ▶ Our indicator of market access may be badly measured

Proposed solutions

- ▶ Control for any *national-level* shocks that might be driving road building and city growth in a given decade (country-year fixed effects)
    - ▶ e.g. coups
- ▶ Control for smoothly varying spatial shocks (year-specific spatial poynomials)
    - ▶ e.g. climate
- ▶ Control for lagged population
    - ▶ mean reversion
- ▶ Use restricted variation in market access change (instrumental variable)
    - ▶ Only changes due to roads, not population
    - ▶ only changes to roads "far" away (more than 50 km; more than 100 km; outside country) from the city in question
    - ▶ valid if these "far" away roads are built for reasons unrelated to the city in question

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Summary of Average Effects

▶ Naive effect of a 100% change in market access: ≈ 1% - 1.5% per decade for three decades (total 30-year effect: 3-4%).

▶ **Better identified effect: ≈ 5–18% over 30 years.**

▶ Concentrated in first two decades (i.e. decade of construction and following decade)

▶ No measurable effect in fourth decade.

Comparison to literature

▶ Somewhat smaller than railroads in the 19th century US using similar method (Donaldson & Hornbeck 2015): ≈20–35%.

▶ Other contexts are too

▶ **Contextual differences:**

  ▶ Not a transportation revolution like in the 19th century US. Railroads already existed in Africa before roads (and poor roads existed before good roads).

  ▶ Migration costs likely higher at least for large distances.

  ▶ Context of lower economic growth.

Heterogeneous Effects?

- ▶ Heterogenous effects? Focusing on space right now.

- ▶ We classify the cities into two groups depending on:

  - ▶ High vs. low initial city size

  - ▶ High vs. low initial market access

  - ▶ Near vs. far from coast, borders, largest cities

    etc.

  and see if the effect of a same change in road market access varies across the two groups.

- ▶ This will allow us to test various existing theories in trade and urban economics.

Heterogeneous Effects?

- ▶ No consistent robust effects for any of them

- ▶ Instruments get weaker.

- ▶ **Still work in progress**

Conclusion

▶ Study the effects of road construction and market access on city population growth in Sub-Saharan Africa in 1960-2010.

▶ New panel data set on road surface and city population for 39 African countries every ten years in 1960-2010.

▶ Average effect of a 100% change in market access $\approx$ 5-18%. Effect concentrated in first 3 decades.

▶ Still exploring the heterogeneous spatial and temporal effects of the same road investments.

Effects of Possible Future Highway Networks?