The Permanent Effects of Transportation Revolutions in Africa

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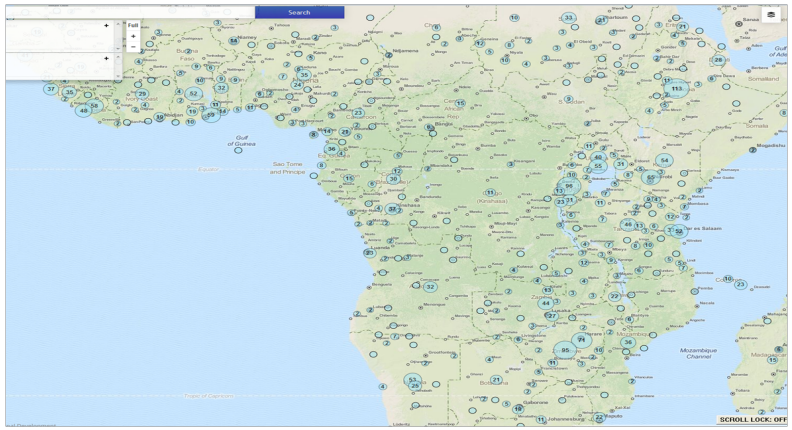
Significant investments in transport infrastructure

Tanzania-Gabon railway ($33bn), Mombasa-Kampala-Kigali railway ($14bn), Trans-Kalahari railway ($9bn), Abidjan-Lagos motorway ($8bn)...



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April 28, 2015 5:02 am

China rail group signs $5.5bn in Africa deals

Gabriel Wildau in Shanghai

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A Chinese state-owned rail company has signed $5.5bn worth of contracts in Africa, in the latest sign that the country's "New Silk Road" strategy to build infrastructure around the developing world is showing tangible results.

African units of China Railway Construction Corp will build a $3.5bn intercity rail line in Nigeria and a $1.9bn residential real estate project in Zimbabwe, the company said in exchange filings overnight on Monday.

The latest deal follows a $12bn contract that CRCC reportedly signed for a separate rail line in Nigeria last

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Research Question

What is the impact of transportation infrastructure on economic change in poor countries, and in Africa in particular?

1. **Impact** of investments in transportation infrastructure?
   - Large positive effects expected for various grand projects
   - In the long run? Industrialization? (e.g., railroads in the UK and the US)
   - Rent-seeking? (Burgess et al 2014: ethnic favoritism and roads)

2. It depends on the **context** in which such investments take place.
   - In poor countries with basic infrastructure and high trade costs?
   - In middle-income countries with more extended networks?

Research Question

Are we currently observing a third "transportation revolution" in Sub-Saharan Africa?

- **First** transportation revolution (1900-1960):
  Construction of colonial railroads $\approx 1/3$ of colonial budgets.
- **Second** transportation revolution (1960s-70s):
  Massive road investments $\approx 20\%$ of development budgets.
- **Third** transportation revolution (2010s):
  Significant re-investments in railroads and roads.
- Study the first and second revolutions to learn about the third.
  Effects of railroads and roads on the development of cities in Africa? Use panel data at fine spatial level, 1900-2010

Path Dependence & Development

- Spatial economic patterns often match the distribution of **locational fundamentals** (i.e., geographical endowments).

  $\rightarrow$ Unique spatial equilibrium (determined by geography)

- If strong **local increasing returns**, localized historical shocks can have large, permanent effects.

  $\rightarrow$ Multiple spatial equilibria (determined by history)

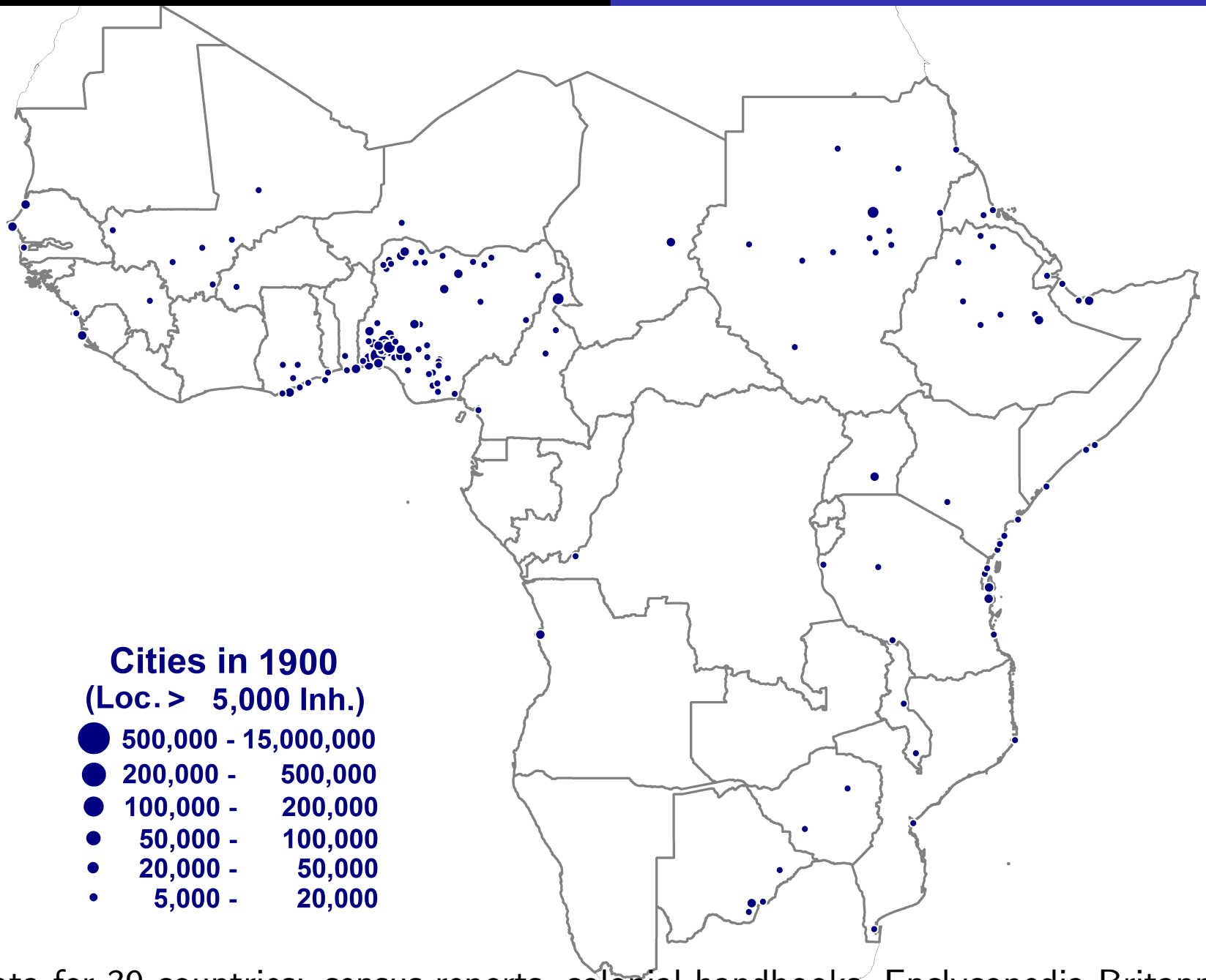
- Implications for regional policy. Invest in poor regions?

Outline

- **Setting: Background and Data**
- Emergence of the Urban Equilibrium
- Persistence of the Urban Equilibrium
- Discussion

Background: Rail Construction in Colonial Africa

1. Transportation costs extremely high around 1900.
   - Few navigable waterways
   - Draft animals not used in Tsetse-infected areas
   - No proper roads before the 1930s
   - Goods **headloaded** on short distances, slaves walked
   - Economic change limited to a few areas



Data for 39 countries: census reports, colonial handbooks, Enclycopedia Britannica

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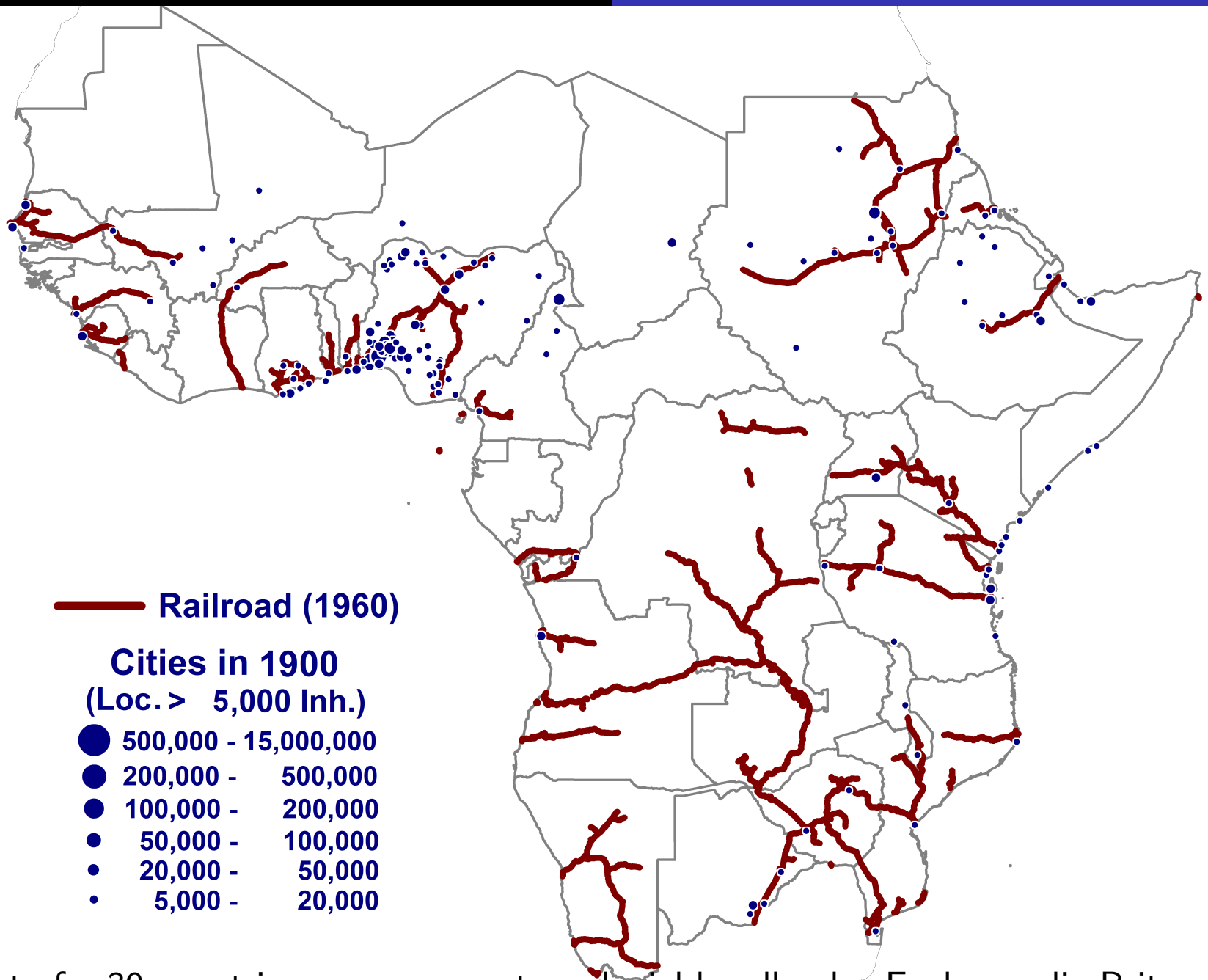
   - Economic change mostly limited to the coast

2. The colonizers built **railroads** to transform the continent.
   - 90% of African railroad lines built before 1960
   - Mostly for military domination (scramble for Africa), then mining (European-owned mines) and cash crops (White settlers)

The human cost of railroad construction was high.



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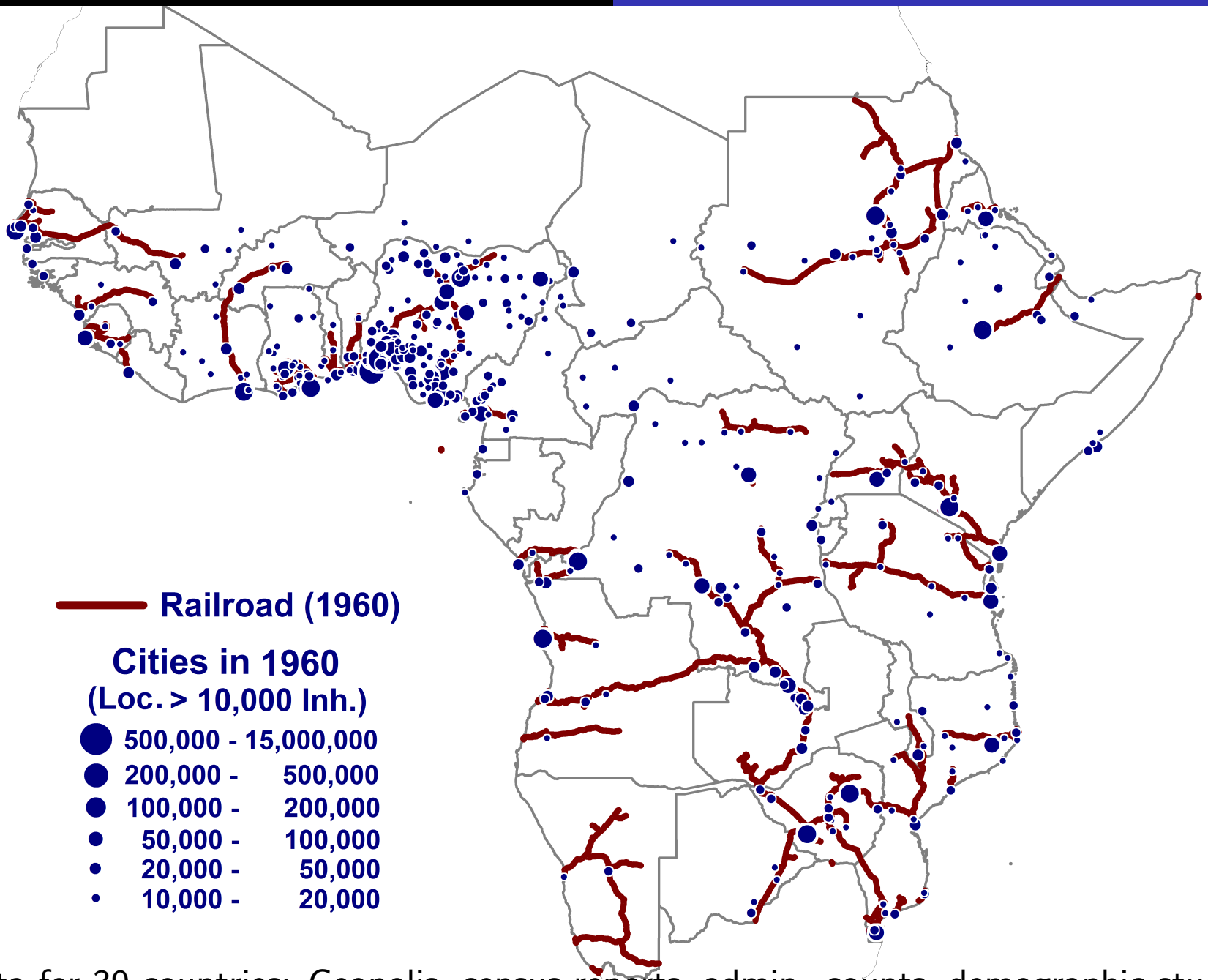
Many villages became railroad stations and **cities** at independence.



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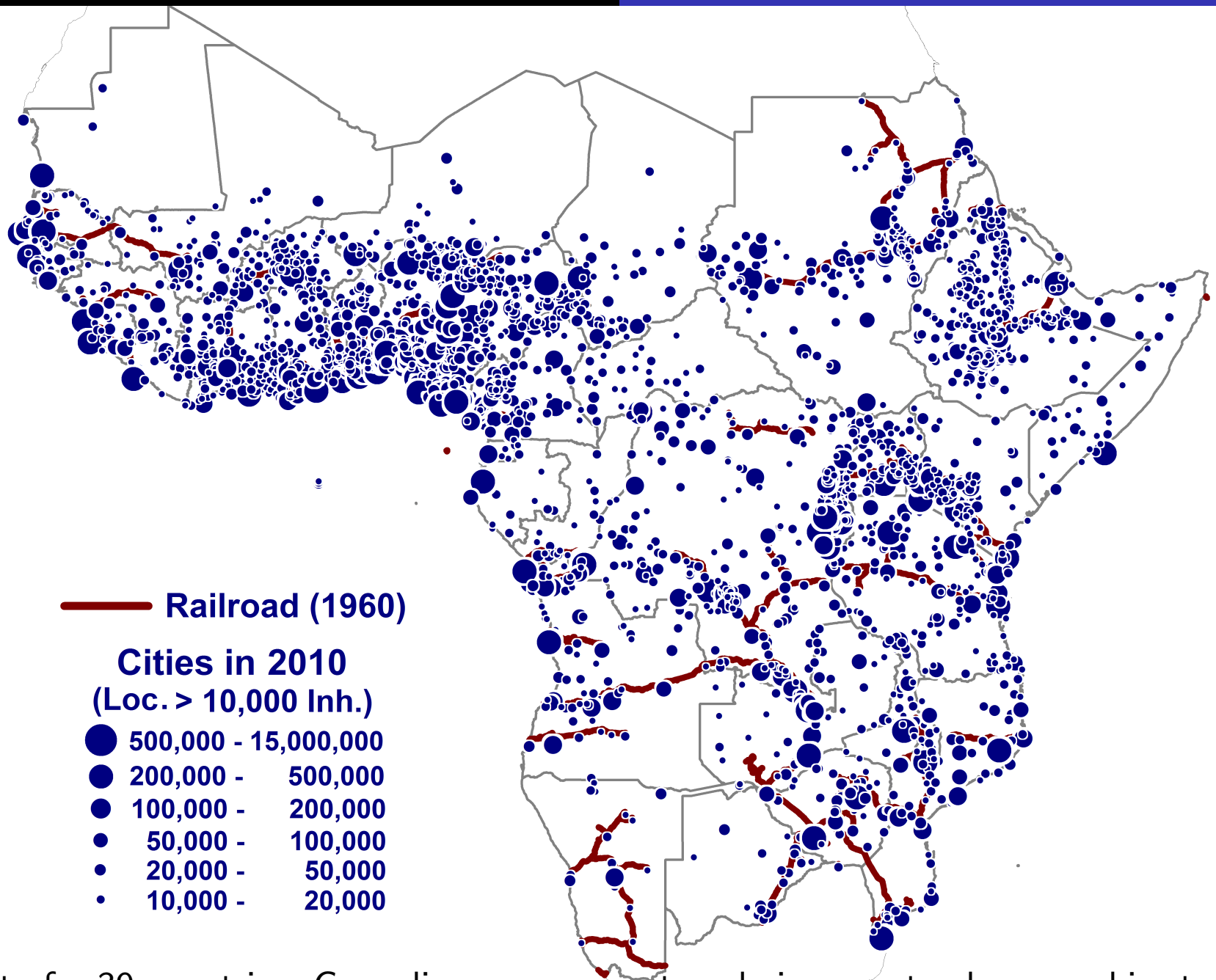
3. Many railroad lines **declined** in the 1970s.
   - Lack of maintenance and mismanagement
   - Massive road investments away from the railroads
   - The railroad locations have lost their initial advantage



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Data

1. Data for **194,000 grid cells** of 0.1x0.1° (10x10km).
   - 39 countries in SSA (excl. Madagascar, Lesotho, South Africa, Swaziland). Analysis *within* country (we include country FE).
2. Data on **transportation technologies**:
   - *Pre-colonial:* access to the coast, navigable river
   - *Colonial:* railroad line (year and motivation for each line)
   - *Post-colonial:* paved (bitumenized) and improved (laterite) roads
3. Data on **economic development**:
   - Data on all cities above 10,000 inh. (5,000 for earlier years) in 1890, 1900, 1910, 1920, 1960, 1970, 1980, 1990, 2000, 2010
   - Various sources: colonial and post-colonial census reports or gazetteers, Encyclopedia Britannica 1911, colonial handbooks, Geopolis, various historical sources, Google Earth

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Emergence of the Urban Equilibrium - Focus on Railroads

- **Hypothesis:** rail connectivity has a causal impact of the number of urban inhabitants in 1960 ($\approx$ independence).

- **Long-differenced estimations** for grid cells c, in 39 countries s, 1900-1960:

$$ZUpop_{c,s,60} = \alpha_s + Rail_{c,s,60}\beta_{SSA} + \rho_{SSA} ZUpop_{c,s,00} + X_{c,s,00}\zeta_{SSA} + u_{c,s}$$

  - $Rail_{c,s,60}$ set of rail dummies: 0-10, 10-20, 20-30 and 30-40 km from a colonial railroad (1960). $\beta_{SSA} > 0$
  - The urban population is standardized each year (Z-scores).

Emergence of the Urban Equilibrium

- **Drop largest, second largest and capital cities**
- **Country fixed effects**
- **Controls at the grid cell level**

  Pre-colonial transportation: dummies 10km from coast or a navigable river, Euclidean distances (km) to coast and river

  Economic geography: Euclidean distances (km) to largest city, second largest city and capital city

  Physical geography: altitude, ruggedness, rainfall, soils

- **SEs clustered at district level (N = 2,304)**

Strategies to Estimate Causal Effects

- Causal effect? Connect places with highest return (**upward bias**) or objective to connect poor regions (**downward bias**).

- Compare **contiguous cells**, assuming they are the same

  0-10 vs. 10-20 km; include ethnic group or district fixed effects, or fourth order polynomial in longitude and latitude

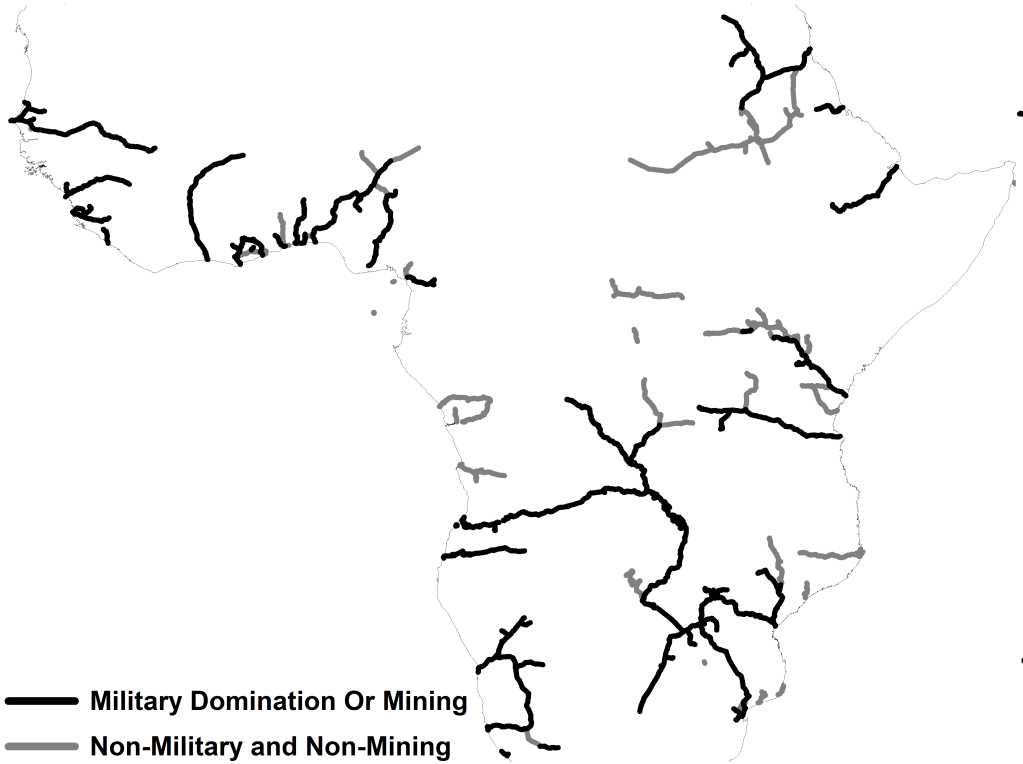
- Compare railroads built for **different reasons**

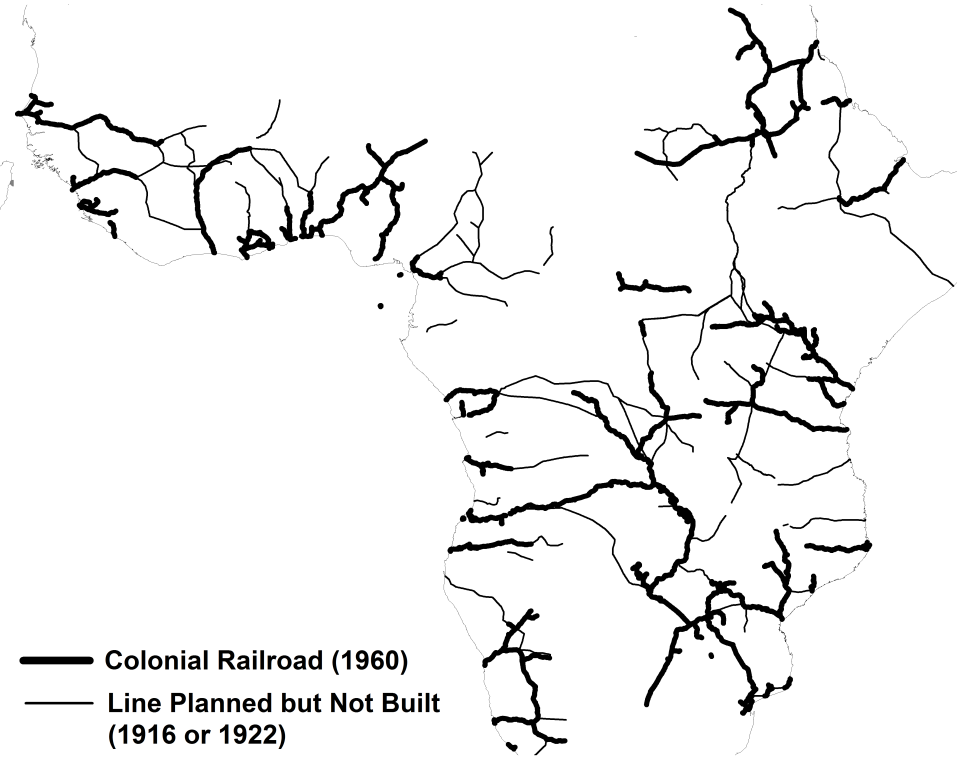
  Data on reason why built: military domination (MD) vs. mining (M) vs. cash crops. MD-M more exogenous "locally"

- Study **"placebo" railroads** that were proposed but never built

  Data on lines that were proposed in 1916 and 1922.

Military-Mining Lines and Placebo Lines





The placebo lines are railroad lines that were proposed (in 1916 or 1922) but never built. Sources: Metcalfe (1916), *Map of Africa* in National Geographic Magazine (1922)

Strategies to Estimate Causal Effects

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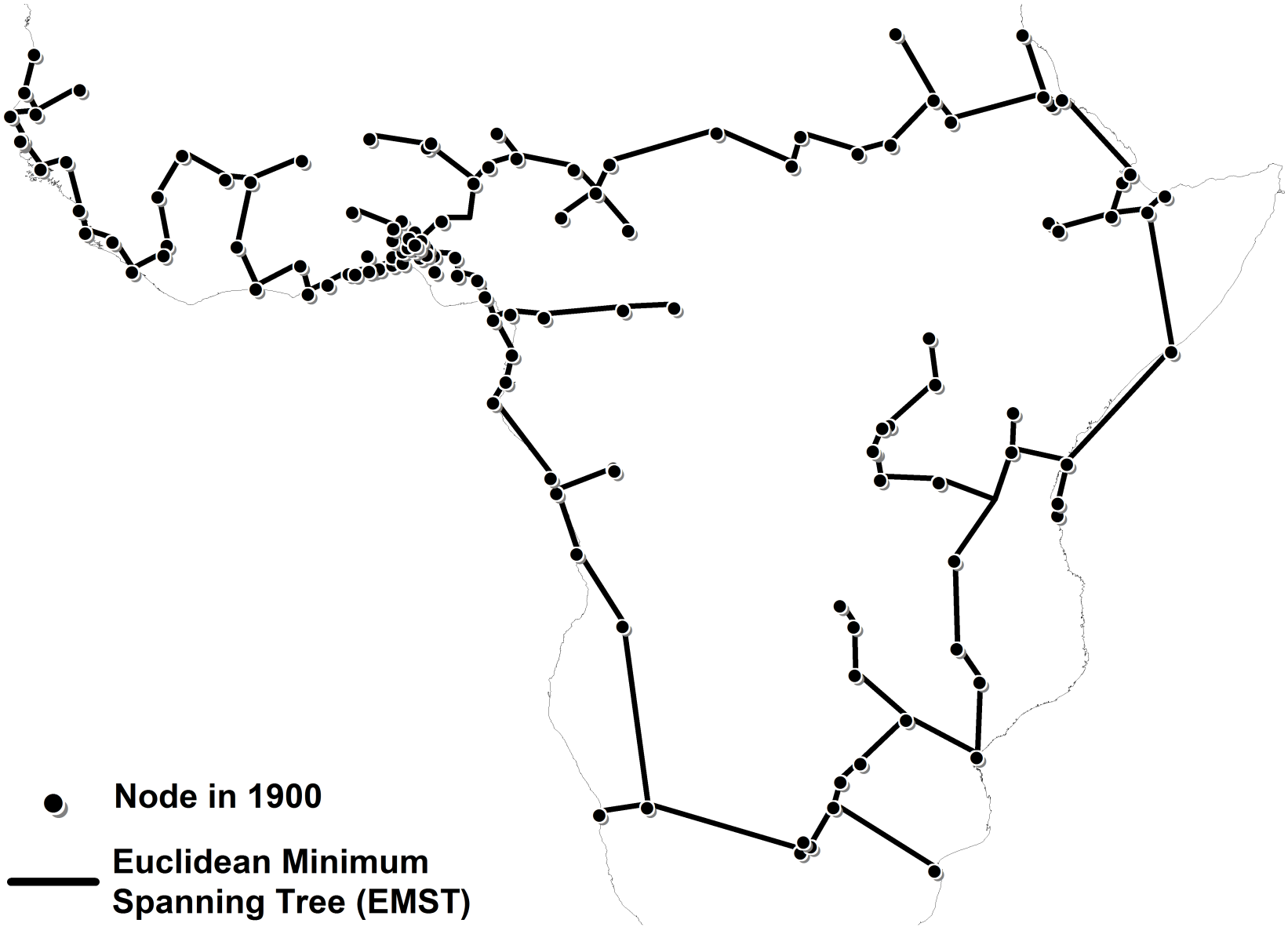
  Data on lines that were proposed in 1916 and 1922.
- Euclidean minimum spanning tree (EMST) for cities in 1900. **Instrumental variable:** Straight lines across nodes (dropping the nodes).

Use Euclidean spanning tree network (EMST) as an IV



Optimally link cities in 1900 ($\geq$ 10,000 inh., largest, 2nd largest and capital)

TABLE : COLONIAL RAILROADS AND URBAN GROWTH, AFRICA 1900-1960

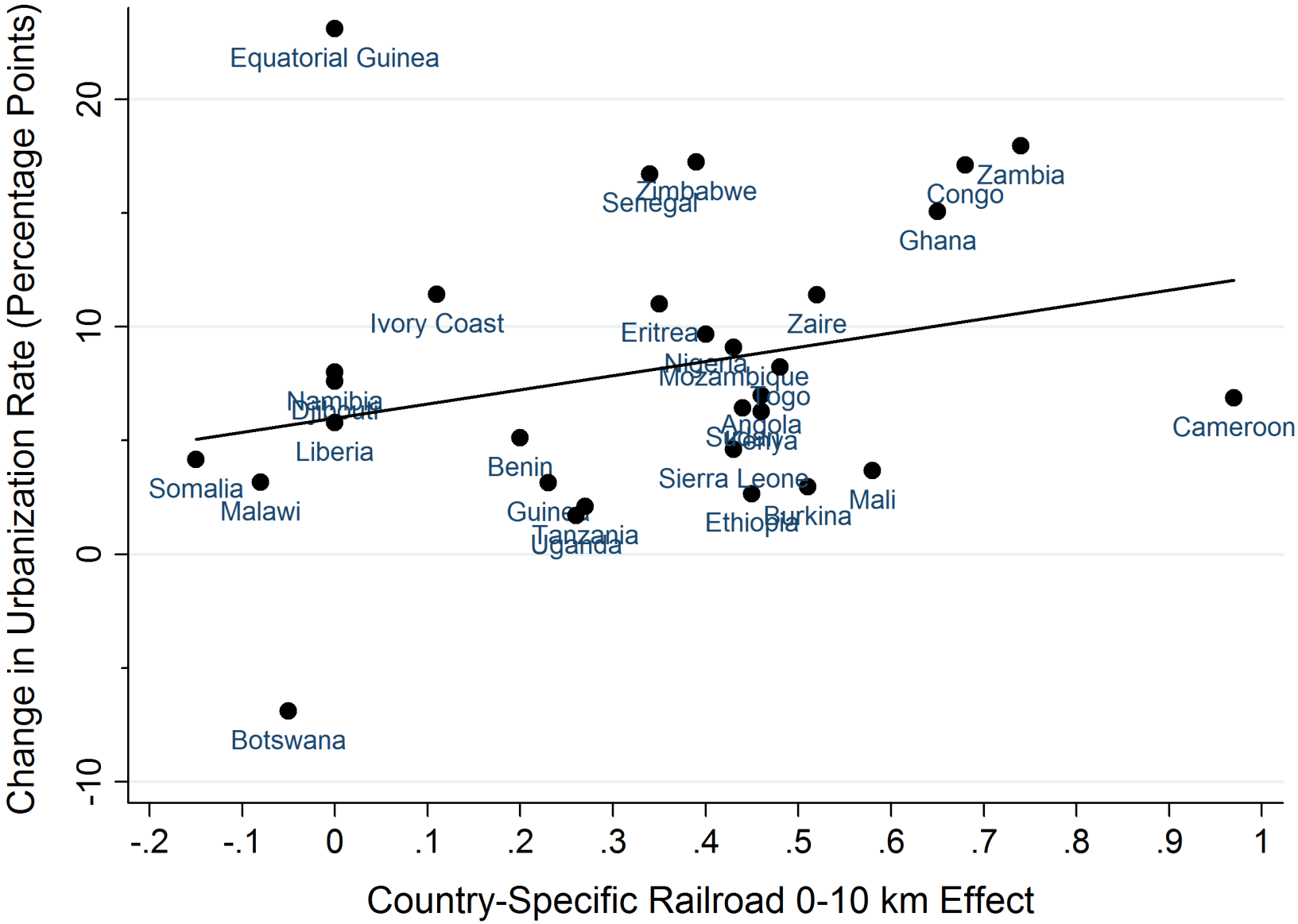
Dependent Variable:	Columns (1)-(8): Urban Population (Z) in 1960								City 1/0 (Z) 1960
Strategy:	*OLS*	*Ethnic*	*District*	*Long-Lat*	*Mil-Min*	*Placebo*	*C:Placebo*	*IV*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rail 1960, 0-10 km	0.37***	0.37***	0.28***	0.37***	0.34***	0.04	0.30***	0.39***	0.46***
(Col.(7): Placebo 0-10km)	(0.05)	(0.05)	(0.04)	(0.05)	(0.07)	(0.02)	(0.05)	(0.16)	(0.04)
Urban Pop. (Z) 1900	0.46***	0.46***	0.39***	0.46***	0.46***	0.46***	0.67***	_	0.30***
	(0.10)	(0.10)	(0.06)	(0.10)	(0.10)	(0.10)	(0.24)	_	(0.03)
Country FE, Cell Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-Squared	0.22	0.23	0.52	0.22	0.23	0.22	0.24	0.11	0.11

Notes: OLS regressions using data on 193,923 cells for 39 Sub-Saharan African countries for the years 1900 and 1960. Robust standard errors clustered at the district level (N = 2,304) in parentheses; * p<0.10, ** p<0.05, *** p<0.01. We drop the largest city, the second largest city and the capital city of each country at independence. In columns (2) and (3), we include 755 ethnic group fixed effects and

General Equilibrium Effects

- **Structural change** or **urban reorganization**?
- Qualitative evidence (historians): migration from rural areas, because of new opportunities in the new cities.
- Test if negative effects for the cells more susceptible to have lost urban residents because of the railroad
  - 10-100 km from the railroad vs. rest of the country
  - Traditional/pre-colonial cities: e.g., $>$ 10,000 inh. in 1900

General Equilibrium Effects: Aggregate Urban Patterns



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Persistence of an Urban Equilibrium

Persistence of the equilibrium?

1. **Railroads** fell largely out of use in the 1970s, due to lack of maintenance, mismanagement. Evidence for selected countries.
2. Massive **road investments**. Most hinterland locations are now connected to the coast. Evidence for selected countries.

   The railroad locations have lost their initial *relative* advantage in terms of transportation infrastructure.

Persistence of an Urban Equilibrium

- Locations along the railroad lines are more urban and developed today (2010)
- Railroad effect in 2010 is the same as in 1960

- **Dynamics in 1890-2010**: repeated regressions of urban pop. t on rail dummies, with control for urban pop. t-1:

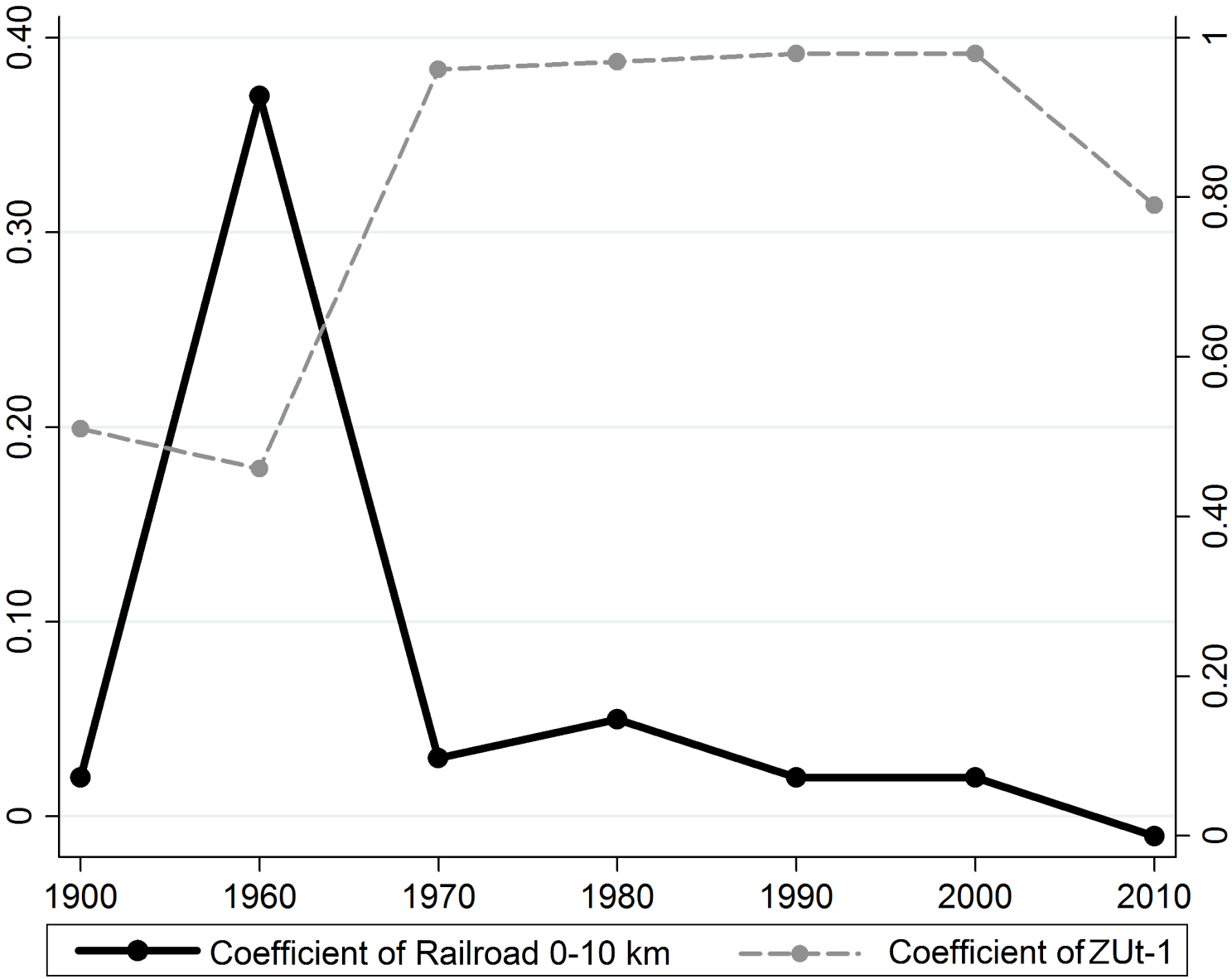
$$ZUpop_{c,t} = \alpha_t + \delta_t ZUpop_{c,t-1} + Rail_{c,1960}\,\kappa_t + X_c \pi_t + w_{c,t}$$

t = [1890, 1900, 1960, 1970, 1980, 1990, 2000, 2010]

$\kappa_t < 0$: convergence. > 0: divergence. $= 0$: stability.

$\delta_t = 1$: stability of the whole urban network.

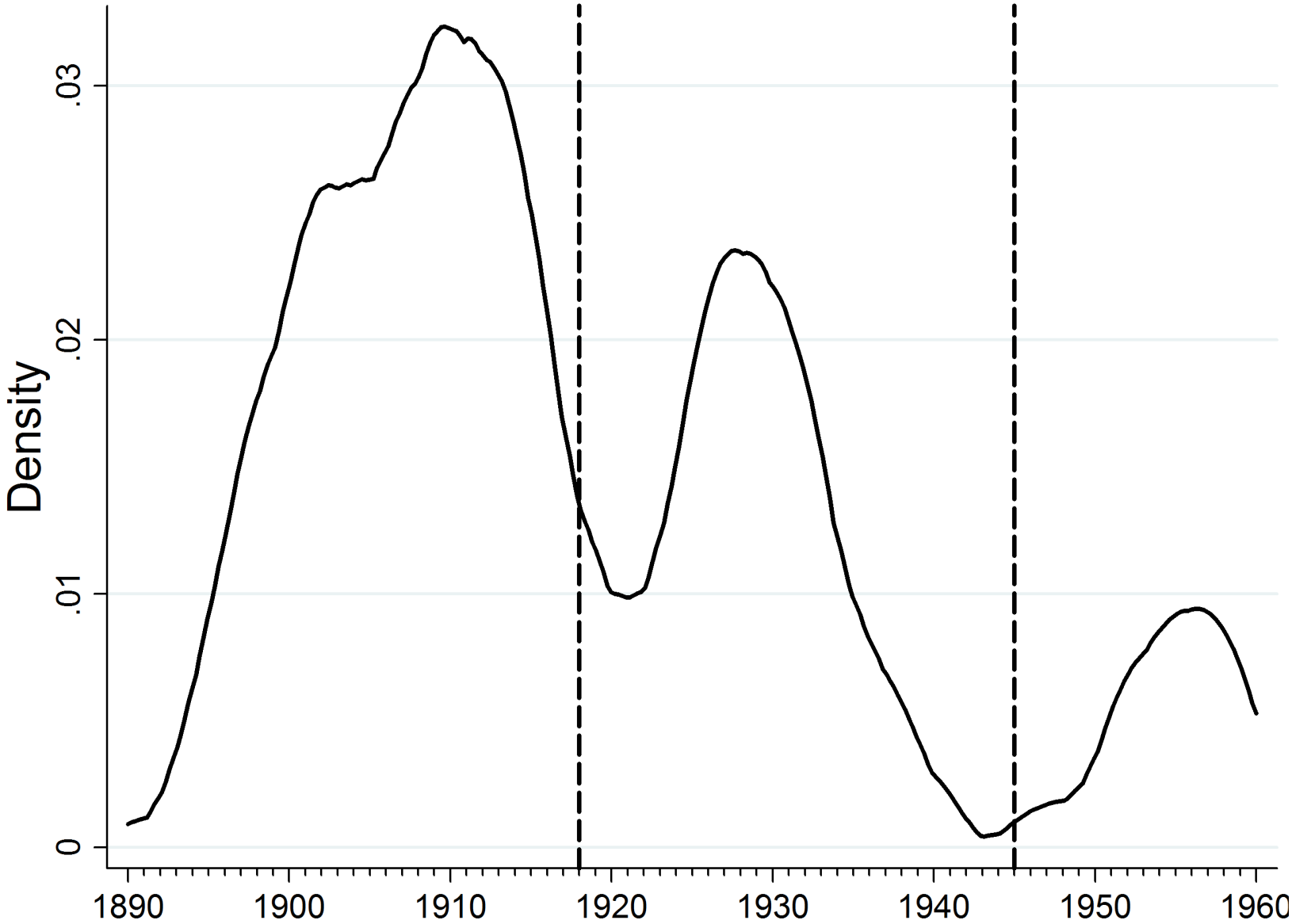
Effects of Railroads on Urban Population for Each Period, Controlling for Urban Population in the Previous Period



The Channels of Path Dependence

- Path dependence must be due to increasing returns.
- Krugman 1991: "history" vs. "expectations". Bleakley & Lin 2012: sunk investments vs. coordination problem.
- **Sunk investments**: fixed costs of building cities
- **Coordination problem:** if increasing returns, factor accumulation (people, capital) in one location, but where?
- Quantitative evidence from Ghana and Kenya (Jedwab& Moradi 2015; Jedwab, Kerby & Moradi 2015):
  - Colonial sunk investments: railroad cells better endowed in colonial schools, missions, hospitals, roads at independence. Only partly contributed to path dependence ($\approx 25\%$).
  - Railroad cities persisted because early emergence solved the coordination failure (market failiure) for colonial and subsequent period ($\approx 75\%$).

Year of Connection for the 0-10 km Railroad Cells



Three episodes of rail building: 1890-1918, 1919-1945 and 1946-1960

General Discussion

Impact of transportation infrastructure on economic change in poor countries, and in Africa in particular?

- Strong effects for first transport revolution (railroads)
- Limited urban/economic decentralization for second transport revolution (roads), since stable urban distribution?

- This could suggest that:

  Multiple spatial equilibria, mostly due to coordination problem

  Decreasing marginal returns to such investments

  If expectations more difficult to adjust than factors, no role for regional public policy?