Using Quantitative Spatial Models for Policy

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Presentation at 8th World Bank / GWU (ESIA-IIEP) / IGC / MCC Urbanization & Poverty Reduction Research Conference 2024

Motivation

- Recent theoretical and empirical advances have enhanced our understanding of the impact of transportation infrastructure and other public policy interventions

- Theoretical advances
  - New quantitative spatial models are rich enough to connect to features of the data (e.g. gravity)
  - Tractable and amenable to a theoretical analysis of the properties of equilibrium and comparative statics
  - Parsimonious with small number of structural parameters to estimate
  - Undertake counterfactuals for realistic public policy interventions (e.g. new subway line between two real-world locations)

- Recent empirical advances
  - Geographical Information Systems (GIS) revolution has provided more data at smaller spatial scales than hitherto possible

Outline

1. The Making of the Modern Metropolis: Evidence from London (joint with Stephan Heblich and Daniel Sturm)
   - *Quarterly Journal of Economics*, 135(4), 2059-2133, 2020.

2. Trade, Structural Transformation and Development: Evidence from Argentina (joint with Pablo Fajgelbaum)
   - *Journal of Political Economy*, 130(5), 1249-1318, 2022.

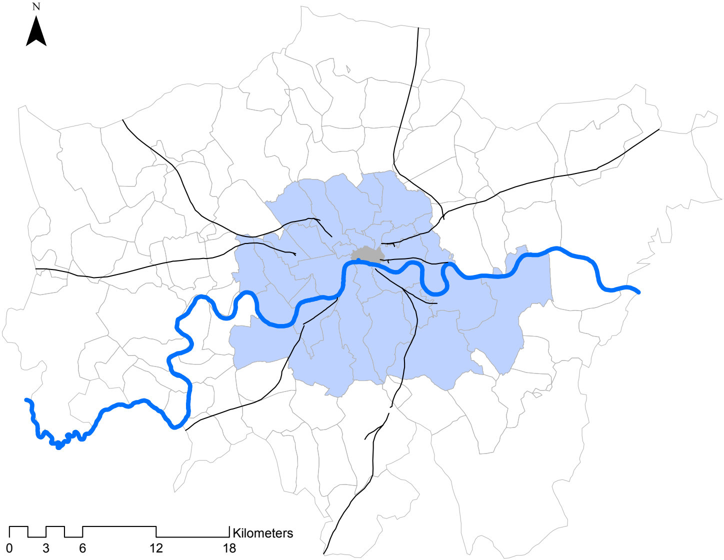
3. Code and data available from
   - https://www.princeton.edu/ reddings/
   - https://www.quantitativeurbanmodels.com/home

The Making of the Modern Metropolis: Evidence from London

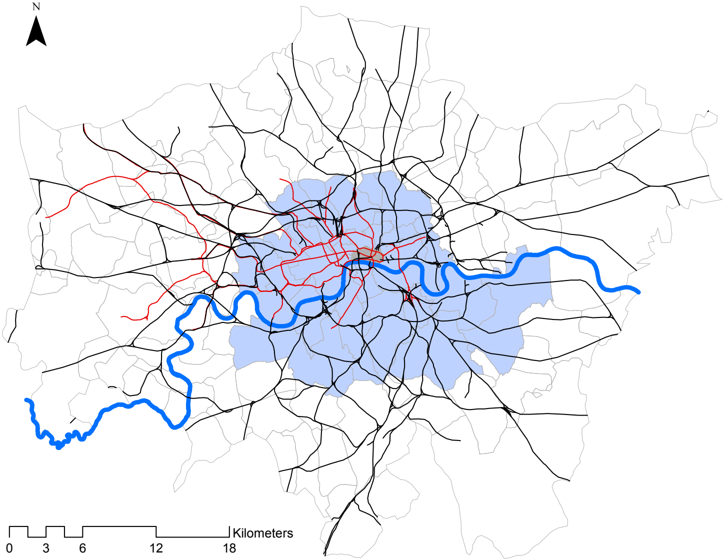
Model Outline

- Consider a city that consists of a set of discrete blocks indexed by i, with supply of floor space depending on the density of development
- There is a single final good which is costlessly traded and is chosen as the numeraire
- Markets are perfectly competitive
- Workers choose a block of residence, a block of employment, and consumption of the final good and floor space to max utility
- Firms choose a block of production and inputs of labor and floor space to max profits
- Floor space within each block optimally allocated between residential and commercial use
- Productivity depends on fundamentals & spillovers
- Amenities depend on fundamentals & spillovers
- Workers face commuting costs that depend on travel time using the transport network (rail, bus, etc.)

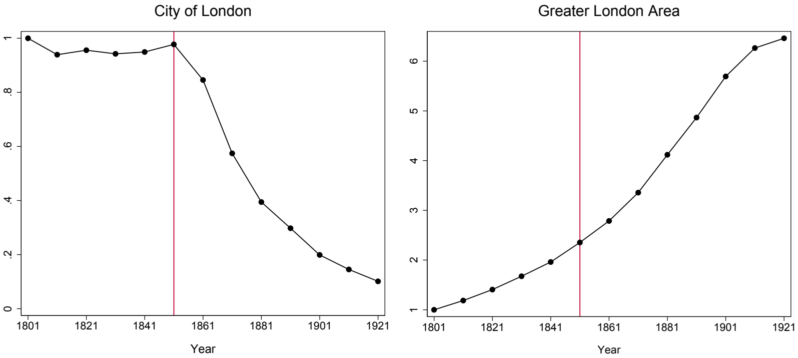
Rail Network 1841



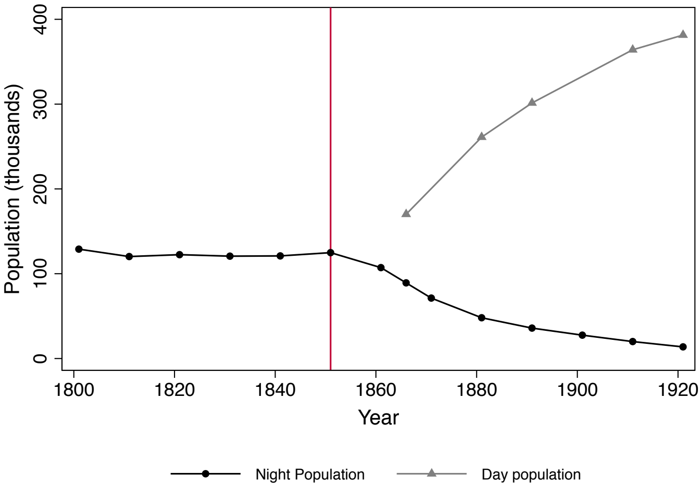
Rail Network 1921



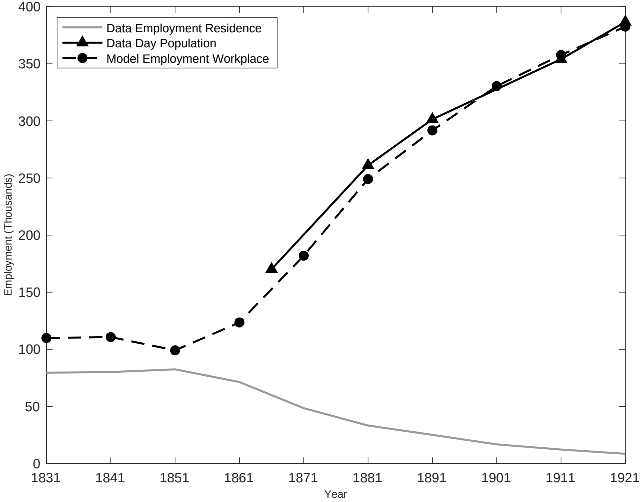
Residential (Night) Population



Day and Night Population



Model and Data



Counterfactuals

- Undertake counterfactuals
  - Removal of entire railway network
  - Removal of underground railway network
  - Removal railway lines constructed from 1911-1921

- We undertake these counterfactuals under a range of assumptions about the floor space supply elasticity and agglomeration forces

- Assume population mobility with the rest of the economy with an estimated elasticity of labor supply

- We compare the change in the net present value of land and buildings to historical estimates of construction costs
  - Overground railways: £60,000 per mile
  - Cut-and-cover underground railways: £355,000 per mile
  - Bored-tube underground railways: £555,000 per mile

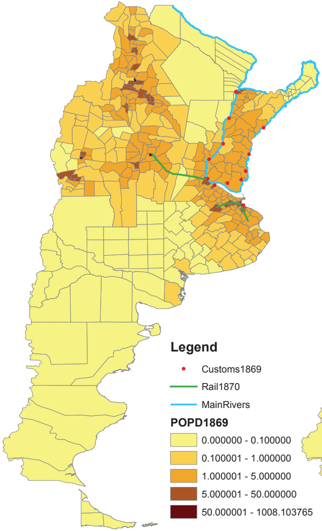
- Ratio of NPV land prices to construction costs greater than one
  - Agglomeration forces and endogenous supply of floor space increase this ratio further above one

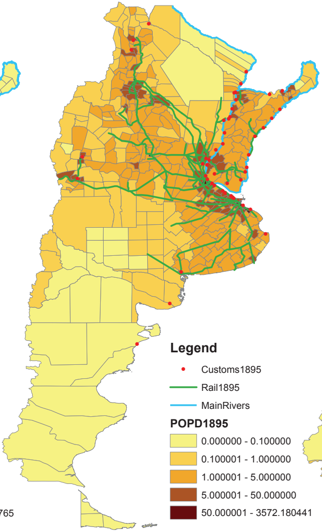
All Rail Counterfactual

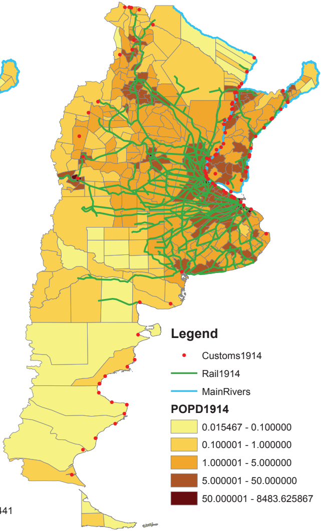
	(1)	(2)	(3)	(4)
Floor Space Supply Elasticity	$\mu = 0$	$\mu = 1.83$	$\mu = 1.83$	$\mu = 1.83$
Production Agglomeration Force	$\eta^L = 0$	$\eta^L = 0$	$\eta^L = 0.086$	$\eta^L = 0.086$
Residential Agglomeration Force	$\eta^R = 0$	$\eta^R = 0$	$\eta^R = 0$	$\eta^R = 0.172$
Removing the Entire Overground and Underground Railway Network				
Economic Impact				
Rateable Value	$-£8.24$m	$-£15.55$m	$-£20.78$m	$-£35.07$m
NPV Rateable Value (3 percent)	$-£274.55$m	$-£518.26$m	$-£692.76$m	$-£1,169.05$m
NPV Rateable Value (5 percent)	$-£164.73$m	$-£310.96$m	$-£415.66$m	$-£701.43$m
Construction Costs				
Cut-and-Cover Underground	$-£9.96$m			
Bored-tube Underground	$-£22.90$m			
Overground Railway	$-£33.19$m			
Total All Railways	$-£66.05$m			
Ratio Economic Impact / Construction Cost				
$\frac{\text{NPV Rateable Value (3 percent)}}{\text{Construction Cost}}$	4.16	7.85	10.49	17.70
$\frac{\text{NPV Rateable Value (5 percent)}}{\text{Construction Cost}}$	2.49	4.71	6.29	10.62

Trade, Structural Transformation and Development: Evidence from Argentina

Population Density







Rail Evaluation

	(1)	(2)
	Starting from 1914 External Integration	Starting from 1869 External Integration
Economic Impact		
(1) GDP	248.79	199.66
(2) Land Income	126.85	101.95
(3) NPV GDP (3%)	8292.93	6655.43
(4) NPV GDP (5%)	4975.76	3993.26
(5) NPV Land Income (3%)	4228.39	3398.22
(6) NPV Land Income (5%)	2537.04	2038.93
Construction Costs		
(7) Total Construction Costs	1308.00	1308.00
Ratio Economic Impact to Construction Costs		
(8) NPV GDP (3%) / Construction Cost	6.34	5.09
(9) NPV GDP (5%) / Construction Cost	3.80	3.05
(10) NPV Land Income (3%) / Construction Cost	3.23	2.60
(11) NPV Land Income (5%) / Construction Cost	1.94	1.56

Conclusions

- Recent development of quantitative spatial models
  - Sufficiently rich to rationalize key features of the data (e.g. gravity)
  - Sufficiently tractable to be amenable to analytical analysis and policy-relevant counterfactuals
  - Spatial organization of economic activity within cities
  - Spatial distribution of economic activity across cities

- Provide a key benchmark for policy evaluation
  - General equilibrium effects (e.g. choice of workplace and residence)
  - Agglomeration forces in production and residence
  - Complementary changes in land use and zoning policy

- Exciting opportunities to combine these quantitative spatial models with new sources of big data
  - Ride-hailing data (e.g. Uber and Lyft)
  - Smartphone data with Global Positioning System (GPS) information
  - Firm-to-firm data from sales (VAT) tax records
  - Credit card data with consumer and firm location
  - Public transportation commuting data
  - Satellite imaging data

Thank You

References

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