The Economics of Speed: the Electrification of the Streetcar System and the Decline of Mom-and-Pop Stores in Boston, 1885-1905

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Motivation

- The prevalence of small firms in
  - The history of the American economy ▷
  - Developing countries today ▷
- Small firms are unproductive and stagnant
  (La Porta and Shleifer, 2008, 2014; Hsieh and Klenow, 2014)
- Growth in overall productivity involves small firms $\rightarrow$ big firms
  (Foster, Haltiwanger, and Krizan, 2006)
- Policy relevance: how to shift the firm size distribution to the right?

Existing Explanations

- Regulatory and institutional barriers (Lewis, 1954; Harris and Todaro, 1970; Rauch, 1991; De Soto, 1989; Levy, 2008);

  Capital-constrained entrepreneurs (McKenzie, 2017);

  Delegation costs of outside managers (Akcigit, Alp, and Peters, 2016)

- Market segmentation hypothesis (Chandler, 1977; Lagakos, 2016)

Difficulty in Testing the Market Segmentation Hypothesis

- Ideally, an exogenous and large shock to transport costs, e.g. construction of large-scale transport infrastructure
- However, the placement of new routes is typically nonrandom

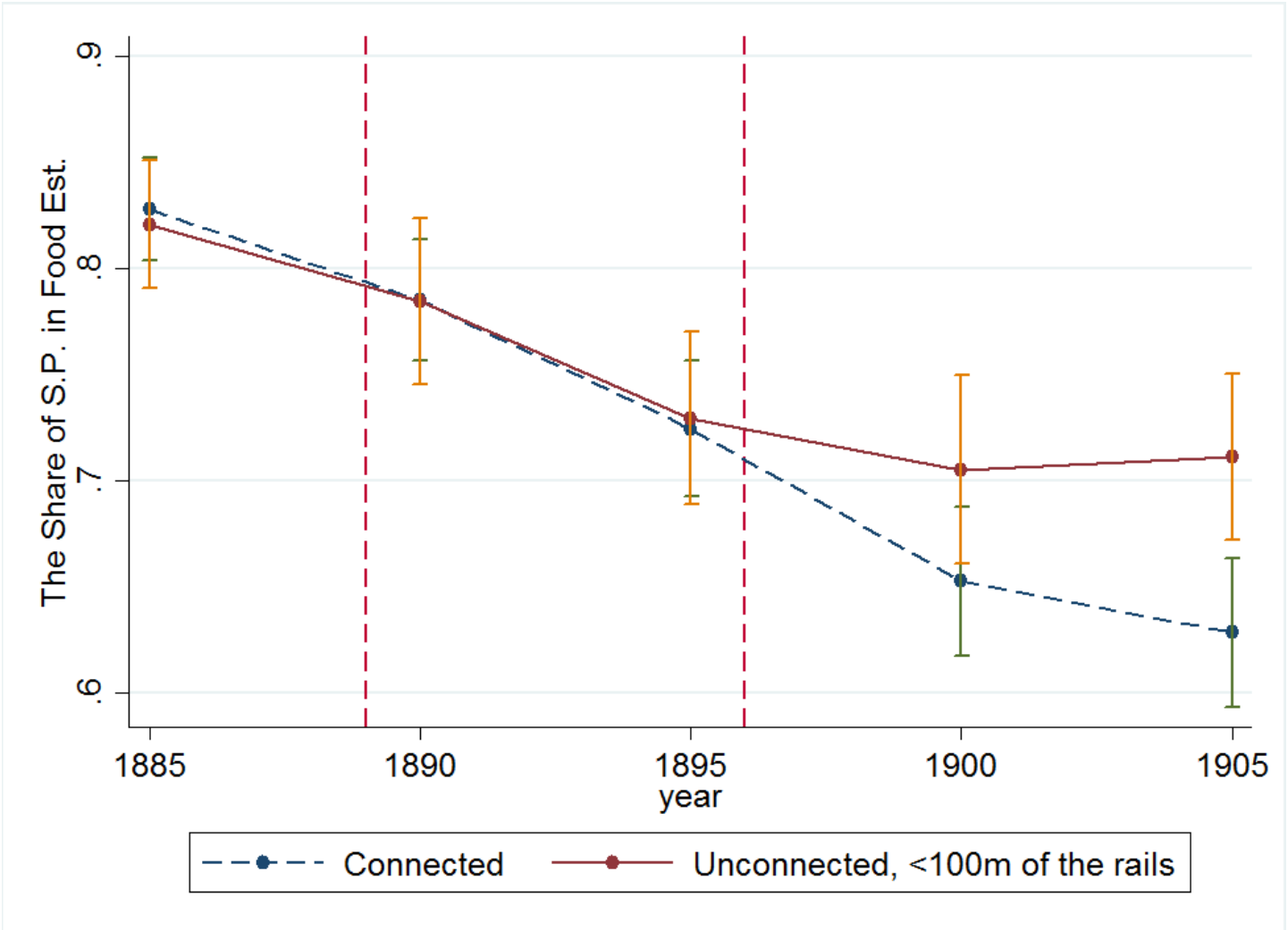
Contribution of this Paper

- First well-identified evidence on the market segmentation hypothesis
  Context: late-nineteenth century Boston, which quickly electrified its streetcar system between 1889 and 1896
- Advantages:
  1. A large intra-city transport shock: long-existing horse-drawn systems $\rightarrow$ a city-wide electric streetcar system in 7 years, doubling speed, tripling capacity, reducing the fares by half
  2. Routes upgraded from pre-existing horse trolley routes
- A novel dataset assembled from 1885-1905 Boston city directories
  1,660 plot-level maps georeferenced $\rightarrow$ fully recover the spatial distribution of businesses and residents

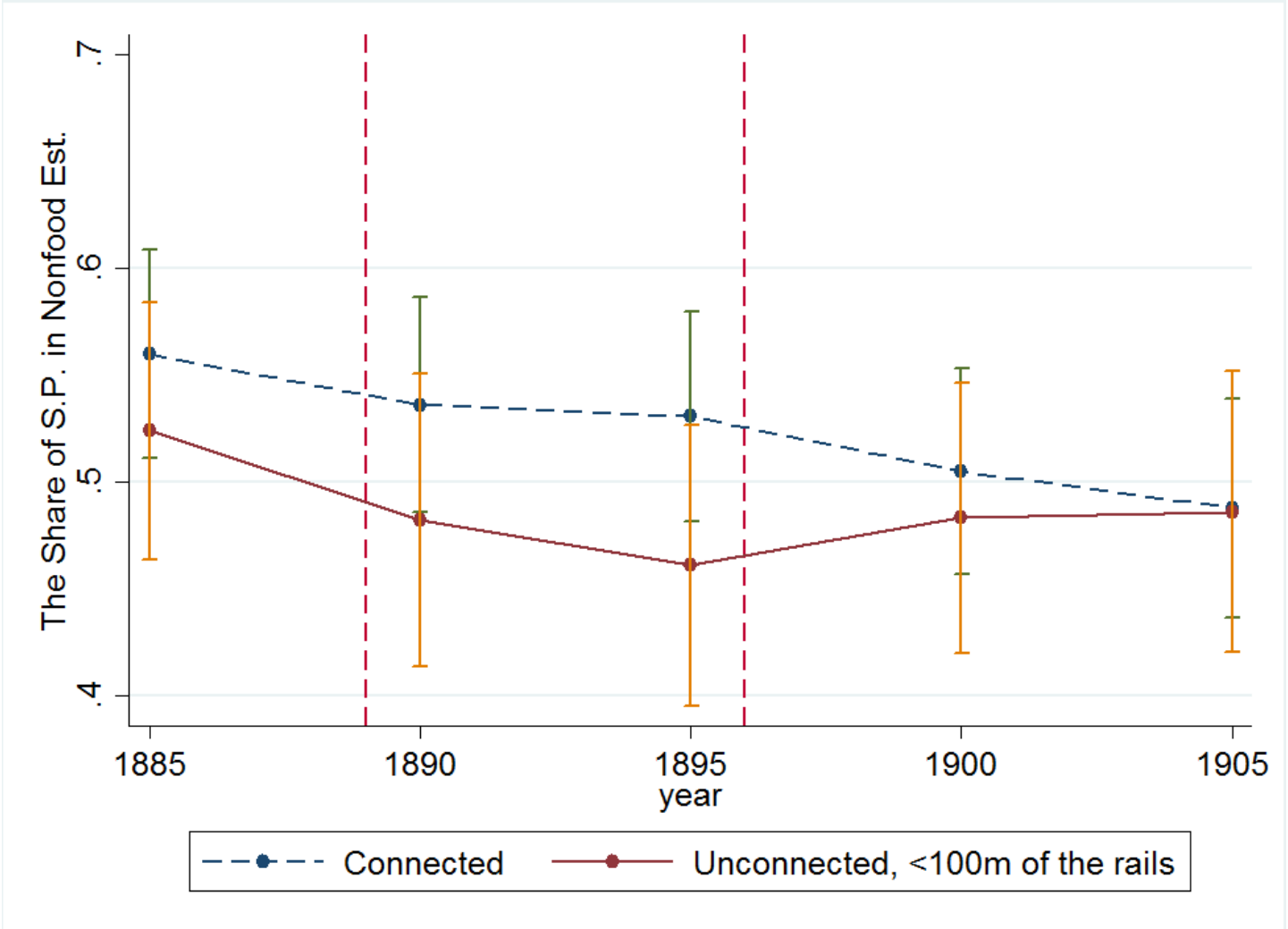
Method

- Outcome: the share of firms that were sole proprietorships in each location/neighborhood
- DID: compare changes in outcome in rail-connected (treatment) locations to changes in neighboring unconnected (comparison) locations.
- Treatment locations: $< 25m$ of rails, covering 51% firms; Comparison locations: 25-100m away from rails, covering another 30% firms
- Implications for the treatment effect:
  Access to labor markets (unlikely)
  Access to consumers (more likely) – particularly among high-purchase-frequency products (food grocery)

Preview of Main Results: Food Establishments



Preview of Main Results: Nonfood Establishments



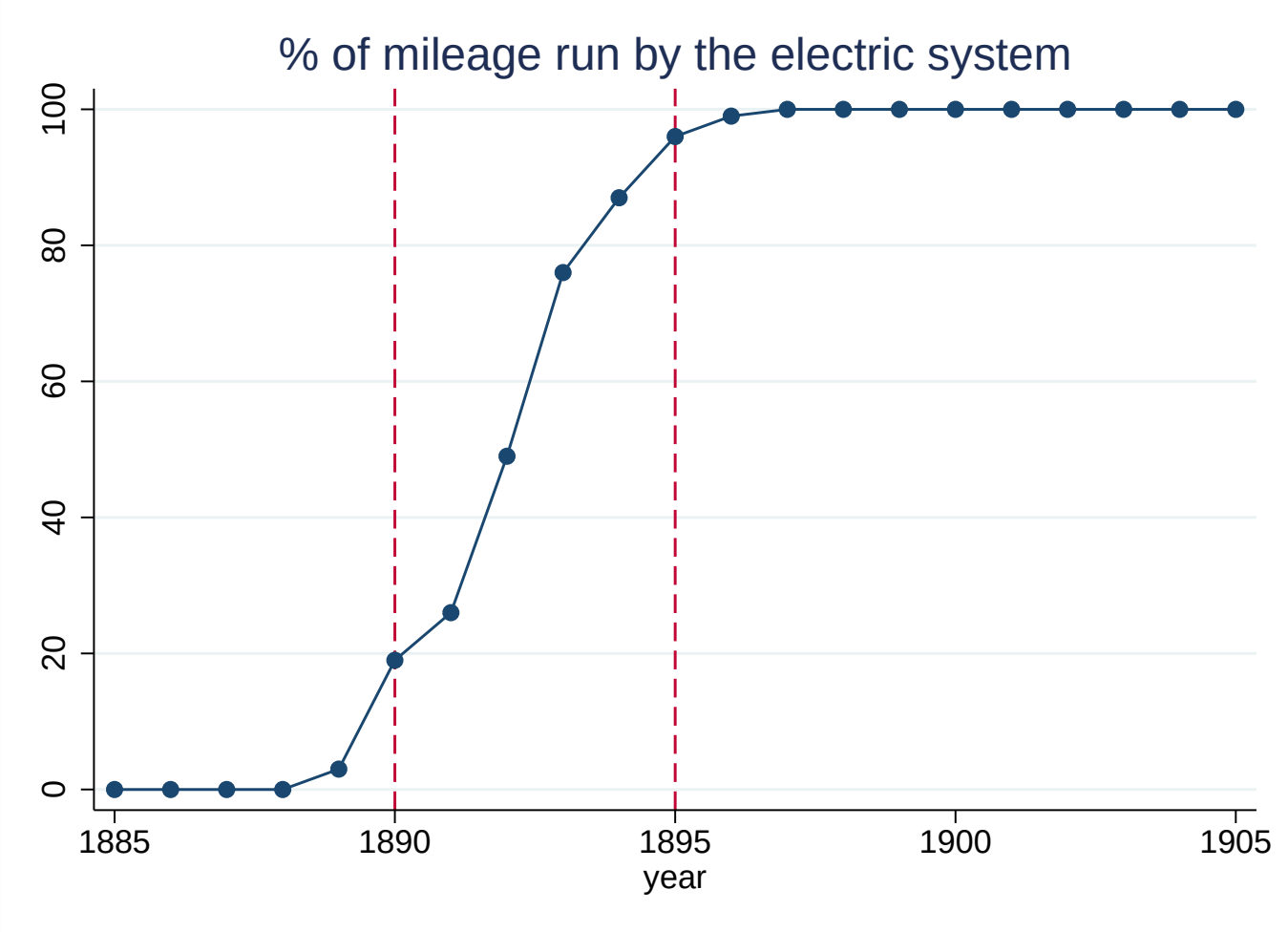
Related Literature

- Firm size and development
  - Facts: La Porta and Shleifer (2008, 2014); Gollin (2008); Jensen (2015); Hsieh and Olken (2014); Margo (2013)
  - Market segmentation hypothesis: Chandler (1977); Holmes and Stevens (2014); Lagakos (2016)
- Market integration and economic growth: Michaels (2008); Donaldson (2012); Faber (2014); Donaldson and Hornbeck (2016)
  - This paper: firm size
- Microdata evidence of the impacts of intra-city transit system on the spatial structure of cities: Brooks and Lutz (2014); Heblich, Redding, and Sturm (2017); Tsivanidis (2017); Severen (2017)
  - This paper: responses of *businesses* to a transport shock in a *historical* city

Historical Background: Prior to Electric Streetcars

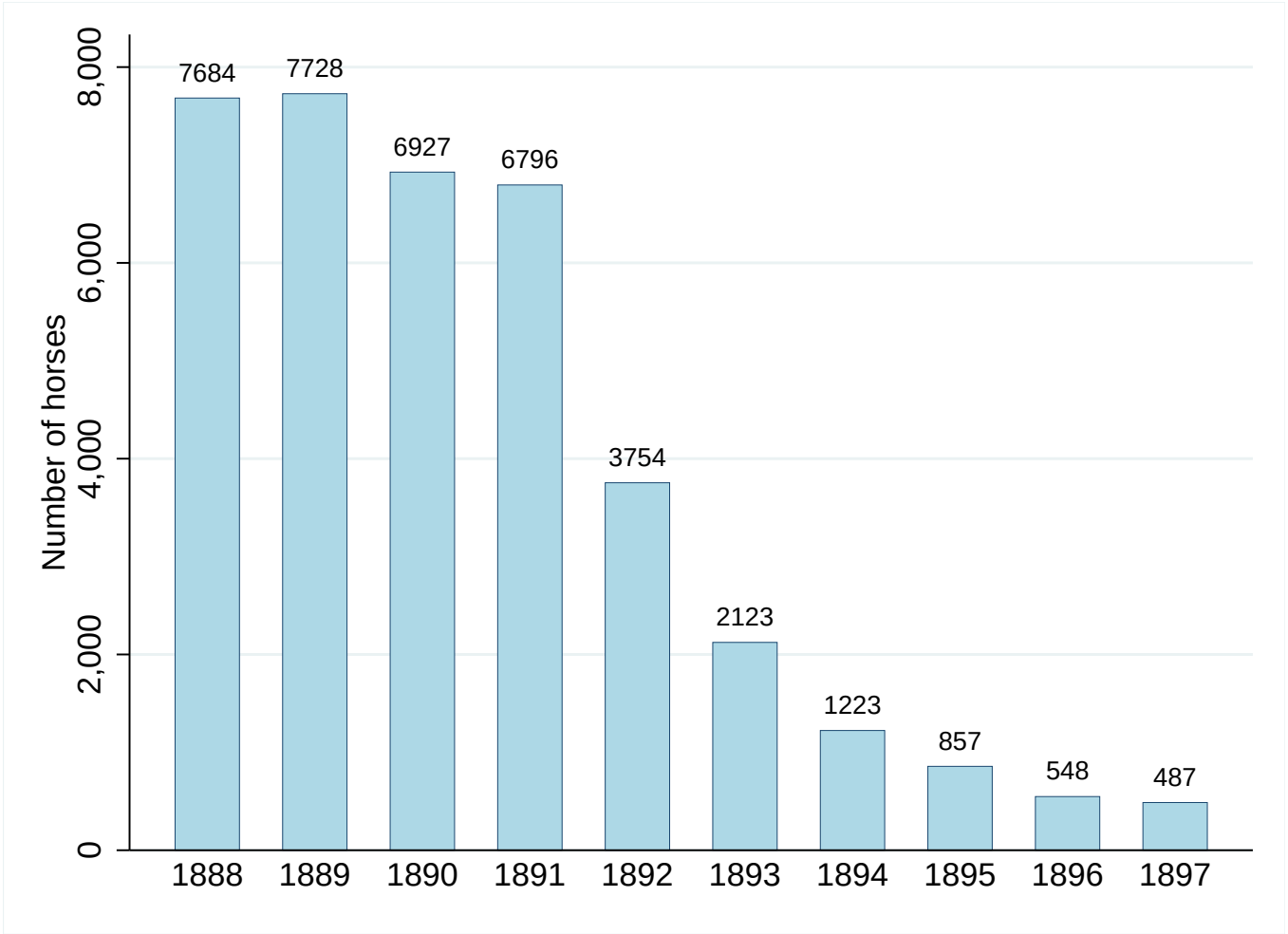
- Disadvantages of long-existing horsecar systems:
  - slow
  - expensive
  - weather shocks
  - horse pollution
- In the 1880s, most of major American cities $\rightarrow$ cable car systems (a minor fraction)
- Boston went in a different direction – electric streetcar system. Main driving factors:
  - Narrow, winding streets in Boston $\rightarrow$ cable-car system infeasible
  - Great entrepreneur Henry Whitney

Pace of the Electrification in Boston



Source: Annual Reports of the West End Street Railroad Company.

Pace of the Electrification in Boston



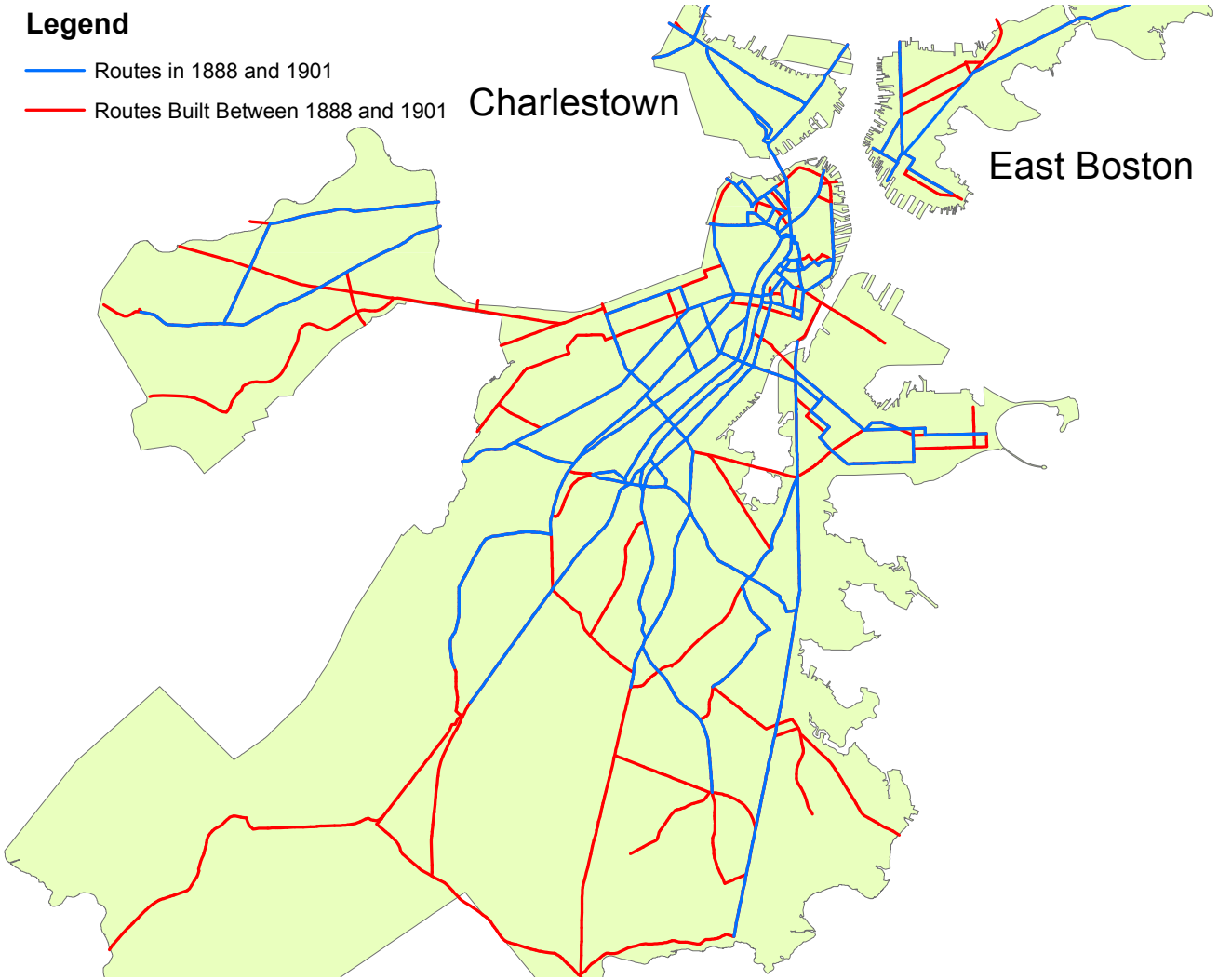
Source: Annual Reports of the West End Street Railroad Company.

The Electrification of Streetcars in the 1890s

Before: Horse-drawn
Speed: 4-5 mph.

After: Electrically-powered $\rightarrow$ Speed $\uparrow$
8-10 mph. Capacity tripled. Fares $\downarrow$ 50%

Routes of the Old and New Systems



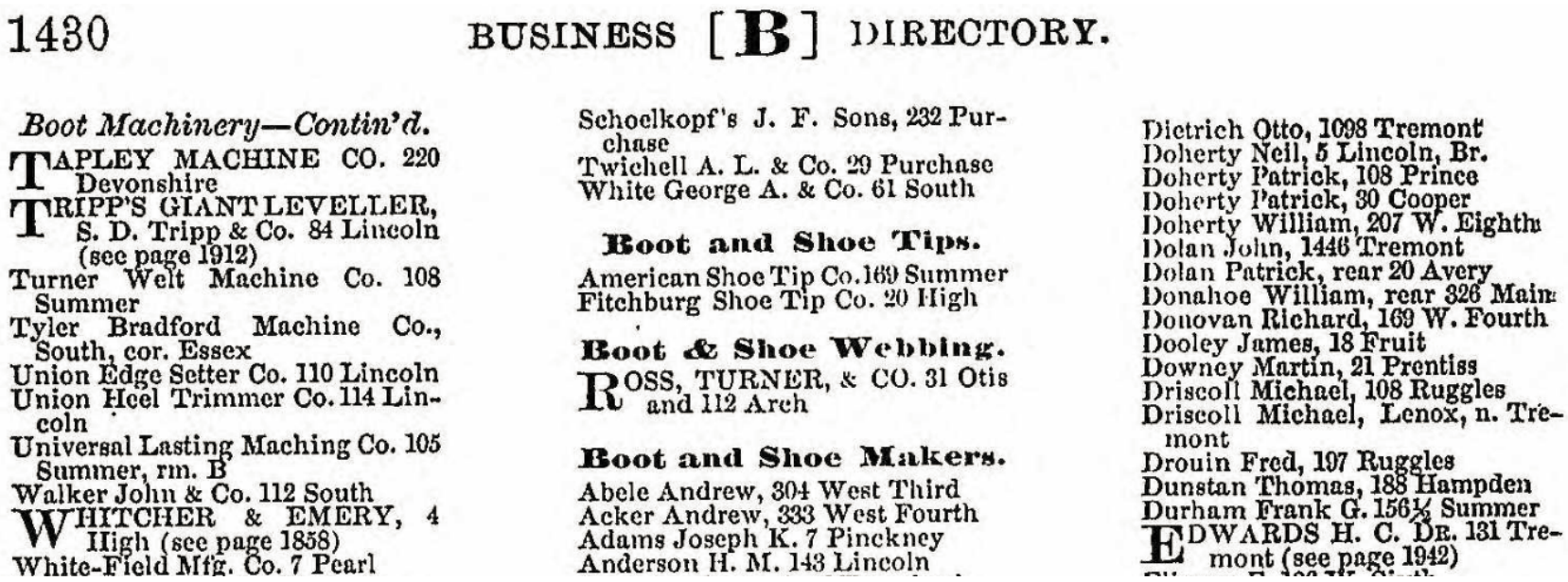
Source: Digitized Boston city maps.

Data Sources

- Main Source: The Boston Directories, 1885, 1890, 1895, 1900, and 1905
  Key variables: **firm (owner) name, address, product**

- Data obtained: 43,643 firms for top 25 retail/wholesale products in the Boston Directories (20% of all firms).
  Three broad categories: food, clothes, others

A Screenshot of the Historical Data



1430 BUSINESS [B] DIRECTORY.

Boot Machinery—Contin'd.

TAPLEY MACHINE CO. 220 Devonshire
TRIPP'S GIANT LEVELLER, S. D. Tripp & Co. 84 Lincoln (see page 1912)
Turner Welt Machine Co. 108 Summer
Tyler Bradford Machine Co., South, cor. Essex
Union Edge Setter Co. 110 Lincoln
Union Heel Trimmer Co. 114 Lincoln
Universal Lasting Maching Co. 105 Summer, rm. B
Walker John & Co. 112 South
WHITCHER & EMERY, 4 High (see page 1858)
White-Field Mfg. Co. 7 Pearl
Schoelkopf's J. F. Sons, 232 Purchase
Twichell A. L. & Co. 29 Purchase
White George A. & Co. 61 South

Boot and Shoe Tips.

American Shoe Tip Co. 169 Summer
Fitchburg Shoe Tip Co. 20 High

Boot & Shoe Webbing.

ROSS, TURNER, & CO. 31 Otis and 112 Arch

Boot and Shoe Makers.

Abele Andrew, 304 West Third
Acker Andrew, 333 West Fourth
Adams Joseph K. 7 Pinckney
Anderson H. M. 143 Lincoln
Dietrich Otto, 1098 Tremont
Doherty Neil, 5 Lincoln, Br.
Doherty Patrick, 108 Prince
Doherty Patrick, 30 Cooper
Doherty William, 207 W. Eighth
Dolan John, 1446 Tremont
Dolan Patrick, rear 20 Avery
Donahoe William, rear 326 Main
Donovan Richard, 169 W. Fourth
Dooley James, 18 Fruit
Downey Martin, 21 Prentiss
Driscoll Michael, 108 Ruggles
Driscoll Michael, Lenox, n. Tremont
Drouin Fred, 197 Ruggles
Dunstan Thomas, 188 Hampden
Durham Frank G. 156½ Summer
EDWARDS H. C. DR. 131 Tremont (see page 1942)

A sample page of the Boston Directory 1890, business directory

- Key problems to solve: data in image format; measurement of outcome; addresses cannot be geocoded using Google Maps

Measurement of Outcome

- From the Boston Directories, any firm can be categorized into:
  - Sole proprietorships (e.g. John Smith)
  - Partnerships (e.g. Whitcher & Emery, Abbott Bros)
  - Companies/Corporations (e.g. Gilchrist Co)

- Is sole proprietorship status a good proxy for firm size?

Table : Estimated Net Worth by Legal Form

Legal Form	mean	p25	p50	p75
Companies/Corporations	82,401	7,000	27,000	100,000
Partnerships	78,031	4,000	15,000	60,000
Sole Proprietorships	11,600	300	1,500	7,000

Source: Matched *Dun & Bradstreet* and Boston Directories, 1885 and 1899.

A Critical Step: Geocoding Addresses

- The Sanborn Fire Insurance Maps (1895-1900) - A total of 1,660 maps, covering the entire Boston area
- ≈100,000 buildings/addresses extracted
- Two sources of addresses matched (95% of the addresses geocoded)

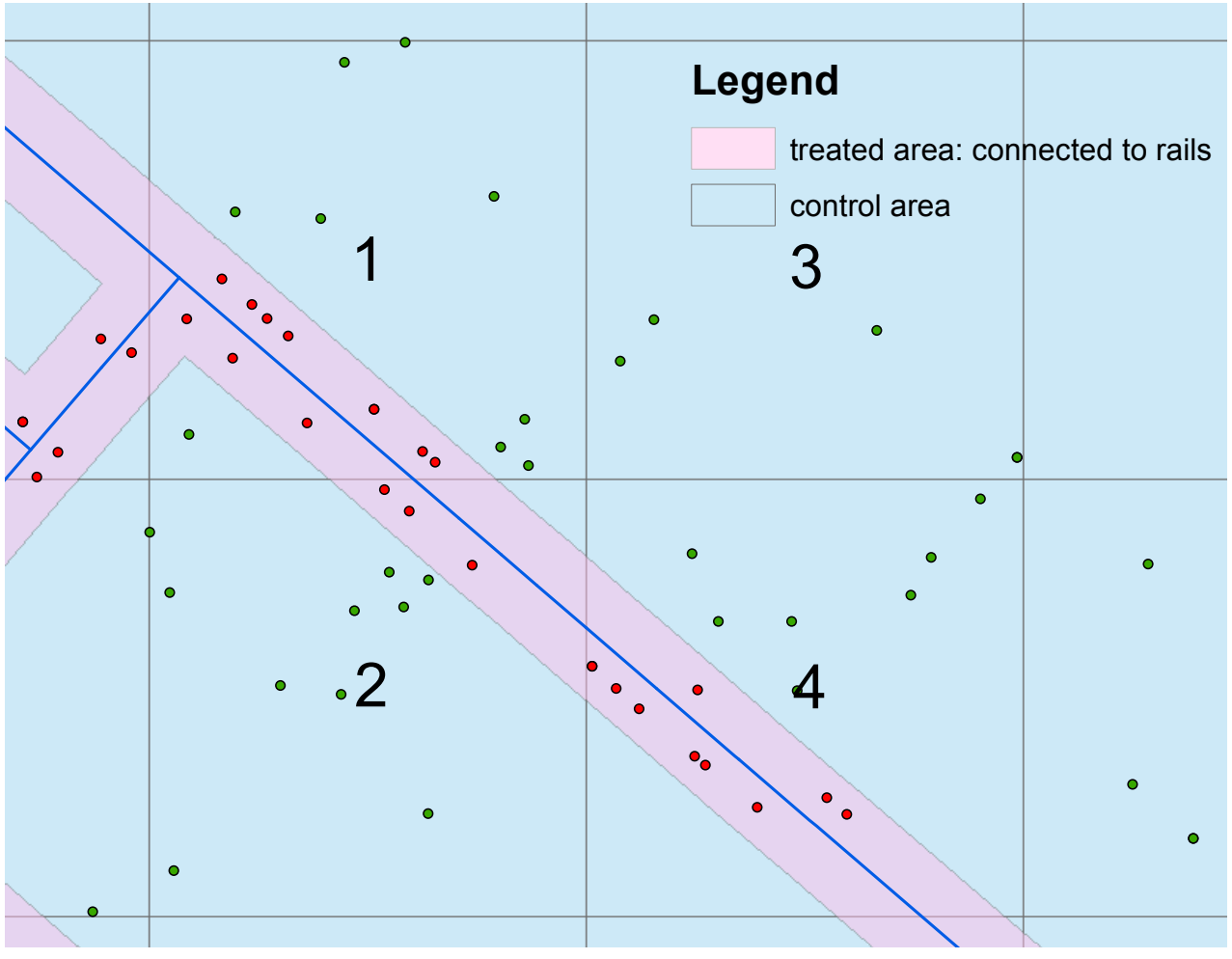
Specification

A Difference-in-Difference approach:

$$\text{Sole}_{ijt} = \beta_1 T_i + \beta_2 Post_t + \beta_3 \text{Post}_t \times T_i + \gamma_j \times \theta_t + \epsilon_{ijt}$$

- i: plots
- j: blocks
- $t = 1885, 1905$
- Sole_{ijt}: share of establishments that were sole proprietorships in plot i at time t
- $T_i = 1$ if along rails (< 25m away); $T_i = 0$ if a "control" location
- $Post_t = 1$ if $t = 1905$; $Post_t = 0$ if $t = 1885$

Construction of Regression Units, Treatment, and Control



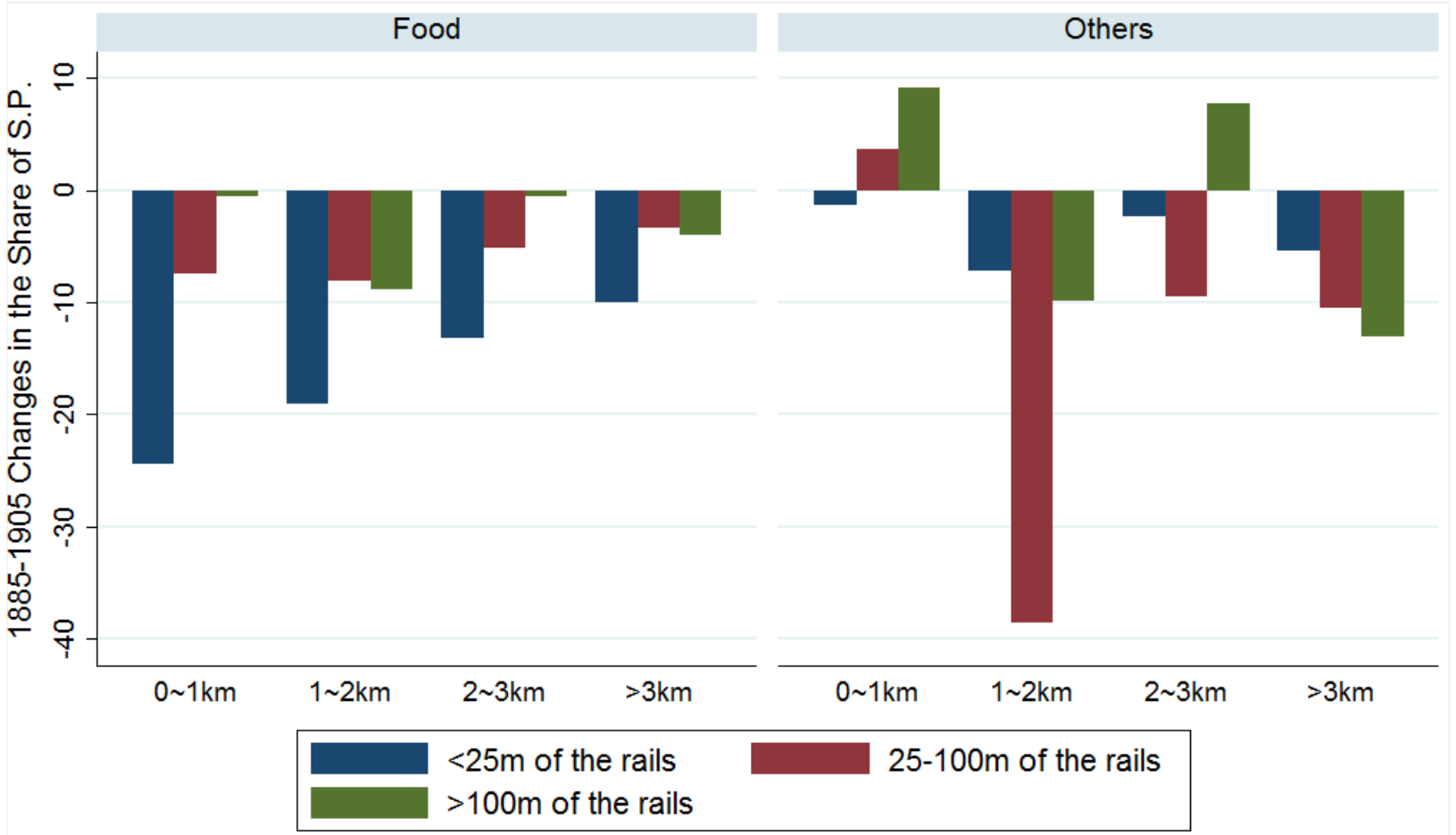
Regression Results: Benchmark

Dependent Variable: Share of S.P. in total est.	(1) Food Products	(2) Food Products	(3) Nonfood Products	(4) Nonfood Products
Treatment	0.007	-0.022	0.035	-0.069
	(0.025)	(0.026)	(0.035)	(0.043)
Post	-0.111***		-0.037	
	(0.022)		(0.029)	
Treatment*Post	-0.088***	-0.121***	-0.036	-0.042
	(0.026)	(0.040)	(0.040)	(0.057)
200m-Block*Year FE		YES		YES
Observations	576	576	276	276
R-squared	0.155	0.776	0.019	0.908

Robustness Check by Treatment Definition

Dependent Variable:	(1)	(2)	(3)	(4)
Share of S.P. in total est.				
Block Size:	200m	300m	400m	400m
		Food		
Treatment, 0-25m	-0.022	-0.009	-0.011	0.010
	(0.026)	(0.028)	(0.028)	(0.031)
Treatment, 25-100m				0.032
				(0.027)
Treatment(0-25m)*Post	-0.121***	-0.108***	-0.117***	-0.135**
	(0.040)	(0.037)	(0.032)	(0.052)
Treatment(25-100m)*Post				-0.028
				(0.063)
Observations	576	436	356	318
R-squared	0.776	0.843	0.857	0.787
		Nonfood Products		
Treatment, 0-25m	-0.069	-0.050	-0.043	0.026
	(0.043)	(0.045)	(0.045)	(0.073)
Treatment, 25-100m				0.059
				(0.056)
Treatment(0-25m)*Post	-0.042	-0.029	-0.029	-0.076
	(0.057)	(0.048)	(0.041)	(0.066)
Treatment(25-100m)*Post				-0.047
				(0.054)
Block*Year FE	YES	YES	YES	YES
Observations	276	232	188	126
R-squared	0.908	0.906	0.930	0.886

Visulization of Outcome



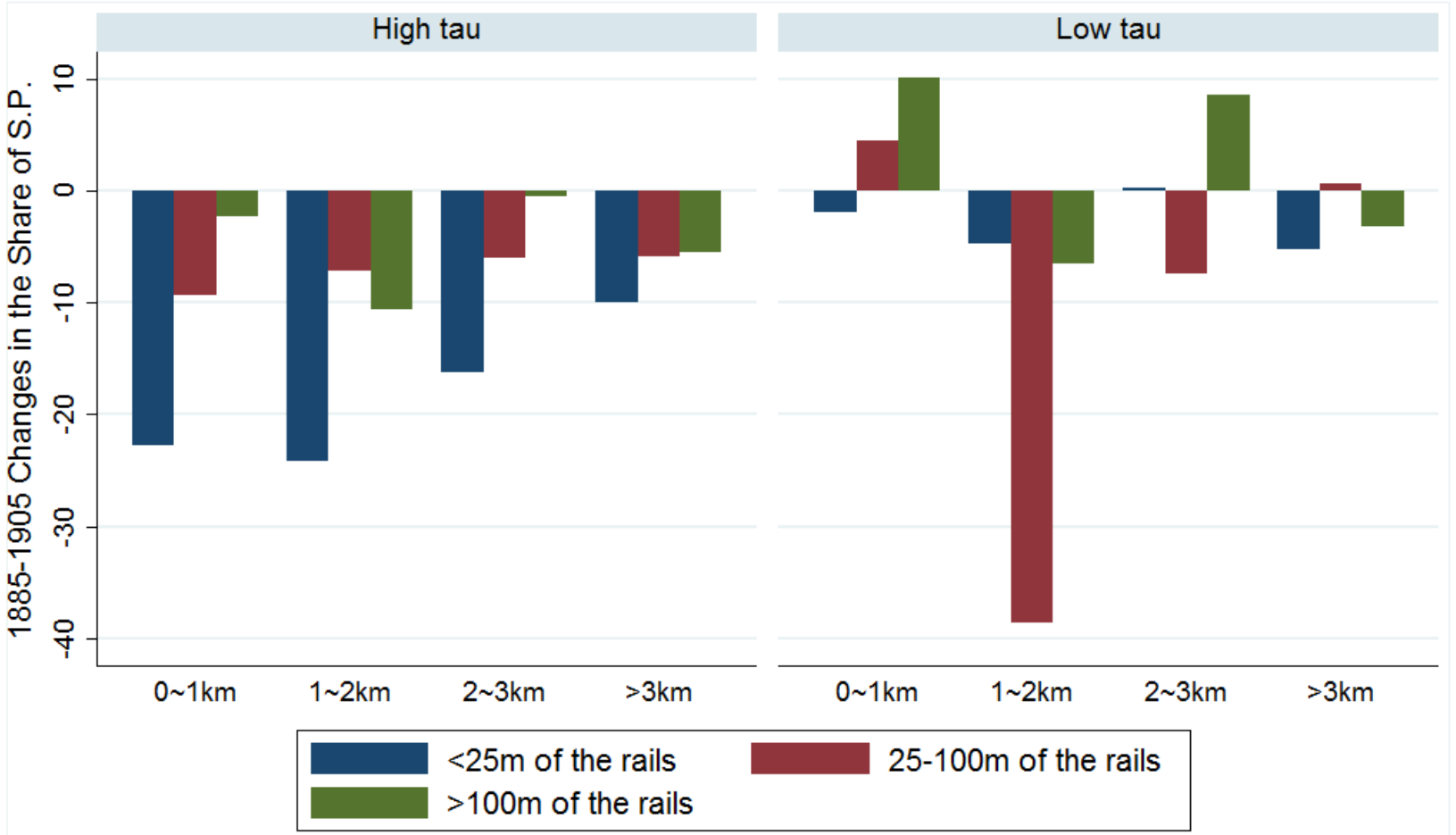
Heterogeneity between Food and Nonfood

- What explains the heterogeneous treatment effects between food and nonfood?
- Is purchase frequency, τ, the critical attribute?

Regressions by τ

Dependent Variable: Share of S.P. in total est.	(1) High τ Products	(2) High τ Products	(3) Low τ Products	(4) Low τ Products
Treatment	0.014	-0.033	0.041	-0.050
	(0.032)	(0.025)	(0.036)	(0.056)
Post	-0.096***		-0.070*	
	(0.023)		(0.042)	
Treatment*Post	-0.111***	-0.122**	-0.029	-0.057
	(0.031)	(0.047)	(0.057)	(0.076)
200m-Block*Year FE		YES		YES
Observations	580	580	192	192
R-squared	0.129	0.812	0.039	0.878

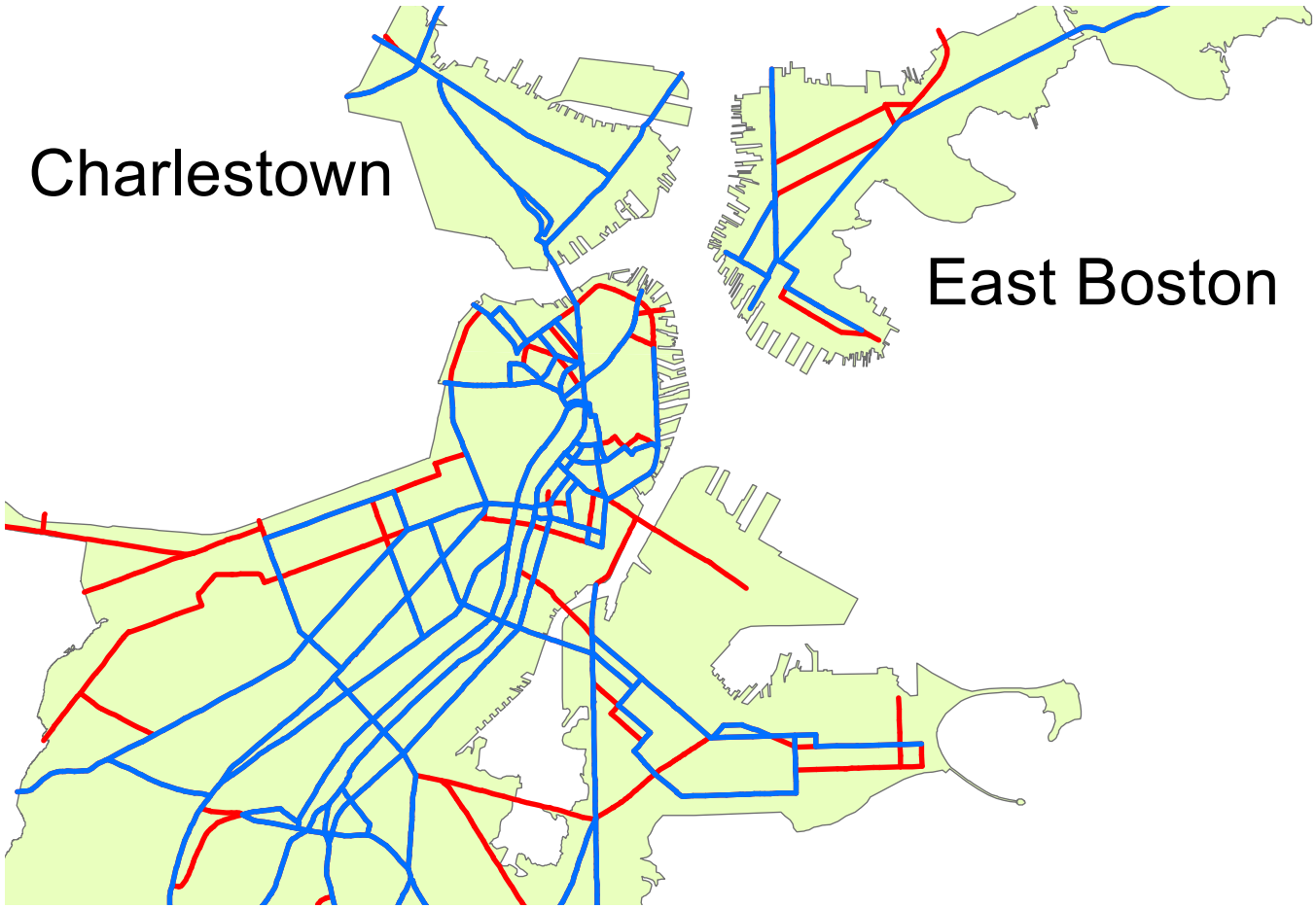
Reclassify Products by Tau



Size of the Treatment Effects

- Why does one street-block of distance matter so much?
- Treatment effect amplified by access to consumers from non-local neighborhoods

Mini-Case Study: Charlestown V.S. East Boston



The Locations of Charlestown and East Boston

Charlestown V.S. East Boston: Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
Area	Charlestown		East Boston		Central Boston	
Treatment	-0.026	-0.032	-0.079	-0.061	0.015	-0.019
	(0.032)	(0.079)	(0.087)	(0.104)	(0.028)	(0.028)
Post	-0.138		-0.124**		-0.109***	
	(0.080)		(0.049)		(0.024)	
Treatment*Post	-0.182*	-0.204	-0.039	-0.052	-0.084***	-0.119***
	(0.097)	(0.141)	(0.091)	(0.160)	(0.028)	(0.043)
Block*Year FE		YES		YES		YES
Observations	80	80	44	44	452	452
R-squared	0.345	0.724	0.177	0.679	0.147	0.784

Conclusions

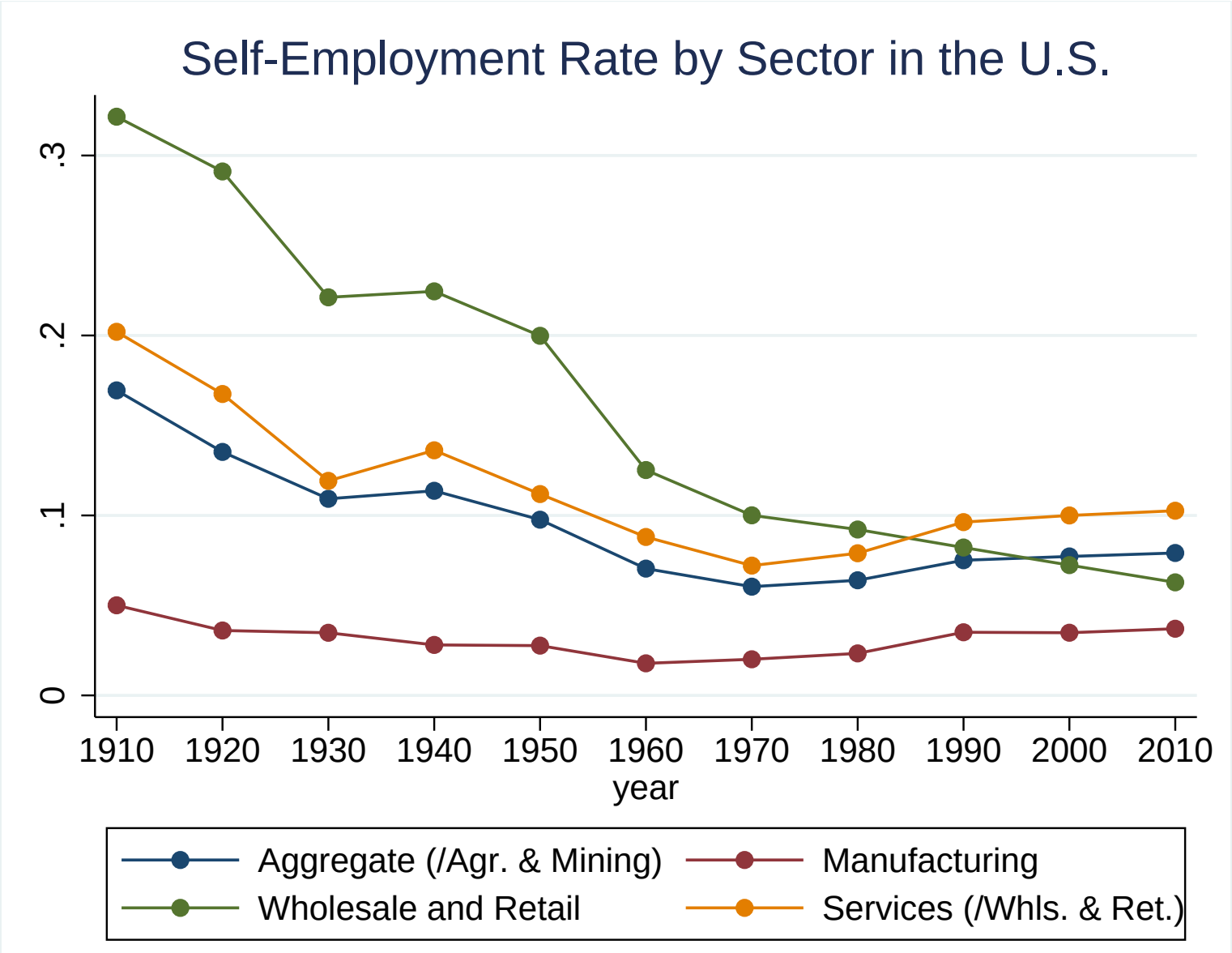
- The electrification of the streetcar system in the 1890s in Boston dramatically decreased the share of sole proprietorships among food firms along the transit rails
- Market access to consumers can explain this effect
- Implications:
  - A very high degree of market segmentation in the historical city $\rightarrow$ today's developing countries?
  - If so, a large number of small, unproductive firms could have market power $\rightarrow$ substantial gains from resource reallocation across firms following an upgrade of transport infrastructure

The Nature of Products

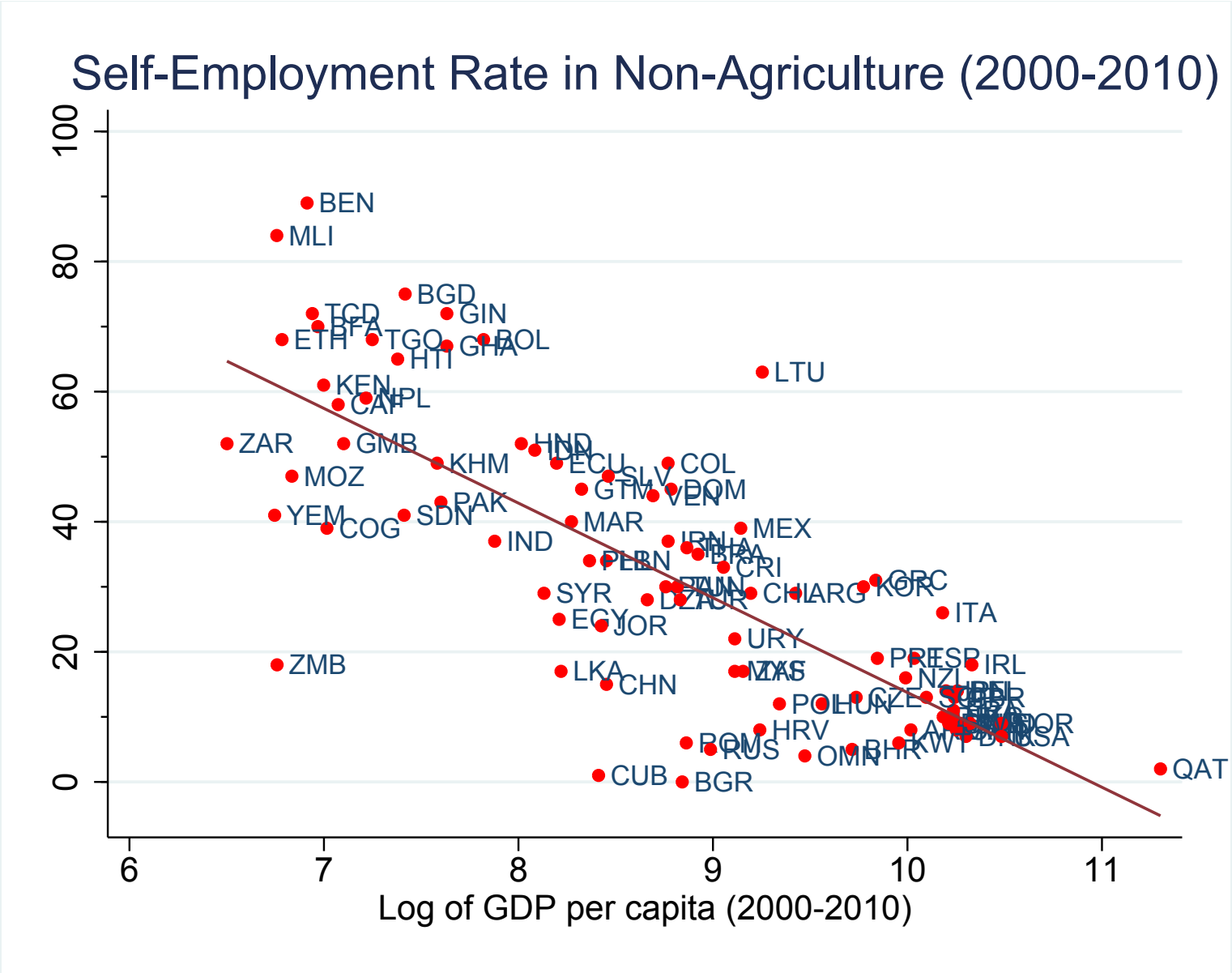
Table : Purchase Frequency by Product

Product	Trips/$100	Product	Trips/$100
Food (53.9%)			
Confectioners	28.7	Produce	13.1
Bakers	22.4	Liquors & Wine	8.4
Fruits	15.7	Restaurants	8.4
Fish	15.4	Provisions	6.6
Grocers	N/A		
Clothing (28.7%)			
Hats, Caps, & Furs	5.8	Boots & Shoes	2.3
Milliners	4.8	Clothing	2.1
Dry Goods	3.8	Men's Furnishings	N/A
Tailors	N/A		
Others (17.4%)			
Cigars & Tabaccos	13.8	Jewelry & Watches	1.6
Books & Publishers	11.7	Leather	1.2
Apothecaries & Drugs	4.3	Music Instruments	1.1
Hardware	3.2	Furniture	0.4

Time-Series Relationship



Cross-Country Relationship



Street Networks in Boston, 1895

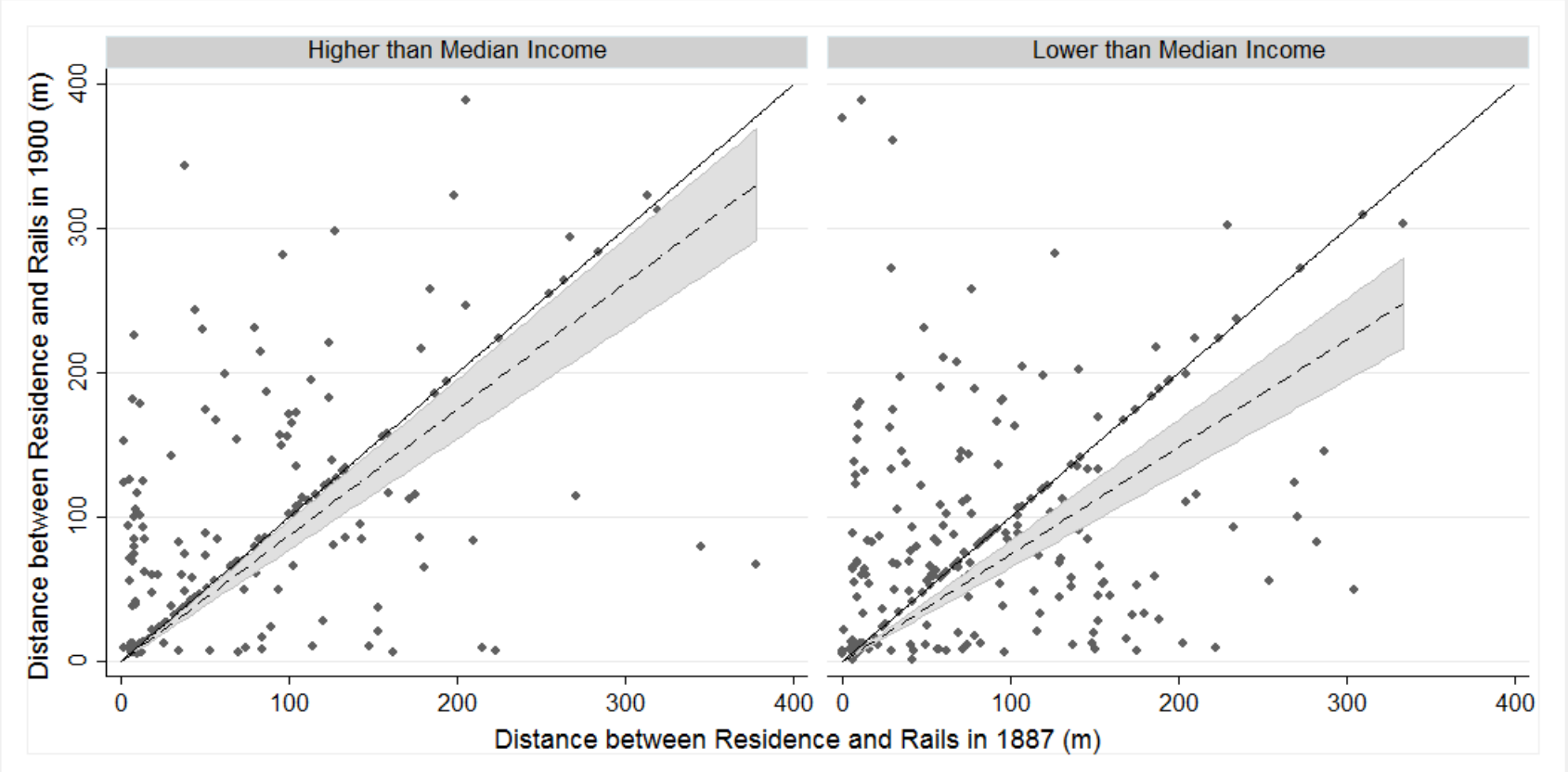
A Screenshot of the Historical Data

Brock Mary E. librarian Brighton branch public library, bds. 39 Parsons [15 Woodville
" Matthias, mechanical expert, 113 Lincoln, h.
" Nathan S. engineer, bds. 39 Parsons
" Newhall, & Fiske (*Geo. E. Brock, Frank G. Newhall, Arthur P. Fiske*), ins. agts. 326 Washington, Br. [den
" Owen, salesman, 31 Hayward pl. h. at Mal-
" Owen & Co. boilermakers, 241 Medford, Chsn. h. 11 Chelsea, do.

Broderick John, laborer, h. rear 85 Wash. Chsn.
" John, teamster, h. 135 Rutherford av.
" John A. compositor, 244 Wash. h. 184 Eustis
" John C. coachman, bds. 54 Dundee
" John G. police station 9, h. 25 Blue Hill av.
" John J. boots and shoes, 387 Federal, bds. 1209 Massachusetts av.
" John J. driver, h. 1808 Washington
" John W. driver, h. Tolman [cester sq.
" Joseph B. compositor, 244 Wash. bds. 21 Wor-

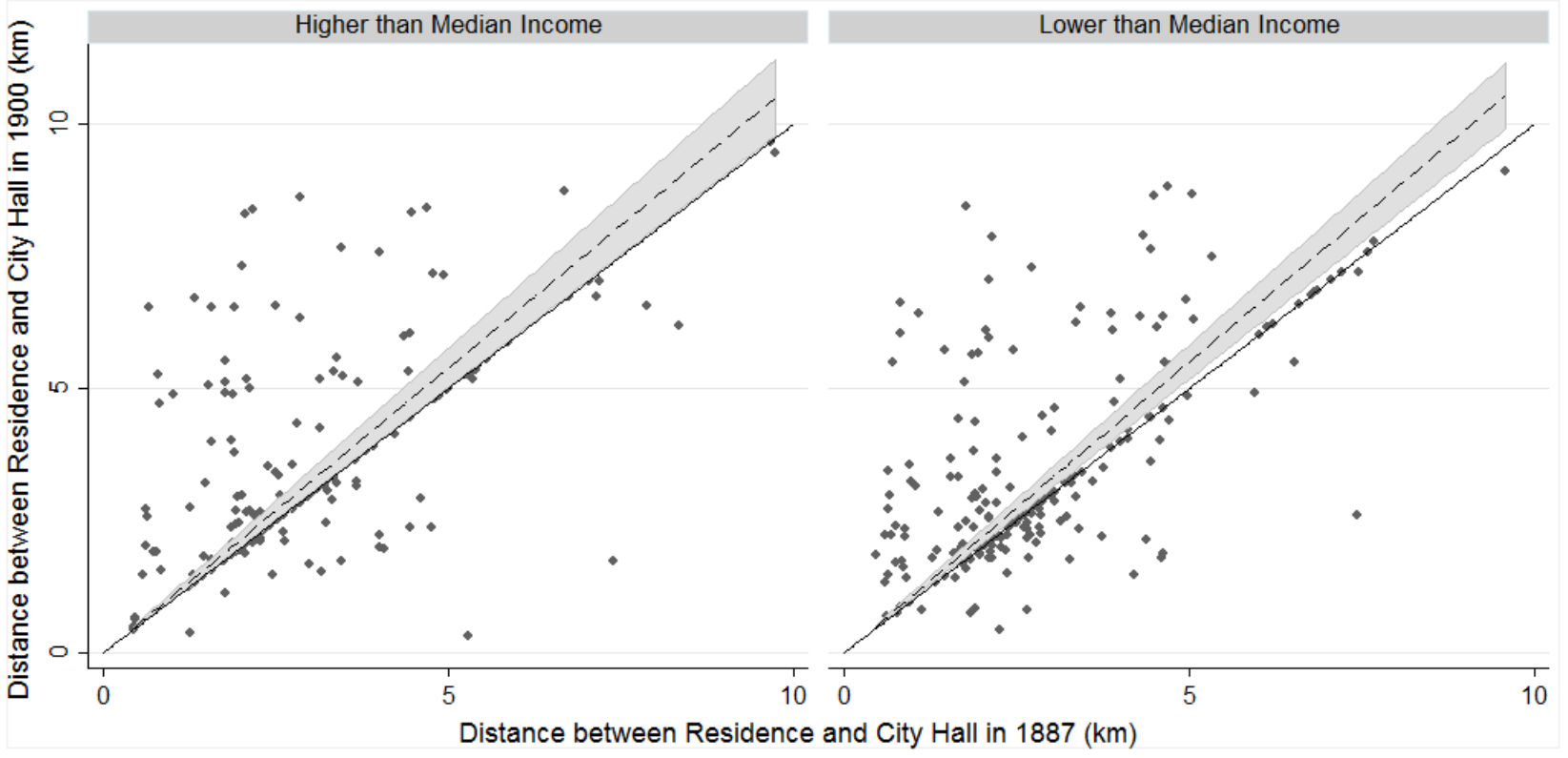
A sample page of the Boston Directory 1890, main directory

Residential Sorting - Distance to Streetcar Rails



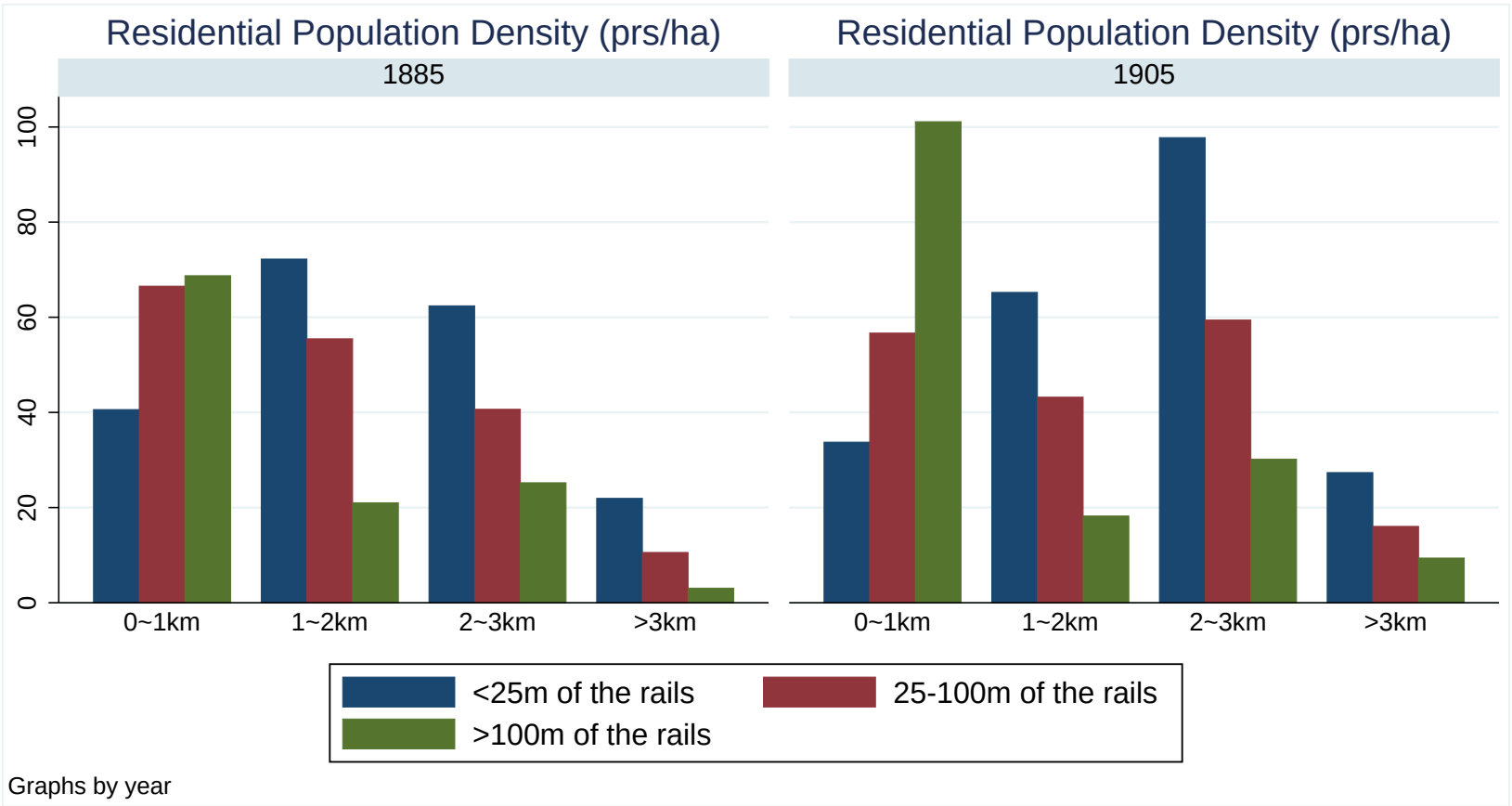
Source: Linked individual-level Census data and the Boston Directories

Residential Sorting - Distance to City Center

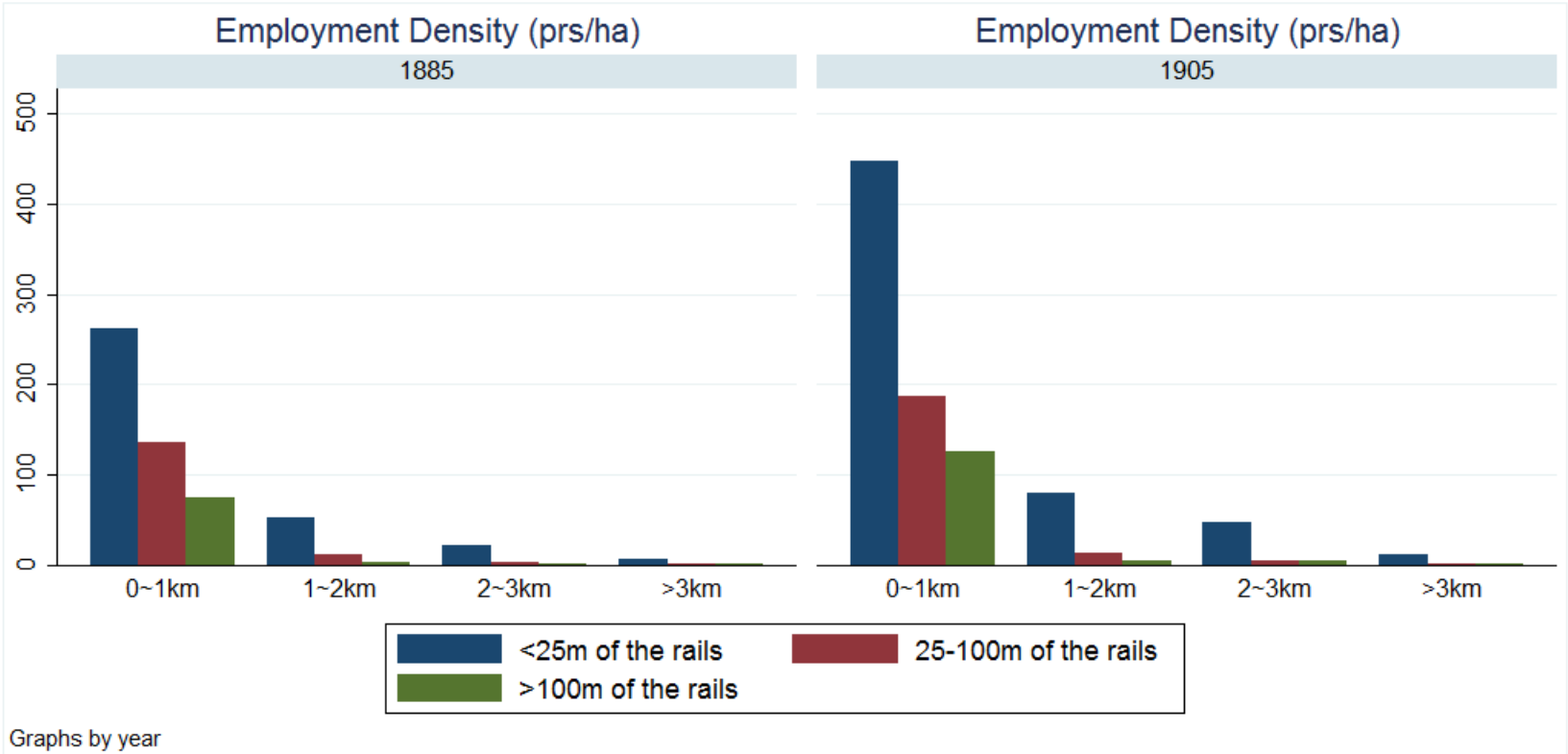


Source: Linked individual-level Census data and the Boston Directories

Residential Population Density



Employment Density



Commuting Patterns

Table : The Centiles of The Commuting Distances (km)

year	p25	p50	p75
1885	0.50	2.19	4.74
1890	0.83	2.90	5.27
1895	0.75	3.03	5.83
1900	1.12	3.95	6.44
1905	1.07	3.97	7.09

Notes: Commuting distance is defined as the distance between the residence and the workplaces of the worker's main occupation.
Source: The geocoded 1% random sample of the inhabitants in the *Boston Directories* between 1885 and 1905.

Dun & Bradstreet Credit Rating Books

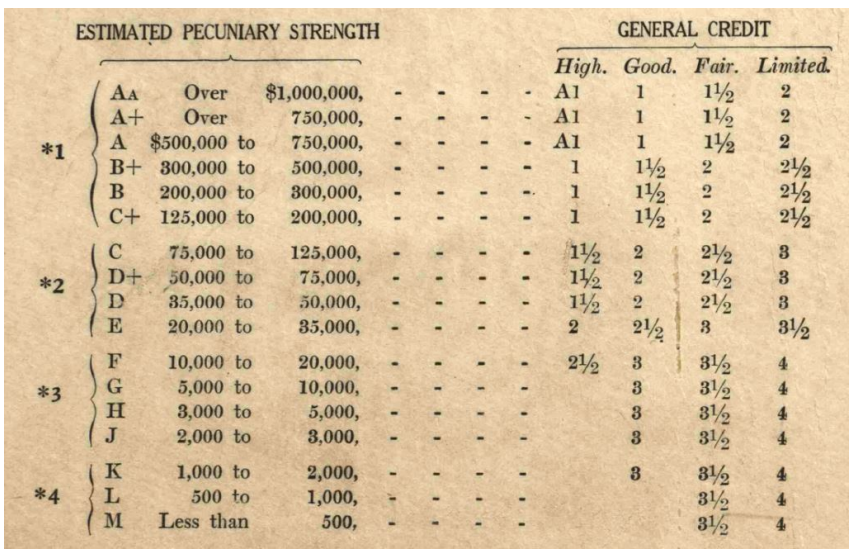
- The Dun & Bradstreet Reference Books of American Businesses, 1885, 1899

Ayer G. A..... Restaurant & Liq. M
Ayer J. F. (Charlestown)...Lumber. M 4
Ayer M. S. & Co.....Whol. Gro. B 1
Ayers A. A. (Jam. Plain).. Carpenter & Builder. 4
Ayers Melvin D. (Roslindale)...Carpenter. G 3

B

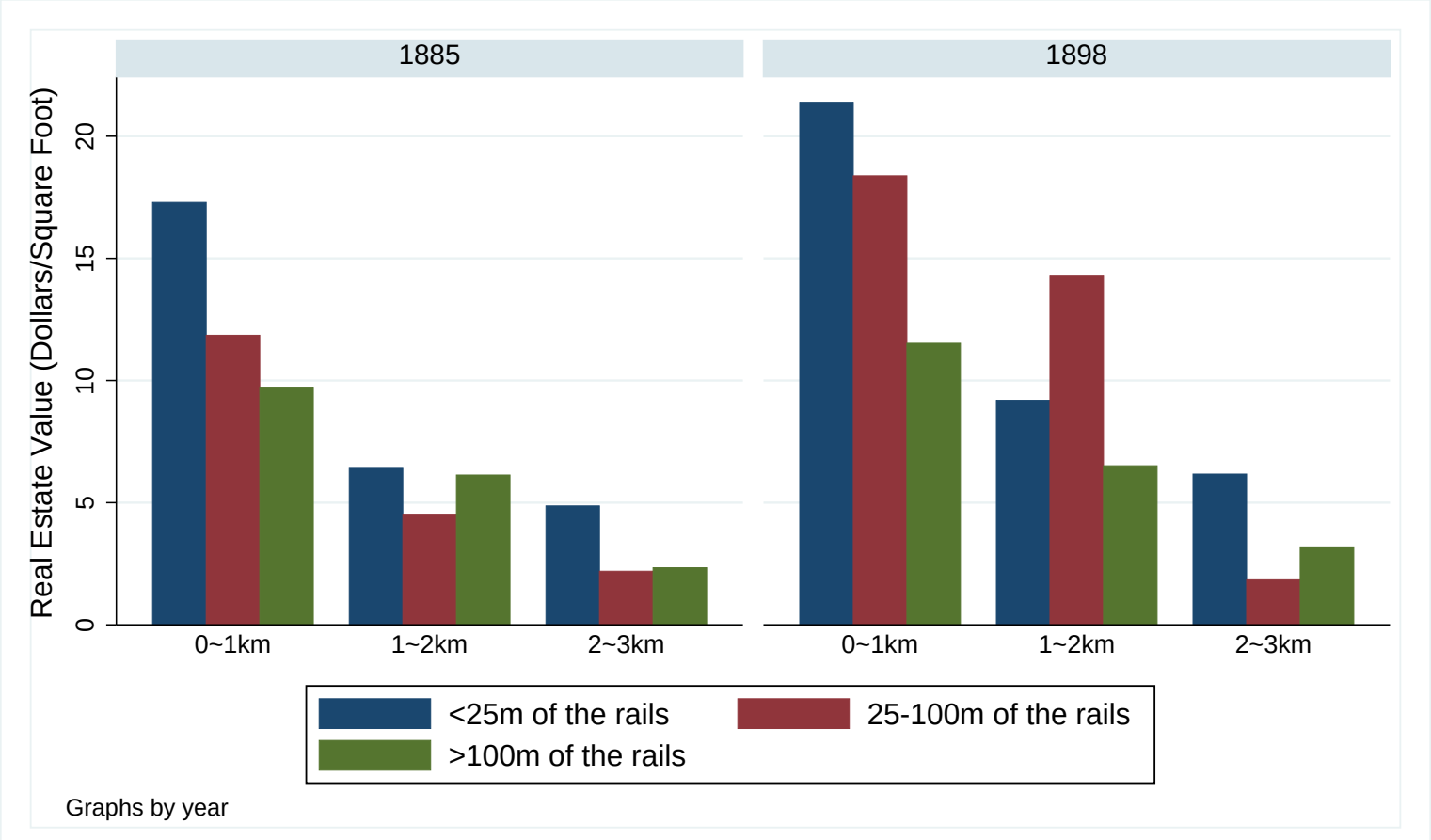
Babb & Stevens..... Printers. G 3
Babbitt F. C..... Watchmkr. & Jeweler.
Babcock C. A..... Painter. M
Babcock John & Co..... Mnfrs. Varnishes, &c. C 1½
Babcock John B. & Co..... Imps. & Com'n. E 2

Ballou I. H. & Co..Prod., Flour, &c. D 2
Ballou John.....Furnaces, &c. G 3½
Ballou Joseph E.....Printer. M
Ballou M. R..... Broker. 3
Bampton Mrs. Olive L. (Roxbury), Ret. Gro. G 3½
Banadini & Funai .....Fruit. L 4
Banash H..... Mnfr. Cigars. L
Banchor John F. & Co.....Whol. & Ret. Liquors. D 2
Banchor & Richardson.....Leather. D 1½
Bancroft & Dyer.....Furniture. G 3½
Bancroft James B.....Cigars, &c. L 4
Bancroft Joseph H..Paperhangings. E 2½
Bancroft S. A..... Variety & Periodicals. M
Bangburn E. B.....Stoves, &c. M



	ESTIMATED PECUNIARY STRENGTH		GENERAL CREDIT			
			High.	*Good.*	*Fair.*	*Limited.*
*1	AA Over $1,000,000,		A1	1	1½	2
	A+ Over 750,000,		A1	1	1½	2
	A $500,000 to 750,000,		A1	1	1½	2
	B+ 300,000 to 500,000,		1	1½	2	2½
	B 200,000 to 300,000,		1	1½	2	2½
	C+ 125,000 to 200,000,		1	1½	2	2½
*2	C 75,000 to 125,000,		1½	2	2½	3
	D+ 50,000 to 75,000,		1½	2	2½	3
	D 35,000 to 50,000,		1½	2	2½	3
	E 20,000 to 35,000,		2	2½	3	3½
*3	F 10,000 to 20,000,		2½	3	3½	4
	G 5,000 to 10,000,			3	3½	4
	H 3,000 to 5,000,			3	3½	4
	J 2,000 to 3,000,			3	3½	4
*4	K 1,000 to 2,000,			3	3½	4
	L 500 to 1,000,				3½	4
	M Less than 500,				3½	4

Rising Real Estate Values



Source: Boston Property Tax Ledgers

Firm Dynamics: Backward Tracking

Table : Locational Choices of Incumbent and Entrant Firms

	Incumbents in 1890 and 1895		Incumbents in 1900 and 1905	
	Co./P.	Sole Prop.	Co./P.	Sole Prop.
Survived from the Past 5 Yrs				
Rails → Rails	30.4%	28.1%	30.3%	28.7%
Rails → Off-Rails	4.3%	3.5%	2.8%	2.5%
Off-Rails → Rails	5.2%	4.8%	8.5%	4.3%
Off-Rails → Off-Rails	28.7%	17.1%	31.7%	17.2%
Entered in the Past 5 Yrs				
Along-Rails	17.4%	24.6%	21.8%	25.8%
Off-Rails	13.9%	21.9%	4.9%	21.5%
Observations	115	228	142	279

- Observed treatment effect is NOT driven by relocation of survivor firms; mostly driven by new entrants

Firm Dynamics: Forward Tracking

Table : Dynamics of Firms between 1888 and 1899

	Off Rails in 1888		Along Rails in 1888	
	Sole Prop.	Co./P.	Sole Prop.	Co./P.
Survived Between 1888 and 1899				
Rails → Rails			36.5%	41.2%
Rails → Off-Rails			6.4%	6.7%
Off-Rails → Rails	9.6%	16.1%		
Off-Rails → Off-Rails	23.9%	48.3%		
Exited Between 1888 and 1899				
Exited	58.9%	29.7%	50.0%	47.9%
Occupation Changed	7.7%	5.9%	7.1%	4.2%
Observations	209	118	282	119

Regression by Initial Share of S.P.

Dependent Variable: Share of S.P. in total est.	(1)	(2)	(3)	(4)
	Above Median Share		Below Median Share	
Panel A:		Food		
Treatment	-0.001	0.002	-0.005	-0.035
	(0.015)	(0.024)	(0.033)	(0.038)
Post	-0.128***		-0.103***	
	(0.027)		(0.031)	
Treatment*Post	-0.137***	-0.170***	-0.055*	-0.094*
	(0.039)	(0.063)	(0.033)	(0.051)
Observations	284	284	292	292
R-squared	0.390	0.742	0.110	0.744
Panel B:		Other Products		
Treatment	-0.132***	-0.142***	0.040	-0.055
	(0.028)	(0.048)	(0.034)	(0.048)
Post	-0.097**		-0.027	
	(0.036)		(0.034)	
Treatment*Post	-0.042	-0.020	-0.029	-0.047
	(0.044)	(0.069)	(0.048)	(0.067)
200m-Block*Year FE		YES		YES
Observations	140	140	136	136
R-squared	0.325	0.772	0.019	0.877