Old But Gold: Historical Pathways and Path Dependence

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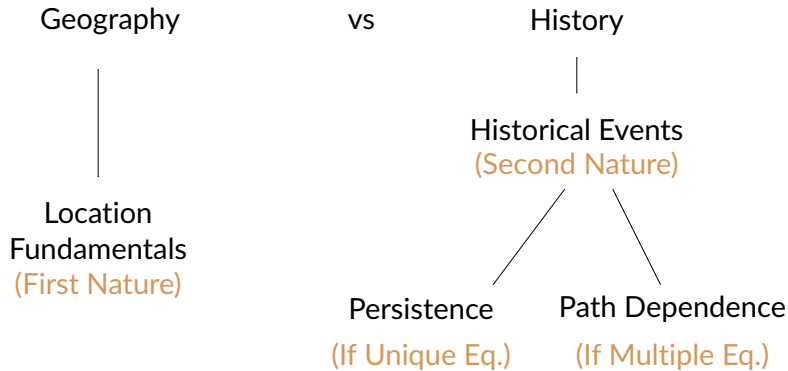
Introduction

Motivation

- What drives the spatial distribution of economic activity and population?



$\rightarrow$ Unique/Multiple Equilibria depend on magnitude of spillovers (Allen and Donaldson, 2022)

What we do?

1. Study the effects of historical pathways (Gold and Mule Roads) on the spatial distribution of population in Brazil
    - Findings: Positive effect
2. Characterize what type of historical shock this is
    - Findings: Path dependence

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1. Study the effects of historical pathways (Gold and Mule Roads) on the spatial distribution of population in Brazil
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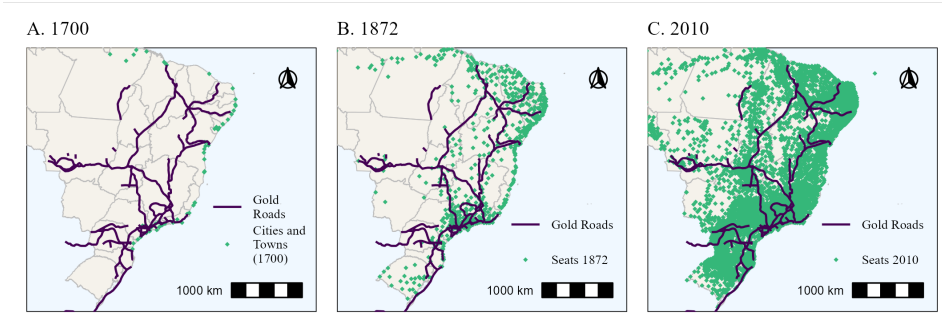
Empirical challenges:

1. Isolate first nature effects from second nature effects
2. Persistence and Path Dependence often lead to same long-run outcome:
    - 2.1 Need to observe dynamics; and
    - 2.2 Quantify the strength of spillovers

Empirical Strategy

Empirical Approach



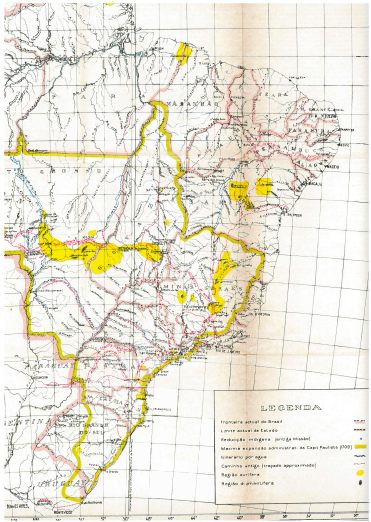
- The growth of Brazilian settlements in the hinterlands followed the Gold Roads

Empirical Approach

- Two complementary analyses:
  - Gold roads that interconnected the primary gold regions discovered since 1700
  - Mule roads that connected the various regions to the economic clusters following the Gold Rush
  - The historical pathways gave birth to the Road towns

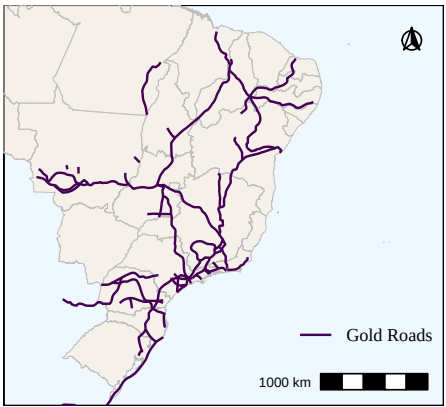
Data

- The information about the gold roads was georeferenced from Simonsen (1977) map
- We compute Gold Road Density as the area of a 5-km buffer around gold roads over municipality's area

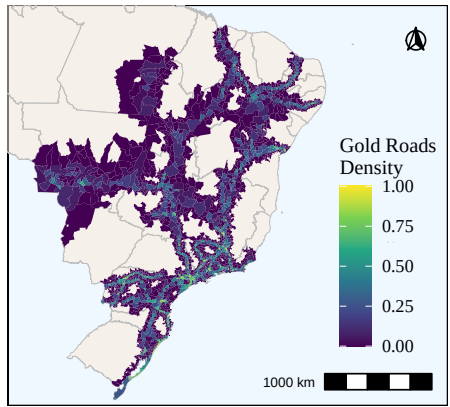


Data

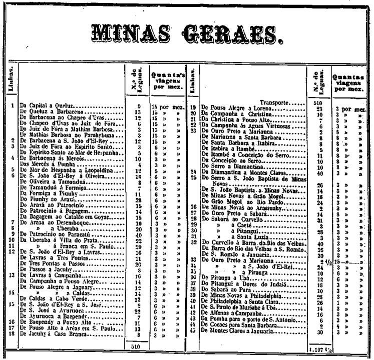
A. Gold Roads



B. Gold Roads Density



Data



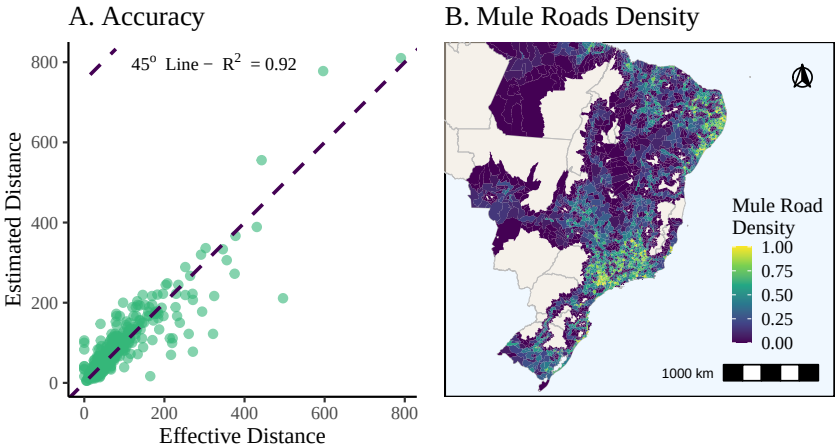
MINAS GERAES.

Linhas.		N.º de Leguas.	Quanta's viagens por mez.
1	Da Capital a Queluz	9	15 por mez.
	De Queluz a Barbacena	13	15 » »
	De Barbacena ao Chapeo d'Uvas	12	15 » »
	Do Chapeo d'Uvas ao Juiz de Fóra	6	15 » »
	Do Juiz de Fóra a Mathias Barbosa	3	15 » »
	De Mathias Barbosa ao Parahybuna	3	15 » »
2	De Barbacena a S. João d'El-Rey	12	15 » »
3	Do Juiz de Fóra ao Espirito Santo	3	6 » »
	Do Espirito Santo ao Mar de Hespanha	5	6 » »
4	De Barbacena ás Mercês	10	3 » »
	Das Mercês á Pomba	4	3 » »
5	Do Mar de Hespanha a Leopoldina	12	5 » »
6	De S. João d'El-Rey á Oliveira	15	6 » »
	De Oliveira a Tamanduá	8	6 » »
	De Tamanduá á Formiga	7	6 » »
	Da Formiga a Piunhy	11	6 » »
	Do Piunhy ao Araxá	28	6 » »
	Do Araxá ao Patrocinio	15	6 » »
	Do Patrocinio á Bagagem	14	6 » »
	Da Bagagem ao Catalão em Goyaz	15	6 » »
7	Do Araxa ao Desemboque	10	3 » »
8	» a Uberaba	20	3 » »
9	Do Patrocinio ao Paracatú	40	3 » »
10	Da Uberaba á Villa do Prata	22	3 » »
11	» á Franca em S. Paulo	20	3 » »
12	De S. João d'El-Rey a Lavras	16	3 » »
	De Lavras a Tres Pontas	11	3 » »
	De Tres Pontas a Passos	26	3 » »
	De Passos a Jacuhy	8	3 » »
13	De Lavras á Campanha	16	3 » »
	Da Campanha a Pouso Alegre	14	3 » »
	De Pouso Alegre a Jaguary	12	3 » »
14	» » a Caldas	14	3 » »
	De Caldas a Cabo Verde	12	3 » »
15	De S. João d'El-Rey a S. José	2	6 » »
	De S. José a Ayuruoca	22	6 » »
	De Ayuruoca a Baependy	7	6 » »
16	De Baependy a Pouso Alto	11	6 » »
17	De Pouso Alto a Arêas em S. Paulo	13	6 » »
18	De Jacuhy á Casa Branca	8	3 » »
		510	

Linhas.		N.º de Leguas.	Quantas viagens por mez.
	Transporte	510	
19	De Pouso Alegre a Lorena	23	3 por mez.
20	Da Companha a Christina	10	3 » »
21	Da Christina a Pouso Alto	7	3 » »
22	Da Campanha ás Aguas Virtuosas	6	3 » »
23	Do Ouro Preto a Marianna	2	8 » »
	De Marianna a Santa Barbara	8	8 » »
	De Santa Barbara a Itabira	8	8 » »
	De Itabira a Itambé	5	8 » »
	De Itambé a Conceição do Serro	11	8 » »
	Da Conceição ao Serro	10	8 » »
	Do Serro a Diamantina	10	8 » »
24	Da Diamantina a Montes Claros	40	3 » »
25	Do Serro a S. João Baptista de Minas Novas	26	3 » »
	De S. João Baptista a Minas Novas	14	3 » »
	De Minas Novas a Grão Mogol	18	3 » »
	Do Grão Mogol ao Rio Pardo	24	3 » »
26	De Minas Novas ao Arassuahy	2	3 » »
27	Do Ouro Preto a Sabará	14	8 » »
28	Do Sabará ao Curvello	31	3 » »
29	» a Caeté	3	3 » »
30	» a Pitangui	28	3 » »
31	» a Santa Luzia	3	3 » »
32	Do Curvello á Barra do Rio das Velhas	40	3 » »
	Da Barra do Rio das Velhas a S. Romão	26	3 » »
	De S. Romão a Januaria	30	3 » »
33	Do Ouro Preto a Marianna	2 1/2	15 » »
34	» » a S. João d'El-Rei	24	3 » »
35	» » a Piranga	10	6 » »
36	De Piranga a Ubá	12	6 » »
37	Do Pitangui a Dores do Indaiá	18	3 » »
38	Do Sabará ao Pará	10	3 » »
39	De Minas Novas a Philadelphia	28	3 » »
40	De Philadelphia a Santa Clara	26	1 » »
41	De S. Paulo de Muriahe á Ubá	14	3 » »
42	De Alfenas a Campanha	16	3 » »
43	Da Pomba para o porto de S. Antonio	6	3 » »
44	De Cocaes para Santa Barbara	2	4 » »
45	De Montes Claros a Januaria	30	3 » »
		1.107 1/2	

- In the case of Mules Roads, we transcribe data from historical documents issued by the Brazilian imperial government in 1863 and 1873.
  - Effective distances between municipality seats traveled primarily by ground transportation
- We only have information about the connections, not the pathways.
- We compute least-cost paths to compute Mule Road Densities

Data


A. Accuracy
45° Line − R² = 0.92
Estimated Distance
Effective Distance
0
200
400
600
800
B. Mule Roads Density
Mule Road Density
1.00
0.75
0.50
0.25
0.00
1000 km

Data

- The sample consists of municipalities crossed by a historical road and their contiguous neighbors
- We exclude from the sample:
  - Municipalities created before 1700
  - Nodes (”Inconsequential Units Approach,” Redding and Turner, 2015)

Regression Equation

- We estimate the following regression equation

$$y_i = \alpha_s + \beta \text{Road Density}_i + \mathbf{X}_i'\gamma + \varepsilon_i$$

- y_i denotes a measure of economic concentration (population density, nightlight incidence, or urban population density)

- Road Density$_i$ captures the influence of historical road density

- $\mathbf{X}_i$ contains additional geographical covariates (temperature, elevation, precipitation, TRI, area, and second-order polynomial of latitude and longitude)

Threats to Causal Interpretation of β

1. Pathways are built along previously developed areas:
   - Inconsequential Units Approach + Use least-cost paths as instrumental variable (or directly as in the case of Mule roads)
2. Least-cost paths capture advantageous geography:
   - Geography controls + Placebo test
3. Pathways are optimal routes between previously developed areas:
   - Random location of gold deposits + Placebo test
4. Central regions are more likely to receive treatment (pathways) and to develop:
   - Random location of gold deposits + Re-centering (Borusyak and Hull, 2023)

Historical Pathways and Current Population Density

Pathways of the colony: Gold Roads

Table 1: Gold roads and current population density

	(1)	(2)	(3)	(4)
Panel A - Dep. Var.: Population Density:				
Gold Road Density	5.27***	3.62***	1.97***	2.01***
	(0.954)	(0.747)	(0.602)	(0.632)
Observations	2,092	2,092	2,092	2,092
Cluster Groups	260	260	260	260
Panel B - Dep. Var.: Nightlights:				
Gold Road Density	4.32***	2.65***	1.45***	1.40***
	(0.519)	(0.392)	(0.386)	(0.412)
Observations	2,092	2,092	2,092	2,092
Cluster Groups	260	260	260	260
Panel C - Dep. Var.: Urban Population Density				
Gold Road Density	6.03***	4.12***	2.34***	2.34***
	(1.04)	(0.805)	(0.665)	(0.699)
Observations	2,091	2,091	2,091	2,091
Cluster Groups	260	260	260	260
Kleibergen-Paap F:	83.159	87.724	82.966	82.869
Fixed-Effects:		State	State	State
Geography Controls			✓	✓
Lati-Longi Polynomial:				✓

- Positive association between access to gold roads and population density, nightlights, and urban population density
- **Robustness** - the results remain unchanged when:
  - Include all municipalities
  - Exclude municipalities located within 100 km from the coast
  - Spatially robust standard errors

Pathways of the empire: Mule Roads

Table 3: Mule roads and population density

	(1)	(2)	(3)	(4)
Panel A - Dep. Var.: Population Density:				
Mule Road Density	1.91***	1.28***	0.453***	0.425***
	(0.221)	(0.118)	(0.083)	(0.082)
Observations	3,347	3,347	3,347	3,347
Cluster Groups	367	367	367	367
Panel B - Dep. Var.: Nightlights:				
Mule Road Density	1.64***	1.18***	0.533***	0.468***
	(0.138)	(0.109)	(0.083)	(0.084)
Observations	3,347	3,347	3,347	3,347
Cluster Groups	367	367	367	367
Panel C - Dep. Var.: Urban Population Density				
Mule Road Density	2.22***	1.51***	0.597***	0.549***
	(0.226)	(0.134)	(0.099)	(0.099)
Observations	3,346	3,346	3,346	3,346
Cluster Groups	367	367	367	367
Fixed-Effects:		State	State	State
Geography Controls			✓	✓
Lati-Longi Polynomial:				✓

- This association is not restricted to gold roads
- Results are similar when we use the ground transportation network in 1870s that grew out of the gold roads

Placebo

Table 4: Placebo roads and population density

	(1)	(2)	(3)	(4)
Panel A - Dep. Var.: Population Density:				
Placebo Density	1.36***	0.655***	0.169*	0.125
	(0.293)	(0.144)	(0.102)	(0.094)
Observations	3,240	3,240	3,240	3,240
Cluster Groups	347	347	347	347
Panel B - Dep. Var.: Nightlights:				
Placebo Density	1.64***	0.438***	0.121	0.014
	(0.089)	(0.116)	(0.094)	(0.086)
Observations	3,240	3,240	3,240	3,240
Cluster Groups	347	347	347	347
Panel C - Dep. Var.: Urban Population Density				
Placebo Density	2.30***	0.758***	0.232**	0.173
	(0.170)	(0.151)	(0.116)	(0.109)
Observations	3,239	3,239	3,239	3,239
Cluster Groups	347	347	347	347
Fixed-Effects:		State	State	State
Geography Controls			✓	✓
Lati-Longi Polynomial:				✓

- Moreover, the effects are driven by the existence of routes rather than representing optimal paths between previously developed locations

Findings

- History matters: The evidence suggests that the historical event of gold and mule roads influence the distribution of population in 2010

Why?

- These pathways became obsolete a long time ago: they are unlikely to bring any advantage today

- Persistence: did pathways lead to a larger factor densities that take long to fade out?

- Path Dependence: did pathways lead to strong agglomeration effects?

The Role of Factor Densities

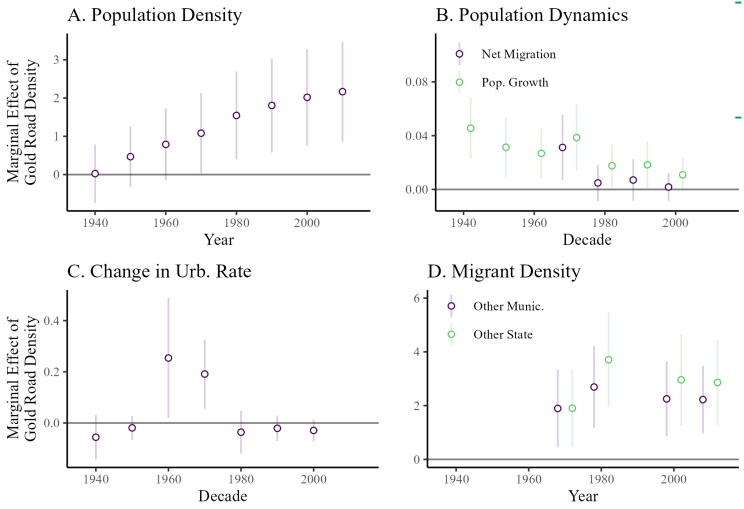
Short-run historical factor densities

Table 6: Gold roads and factor densities in 1920

	Baseline	Popul.	Stations	Railroad	Literate	Teachers	Agric	Manuf.	Services	Transp.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A - Dependent Variable: Factor Densities / Kleibergen-Paap F: 40.1										
Gold Road Density		-0.217	1.38	0.972	0.119	0.788	-0.671	0.594	0.546	0.430
		(0.450)	(2.13)	(1.86)	(0.459)	(0.660)	(0.466)	(0.660)	(0.537)	(0.857)
Panel B - Dependent Variable: log(Population Density)										
Gold Road Density	2.17***	2.34***	2.03***	2.07***	2.08***	1.80***	2.62***	1.91***	1.84***	2.04***
	(0.795)	(0.643)	(0.747)	(0.759)	(0.633)	(0.664)	(0.673)	(0.672)	(0.644)	(0.725)
Factor Density		0.7698***	0.101***	0.103***	0.725***	0.474***	0.679***	0.438***	0.607***	0.302***
		(0.0715)	(0.017)	(0.017)	(0.063)	(0.056)	(0.077)	(0.044)	(0.049)	(0.034)
Kleibergen-Paap F:	40.984	41.110	39.999	40.440	41.027	40.879	40.661	40.922	40.723	41.257
Observations	620	620	620	620	620	620	620	620	620	620

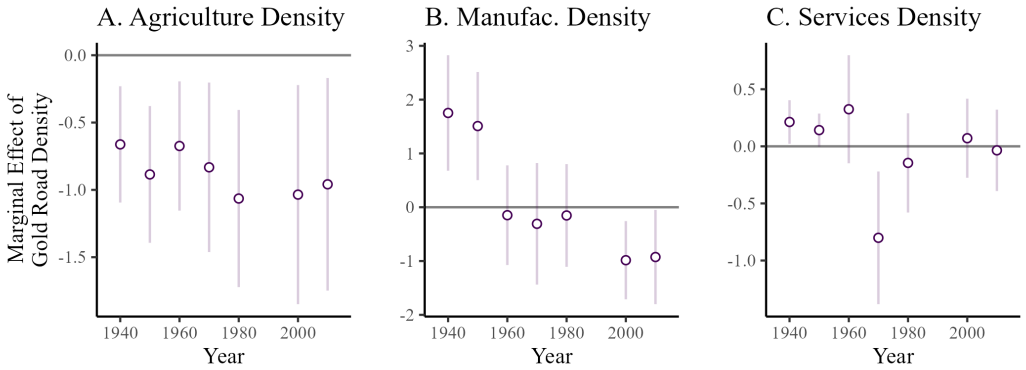
- There is no relationship between the gold roads and population density in the initial years
- There is no support for the sunk investments hypothesis

Long-run: population dynamics



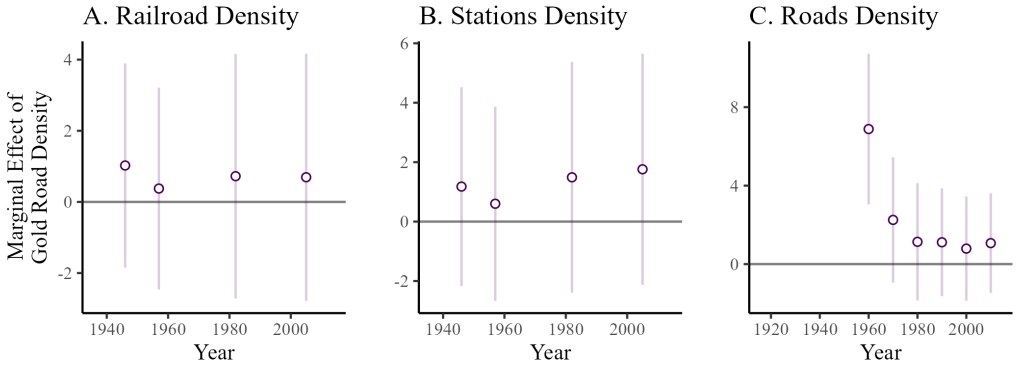
- The influence gradually intensifies from 1950 onwards (Panel A)
- A higher density of Gold roads is associated with accelerated population growth, between 1940 and 1970 (Panel B)

Long-run: sector densities



- Different sectoral compositions of the economies influenced by the historical pathways, likely induced by the characteristics of the road towns

Long-run: Modern transportation densities



- The effect on railroad and station density is approximately zero in all years
- There is an effect on paved roads in 1960.
  - This decade marks the beginning of the expansion of paved road infrastructure in Brazil, which was initially heavily concentrated in the state of São Paulo.

A model of economic geography with history dynamics

Estimating Productivity Spillovers

- Allen and Donaldson (2022):

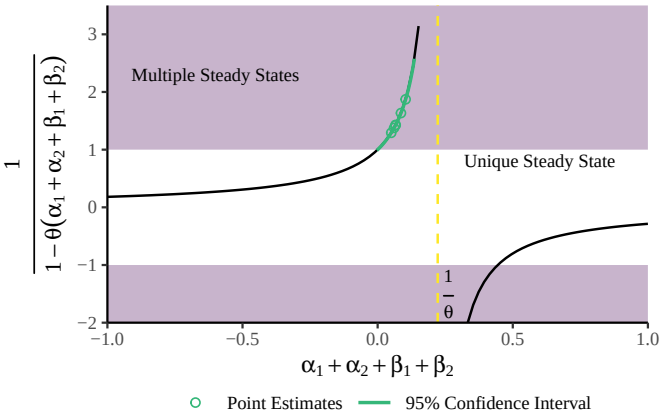
$$\text{(Labor Demand)} \quad \ln w_{it} = \alpha_1 \ln L_{i,t} + \alpha_2 \ln L_{i,t-1} + \ln \bar{A}_{it}$$

$$\text{(Labor Supply)} \quad \ln w_{it} = \left(\frac{1}{\theta} - \beta_1\right) \ln L_{it} + (-\beta_2) \ln L_{i,t-1} + \frac{1}{\theta} \ln IMMA_{it} - \ln \bar{u}_{it}$$

  - α_1 and α_2 denote the strength of contemporaneous and historical productivity spillovers; β_1 and β_2 denote the strength of contemporaneous and historical amenity spillovers; θ represents the dispersion effect

- We use individual-level data to regress population density on hourly wages to measure agglomeration spillovers using historical pathways as an instrument.
  - Since we only use one instrument at a time, we are estimating α_1 and α_2 together

Agglomeration Spillovers



- We find productivity spillovers $\in [0.05, 0.10]$
- From the literature: Amenities spillovers (-0.15 and 0.15); Dispersion effect $\theta = 4$
- Combining the parameters, $[1-\theta(\alpha_1+\beta_1+\alpha_2+\beta_2)]^{-1}$ fall within the region characterized by possible multiple steady states.

Conclusions

- Historical pathways have a positive impact on the current distribution of population
- This effect is not driven by geography factor
- We show that they had no effects on population and factor densities in 1920, ruling out sunken investment and migration restriction forces
- Agglomeration forces featuring multiple equilibria seem to be the main reason why historical pathways are still important nowadays