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

Wei You[†]

January 3, 2018

Abstract

Small family firms dominated the American economy in the nineteenth century, and still dominate in many developing economies today. A long-conjectured cause of this phenomenon, represented by Chandler (1977), is that market segmentation due to underdeveloped transportation technology precludes the emergence of modern firms. This paper provides the first rigorous test of this hypothesis, exploiting the natural experiment from Boston's quick electrification of its previously horse-drawn streetcar system between 1889 and 1896 while keeping the preexisting transit routes almost unchanged. Analyzing new data digitized from Boston business records from 1885 to 1905, I find evidence in support of this hypothesis.

Keywords: Small business; Transportation technology; Market access.

1 Introduction

Before the 1840s, "mom-and-pop" businesses dominated the American economy. This type of firm was typically owned and managed by an individual or a small number of family

[†]New York University, Furman Center for Real Estate and Urban Policy, New York, NY, USA. Tel: +1-646-715-2025. Email: wei.you@nyu.edu. I would like to thank Gordon Hanson, Roger Gordon, Ruixue Jia, David Lagakos, Marc Muendler, Paul Niehaus, Tommaso Porzio, Allison Shertzer, Walker Hanlon, Leah Boustan, Noam Yuchtman, Gregory Clark, Martha Olney, Dan Bogart, David McKenzie, Kilian Heilmann, Sieuwerd Gaastra, and participants of the UCSD lunch seminar, the UC Irvine Transportation, Urban and Regional Workshop, and the All-UC Economic History Graduate Workshop for helpful comments.

members, produced a single product, and served a highly localized market. Chandler (1977) observed that the size and nature of firms in America remained relatively unchanged between 1790 and 1840, despite the substantial growth in population and total volume of trade during this period. The increase in market size translated into a parallel increase in the number of firms, but not in the size of firms. He proposed that the traditional sources of energy–wind and animal power–"simply could not generate a volume of output in production and number of transactions in distribution large enough to require the creation of a large managerial enterprise or to call for the development of new business forms and practices." The revolution in transportation technology since the mid-nineteenth century, first brought on by railroads, made it possible to move goods at a steady, high volume and at high speeds, which demanded organizational innovations within production units. It is in this period that we saw the rise of modern firms.

Chandler's hypothesis is relevant to understand the prevalence of micro and small enterprises in today's developing countries. Hsieh and Olken (2014, p.93) and McKenzie (2017, p.2278) report that close to 100% of firms have fewer than 10 workers in India, Indonesia, and Nigeria. In contrast, the modal manufacturing firm in the United States has 45 workers (Hsieh and Klenow, 2014). [1] "This is a puzzle to standard models of the firm size distribution (Lucas, 1978) unless the distribution of entrepreneurial talent is very limited in developing countries" (McKenzie, 2017). Chandler pointed out that a potentially important impediment to firm size growth in developing countries is the higher transportation costs that segment markets, which in turn cause firms to primarily serve a highly localized market. Similar explanations are also proposed by Lagakos (2016), Tybout (2000), Hsieh and Klenow (2014), and Holmes and Stevens (2014). In this paper, I call these explanations the market segmentation hypothesis.

[1] Another indicator of the prevalence of micro and small enterprises is the self-employment rate. Using increasingly available cross-country data, researchers have established the stylized fact that the self-employment rate decreases as income per capita increases (La Porta and Shleifer, 2008, 2014; Gollin 2008; Jensen, 2016). In the bottom income quartile of countries, nearly one half of the labor force is self-employed, while the fraction of the self-employed in the labor force is around 10% in the top income quartile of countries (La Porta and Shleifer, 2008). This is true even in the non-agricultural sector.

Empirically testing the market segmentation hypothesis is difficult. The causal evidence that a reduction in transportation costs leads to an increase in firm size has been missing in the literature thus far, both in the historical US setting and in today's developing country setting. One needs to find a transportation technology shock that took place in a short period of time and made differential impacts on different areas, and with the intensity of the impacts independent of the possible trends in the outcome of the areas. Moreover, one needs to find a firm-level dataset that contains detailed geographic information, which is not left-tail truncated in the firm size distribution. However, such data sets are rare in developing economies (Hsieh and Olken, 2014).

In this paper, I exploit the natural experiment from Boston's quick electrification of its previously horse-drawn streetcar system during 1889-1896 in order to identify the causal effects of an upgrade of transportation infrastructure on the presence of sole proprietorships. This upgrade increased the speed of the best means of intra-city transportation from 4-5 mph to 8-10 mph, tripled transportation capacity, and enabled services to be provided at lower fares (Warner, 1962).[2] More importantly, the majority of the electric streetcar routes were upgraded from previous, long-existing horsecar routes, which avoided selection of the locations of the new transit lines. Because firms near the streetcar rails have better market access, according to the market segmentation hypothesis, we should be able to observe a relative increase in firm size near the streetcar rails compared to increases in off-rail areas after this technology shock.

While the electrification of streetcar systems took place in virtually every major US city in the late-nineteenth and early-twentieth centuries, two main reasons make Boston particularly well suited for my study. First, Boston followed a distinct direction when modernizing its commuting system. Unlike other major US cities that adopted a mixture of cable car systems and horsecar systems, Boston went directly to a more advanced, entirely electric streetcar

[2] "In 1900, the five-cent fare was almost universal, and no additional charge was needed for transfer rides. In contrast, during the 1870s and 1880s, two full eight-cent fares were typical if riders took two cars run by different companies."

system from a completely horse-drawn streetcar system in seven years. Second, there are two Boston peninsulas–Charlestown and East Boston–that were similar in size and proximity to the city center but that differed sharply in their connectivity to the city center in the study period. This contrast is helpful for testing the market segmentation hypothesis.

I assemble novel data to conduct the empirical analysis. I digitize a data set of the universe of the businesses from the top 25 *retail/wholesale* services/products (accounting for 20% of all businesses) in the *Boston Directories*–a source that resembles today's business yellow pages–for each five-year period between 1885 and 1905.[3] The original function of these directories was to provide information about every citizen and business in the city. I obtain the firms' addresses and legal forms, and correspond the sole proprietorships to the "mom-and-pop stores." This sole proprietorship dummy is the main outcome of interest. In order to analyze the spatial patterns of firms, I also georeference 1,660 plot-level historical city maps to identify the geographic coordinates of all their addresses. These results allow me calculate the distance between each firm and the nearest streetcar route to measure the intensity of shocks associated with the streetcar electrification.

Summary statistics show that the establishments highly gravitated toward the streetcar rails in my study context: 51% of the total establishments were located within 25 meters of the rails, and 81% of them were within 100 meters of the rails. I use the areas within 25 meters of the rails as the treatment locations, and the areas between 25 and 100 meters as the control locations, and apply a difference-in-differences strategy. Each observation is a location. The outcome variable is defined as the share of establishments that were sole proprietorships in each location. Under such narrows bins of treatment and control definitions, I find great heterogeneity in treatment effect across products: there is a strong treatment effect among food establishments, which account for 58.8% of the total establishments and

[3] I focus on analyzing the responses of the firms in the retail/wholesale sector, because the transactions in this sector mostly involved the movement of people, to which the upgrade of the commuter rails was highly relevant. The retail/wholesale sector is also interesting in itself because it features a particularly high self-employment rate. In 1910–the first year in which the census asks subjects their occupation types–the self-employment rate in the retail/wholesale sector was 0.32, while it was 0.17 in the aggregate non-agricultural sector.

64.7% of all sole proprietorship establishments in 1885, and there is no treatment effect among the other retail/wholesale establishments. The magnitude of the treatment effect for food is economically large: under my preferred specification, the share of sole proprietorships in rail-connected(treatment) locations experienced a 12.1-percentage point relative decline over ten years after the upgrade.

I then consider explanations for this heterogeneity. I show that the most plausible explanation is that the establishments in the treatment locations had better access to consumers than the establishments in the control locations. Because consumers are more sensitive to commuting costs to shop for food than to shop for the other products, which is supported by the consumer expenditure survey data, proximity to the rails was more important for food establishments than for nonfood establishments. In addition to this channel, another channel that strengthens the treatment effect among food is the thick left tail in the size distribution of food establishments. As land rents rose relatively in the rail-connected area after the transit upgrade, small establishments were more likely priced out of the rail-connected area.

I also find that the treatment effect for food decays very fast as one moves away from the streetcar rails. Compared to the area more than 100 meters away from the rails, the share of sole proprietorships declined sharply within 25 meters of the rails, and declined only modestly between 25 and 100 meters of rails. I show that this fast spatial decay rate can be understood as a combination of two effects. The first is that the consumers of food are sensitive to commuting costs. The second is that the streetcar system enabled the establishments to get access to a large consumer base from nonlocal neighborhoods. Because of the combination of these two effects, being located a short distance away from the rails made a significant difference in market access for firms. The Charlestown and East Boston case study provides evidence in support of this mechanism: in Charlestown which was better connected to central Boston, I find the treatment effect in this neighborhood is four times larger than the treatment effect in East Boston.

This paper contributes to three bodies of literature. First, it adds to a greater understanding of the prevalence of micro and small enterprises in the process of economic development. Besides the market segmentation hypothesis, existing explanations to this phenomenon include more limited entrepreneurial talent or managerial capital (Lucas, 1978; Bloom et al, 2013), higher regulatory and institutional barriers (Lewis, 1954; Harris and Todaro, 1970; De Soto, 1989; Rauch, 1991; Levy, 2008), and more severe contracting problems for hiring outside managers (Akcigit, Alp, and Peters, 2016) in developing countries than in the developed. By looking at a case when there was a discrete change in transport costs and presumably not in the other factors, this paper identifies the important role played by transportation technology in determining firm size. The dense streetcar network and the high decay rate of treatment effect as one moves away from streetcar rails signify a very high degree of market segmentation in the context of historical Boston. This is consistent with the fact that the vast majority of firms employed fewer than 10 workers and lends strong support to the market segmentation hypothesis.

Second, this paper is related to the literature on market integration and economic growth. Studies have exploited large shocks to transport costs, typically in the form of large-scale investments in inter-city transport infrastructure, and found that the market integration process is associated with changes in relative demand for skilled workers (Michaels, 2008), reduced regional price dispersion and improved welfare (Donaldson, 2012), increases in disparities in economic growth between peripheral and metropolitan regions (Faber, 2014), and increases in agricultural land values in areas with improved market access (Donaldson and Hornbeck, 2016). In this paper, I show that market integration process can also directly affect the organizational form of the basic economic units–firms.

Finally, this paper is related to a small but growing literature that uses highly detailed micro-geographic data to study the impact of urban rail infrastructure on the internal structure of cities. Brooks and Lutz (2016) document that the streetcar built between 1890 and 1910 in Los Angels County had long lasting effects on urban density today, despite the fact that it was removed entirely by 1963. Heblich, Redding, and Sturm (2017) use a quantitative urban model to study the impact of the invention of steam railways on the city size, structure and land prices for London from 1801 to 1921. Tsivanidis (2017) also uses a quantitative spatial equilibrium model to estimate the aggregate and distributional effects of a large-scale bus system in modern Bogota, Columbia. This paper focuses on how businesses reacted to a quick upgrade of their urban rail infrastructure, which has not been documented in a historical context where human and horsepower used to dominate the transportation. As it pertains to methodology, this paper contributes a new identification strategy that exploits the upgrade of existing transit routes to address the endogeneity associated with the non-randomness in new route placement. This strategy is distinct from three currently popular identification strategies in the literature, as reviewed in Redding and Turner (2014).

The remainder of this paper is organized as follows. Section 2 provides the historical background on the electrification of the streetcar system in Boston and describes the data. Section 3 presents summary statistics and discusses their implications for my empirical analysis. Section 4 introduces my empirical strategy and presents the main regression results. Section 5 examines the mechanism underlying the treatment effect. Section 6 concludes.

2 Historical Background and Data Construction

2.1 Historical Background

Up until the 1880s, most cities in the world relied on horsecar for intra-city transportation. There are four commonly cited disadvantages for this mode of transit. First, horsecars were slow. Even if rails were laid on streets to reduce friction, horsecars ran only at a speed of 4 to 5 *mph*, equivalent to the speed of a brisk walk. Second, feeding and caring for the animals was costly. Third, horsecars were unreliable under poor weather conditions. Finally, disposing of the huge quantity of waste that the horses deposited on the city's streets was an important sanitation problem.

Because of these disadvantages of horsecars, in the late-nineteenth century, almost every major American city put efforts into modernizing intra-city transit systems. However, Boston was the winner of this race, in the sense that it was the first to build a large-scale city-wide electric streetcar system. There are two driving factors to Boston's success. The first is the narrow, winding streets of Boston that discouraged the use of cable-cars. In the 1880s, the cable-car system had been set up in several US cities despite the high expense and complex maintenance and operation. However, the difficulty in implementation of cable-cars in Boston invigorated the development of a more efficient system, which culminated in the significant advancement of electric streetcars. The second driving force is the role played by the great entrepreneur and president of the West End Street Railway Company, Henry Whitney (Most, 2014). In 1888, after consolidating Boston's horse-drawn street railway companies under one company, Whitney was ready to modernize the horsecar system. Right before he decided to adopt a cable system, Whitney was invited by an engineer, Frank Sprague, to see a demonstration of an electric street rail in Richmond, Virginia. Whitney was very impressed and quickly abandoned the cable car idea. The West End Street Railway Company then pioneered in meeting the engineering challenge. They made rapid progress in designing and constructing an advanced electric power system for Boston's rapid transit, which attracted the attention of electrical engineers from all across the country. As one major electric journal put it at the time:

The West End Street Railway company of Boston is making rapid progress in the equipment of its line with the Thomson-Houston system and work this winter. The permanent power plant will be a model of its kind, and when completed the largest and best equipped in the world. ⋯ before long the electric car will be a familiar sight in the heart of the city.

The fast pace of this work can also be seen from the percent of mileage that was run as an electric system, presented in the *Annual Report of the West End Street Railway Company.* The left subfigure of Figure 1 documents this statistic annually in my study period, from 1885 to 1905. Starting from an entirely horse-drawn system in 1888, the company completely electrified the system over the next eight years. Another indicator of this fast pace is the transportation-horse population in Boston, which dropped from 7,684 in 1888 to 487 by 1897, as shown in the right subfigure of Figure 1.

Compared to the horse-drawn system, the new electricity powered streetcar system had a number of advantages: First, electric cars ran much faster–8 to 10 miles per hour compared to 4 to 5 miles per hour for horse-powered vehicles.[4] Second, the electric system was much more reliable in bad weather. Third, the carrying capacity tripled compared to that of horsecars. Fourth, the city was able to avoid the pollution generated by animals, making the streets much cleaner than before. Fifth, the marginal costs of the services were lower, so that the fares were reduced by at least one half (Warner, 1962). Compared to the cable car system of other cities, the electric streetcar system was cheaper, more practical, and safer. By 1905, as a consequence of Boston's success, most cable car systems in other US cities were replaced by the electric system. (Vuchic, 2007).

2.2 Data on Streetcar Routes

I obtained digital city maps of Boston in 1888 and 1901 from the online David Rumsey Historical Map Collection, which contained streetcar routes and legible street names. I then georeferenced the two maps such that the points of each of the two city maps were geographically aligned with a common 1930 street centerline shapefile, which I retrieved from the Historical Urban Ecological data set, created by the Center for Population Economics.

Figure 2 shows the streetcar routes in Boston at the two points of time: 1888 in blue, which is one year before the electrification, and hence, using an entirely horse powered system; and 1901 in blue and red, which is four years after complete electrification. Not surprisingly, the technology upgrade was associated with the substantial expansions of previous streetcar lines. For identification, I use the preexisting routes before the electrification as the basis for calculating proximity to the rails. We see that the 1888 routes were already

[4] The speed takes into account average traffic conditions.

extensive and that they covered the core areas of Boston. The new lines put in between 1888 and 1901 were primarily placed in suburban residential areas. I lose only 0.4% of business establishment observations by excluding those near the newly expanded lines.

2.3 Data on Firms

I digitized the primary data source for the firms from the *Boston Directories* published by the Sampson, Murdock, & Company, and printed annually. Each of these volumes consists of two main sections. The first section lists the names of the inhabitants and firms, their occupations/products, and the places of the business and dwelling houses. Generally, the inhabitants in the directories were in the labor force.[5] For firms, the names of partners are typically listed. The second main section of each volume is the business directory. It uses only the firms from the first section, categorizing them according to product/occupation (e.g., lawyers, grocers, bakers, dry goods, etc.), and then providing street addresses for each. A small portion of the firms (4%) have multiple addresses/establishments. I constructed most of the variables in my empirical analysis using the establishments instead of the firms. I obtained scanned images of the full directories for the years 1885, 1890, 1895, 1900, and 1905 from the genealogy website Ancestry.com. I digitized all of the establishments for the 25 most frequent retail/wholesale products from the business directory section. These 25 products are listed in Table 1 in the online appendix. When I matched individuals from the *Boston Directories* with other data sources, I directly worked with the scanned images.

From the names of the establishments in the *Boston Directories*, we can distinguish three legal forms of establishments: (1) sole proprietorships, identified as those listings showing names of individuals rather than business names; (2) partnerships, defined as the names in the format of *A* & *B* (e.g., *Whitcher* & *Emery*), *A Bros* (e.g., *Abbott Bros*), or *A* & *Sons* (e.g., *Reynolds S. H.* & *Sons*); and (3) companies (corporations), identified as those with

[5] In the 1789 Boston Directory, the first issue, the cover shows that it contained "a list of the merchants, mechanics, traders, and others, of the town of Boston; in order to enable strangers to find the residence of any person."

the word "Company (Corporation)" in their names (e.g., *Gilchrist Co*). I use a sole proprietorship dummy to proxy for establishment size, and correspond these establishments to "mom-and-pop" stores.

To verify that the sole proprietorship status is a good proxy for firm size, I collected and digitized a supplementary dataset for the firms–R.G. Dun & Co's *Mercantile Agency Reference Books*. These books cover a wide range of businesses in the United States and Canada, containing their names, main product lines, estimated net worth (pecuniary strengths, grouped into 17 size categories), and credit ratings (8 classes). I digitized the Boston sections of these books for 1885 and 1899. I then manually matched 1,736 firms between the *Boston Directories* and the credit rating reference books, which allowed me to compare the estimated net worth by the legal form of establishment.[6] The details of this dataset and the matching are described in the online appendix.

The mean, 25th-, 50th-, and 75th percentiles of the estimated net worth are shown in Table 1. We can see that there was a very sharp contrast in the estimated net worth between the sole proprietorships and the other two legal forms: the median net worth of the sole proprietorships was only one tenth of the median net worth of the second smallest legal form, partnerships, but there was no significant difference between the companies (corporations) and the partnerships. The net worth of a median sole proprietorship was $\$1,500$, or 5.5 times of the gross domestic product (GDP) per capita in 1900. These facts lend creditability for treating sole proprietorships as a qualitatively different business form.

Finally, because the *Boston Directories* contain a more comprehensive list of firms than the credit rating reference books, and the credit rating reference books are missing for the years 1889-1898, I used the *Boston Directories* as the main data source in the empirical analysis.

[6]Using the rating key (shown in Figure 5 in the online appendix), I converted the letter ratings into numeric values. I assigned the mean of the value range for each letter rating of pecuniary strength. For example, the letter K stands for estimated pecuniary strength of $\$1000 - \$2000$. I assigned \$1500 to every K rating.

2.4 Plot-Level City Maps

The key to combining the digitized streetcar routes data and the establishment-level data is to geocode the addresses of the establishments using contemporaneous city maps. I georeferenced 1,660 plot-level *Sanborn Fire Insurance Maps* of Boston published during the period 1895-1900, which, altogether, covered the entire Boston area. I then manually extracted the street name and number of every building on the maps to a GIS shapefile, generating a point shapefile of 100,743 buildings (Figure 6 in the online appendix shows a sample map). The geographic coordinates of each building were calculated in ArcGIS and then matched to the addresses in the *Boston Directories* by street name and number.[7] For all of the establishments in this study, 95% of them could be geocoded.

The empirical analysis benefited from geocoding the addresses in the *Boston Directories* in three specific ways. First, I was able to calculate the distance of each establishment to the nearest streetcar route. This distance allowed me to define whether an establishment was treated or not. Second, I was able to create a panel data set of fixed geographic locations over time. These fixed geographic locations served as the units of the regressions. Third, the exact location information allowed me to control for the fixed effects of a larger geographic area and adjust for spatial and serial correlations in the error term.

3 Descriptive Statistics

3.1 Statistics on Streetcar Network

Table 2 presents statistics about the spatial distribution of the streetcar routes and the business establishments (for the 25 products). The first row of the table shows the average distance between evenly distributed points (every 50 meters) and the nearest streetcar route. This statistics indicates the density of the streetcar network. We see that the density varied

[7]For special addresses, such as "Street A corner Street B," I manually located them on the georeferenced maps.

a lot by distance to the city center (City Hall). Within 1 km of City Hall where businesses were concentrated, a random point in this area was only 281 meters away from the nearest streetcar route. In contrast, in the areas 2 kilometers farther away from City Hall, a random point is 4,369 meters away from the nearest streetcar route. The second to fourth rows of the table show that the actual spatial distribution of the business establishments gravitated highly toward the streetcar rails. From the second row, third column of the table, we can see that even in the areas 2 kilometers farther away from City Hall, a typical establishment was just 101 meters away from the nearest route. In the whole city, 51% of the establishments were located within 25 meters of the streetcar rails, and 81% of the establishments were located within 100 meters of the streetcar rails. Therefore, in most of the empirical exercises in this study, I use the narrowest possible threshold–25 meters–to define the treatment locations,[8] and define the areas between 25 meters and approximately 100 meters of the rails as the control locations.[9]

Such narrow bandwidths for defining the treatment and control locations have implications for the mechanisms of the impact of this event. Because the treatment and control locations are about 75 meters apart from each other, if we observe a treatment effect, it is unlikely due to differential access of the firms to the labor market: an additional 75 meter walking distance is almost negligible to workers.[10] On the other hand, access to consumers is a more plausible mechanism, especially for products whose consumers are sensitive to commuting costs.

3.2 Statistics on Products and Empirical Implications

Guided by the empirical findings in the previous subsection, I build a simple model to analyze the impact of the streetcar electrification on firm size. The details of the model

[8]25 meters is the average distance between the centerlines of the streetcar routes and the edge of the rail-connected streets.

[9]In this study, "control" locations are also affected by the treatment, but to a lesser degree.

[10]The median commuting distance of the workers in this period is 3 kilometers, calculated from the place of work and place of residence information in the Boston Directories.

are provided in the online appendix. Here I describe a sketch. In my model, population is exogenous. Locations differ by market access to consumers. Firms differ by productivity. Firms sort according to market access. In equilibrium, better market access is reflected in higher land rent. The electrification of the streetcar system is modeled as a reduction in commuting cost along the streetcar rails. This shock results in a resorting between firms and market access and changes in firm size. The treatment effect is defined as changes in the firm size differences between along-rail locations and nearby off-rail locations after the shock.

Two product characteristics turn out to be critical to the magnitude of the treatment effect. The first characteristic is consumers' sensitivity to commuting cost, measured by the ratio of the cost of commuting to the cost of goods, which I call τ hereafter. I expect a stronger treatment effect among high τ products. The second key parameter is related to the firm size distribution. An upgrade of the transit system will improve the market access in the along-rail locations. Complementarity between firm size and market access implies that large firms can better take advantage of market access and outbid small firms in land rent in these locations. If there is a large fraction of small firms in an industry/a product, (or more generally, a thick left tail in the firm size distribution,) then we will see a large decrease in the share of small firms in the along-rail locations for this industry/product.

In this subsection, I show evidence that food products exhibit both a higher τ and a thicker left tail in the firm size distribution compared to the other retail/wholesale products. First, I impute τ–the cost of commuting to the cost of goods ratio–for each product using contemporary consumer expenditure data. Specifically, I use the 1996 Consumer Expenditure Survey and match its products to the 25 products in my Boston data.[11] The details of this match are provided in the online appendix. The data allow me to calculate four statistics related to τ: the costs per item, the number of items purchased per week, the number of trips consumers took each week to purchase any item of this product, and the number of

[11] 1996 is the first year for which this survey is publicly available.

trips the consumers made for purchasing every \$100 of this product. I take the last variable as the most relevant measure of τ, and thus order the products by this measure in Table 3, from highest to lowest.

I find that food-related products feature a low value per item, a high purchase frequency, and more trips made by consumers for every \$100 purchase. These patterns suggest that τ is higher for food for consumers today. In my study period, there was no domestic refrigerator, and food stores were more specialized than they are today. Thus, the purchase frequency for food at that time could have been even higher.

Second, I compare the firm size distribution between food products and the other products. I use net worth as the measure of firm size, which is available from the credit rating reference books. The firm data sample is the 1,736 firms matched between the Boston Directories and the credit rating reference books, described in Section 2.3. The firm size distributions for each type of product are plotted in Figure 3. It can be clearly seen that the food firms have a much thicker left tail in their size distribution.

Therefore, because of these two characteristics, according to the model, if there is any treatment effect, we should expect that the effect will be stronger among food-related products. In the subsequent empirical exercises, I divide the sample into food-related products and nonfood products, and report results using these two subsamples, respectively.

4 Empirical Strategy and Results

4.1 Econometric Specifications

I use fixed geographic locations as the units of the regressions, which I call *plots* hereafter. The outcome variable is the share of establishments that were the sole proprietorships in each plot. The main empirical analysis compares the changes in plots with direct rail connections (treatment) to the changes in neighboring unconnected plots (control).

I use Figure 4 to illustrate my construction of a *plot*. Here, I first divide the entire Boston area into $200m \times 200m$ blocks.[12] I then drop the blocks that do not intersect with any portion of the 1888 streetcar rails. For example, I drop Block 3 in Figure 4. The rest of the blocks are then separated by the rails into two plots: the first plot is a bin enclosing all of the establishments on the rail-connected streets, indicated by the purple areas. The second plot is the remainder of the areas within the block, indicated by the light blue areas. I define the first type of plots as the treatment locations, and the second type of plots as the control locations.

To estimate the causal effects of the upgrade of the transportation infrastructure on the share of sole proprietorships, I estimate the following econometric specification

$$\text{Sole}_{ijt} = \beta_0 \text{Post}_t + \beta_1 T_i + \beta_2 \text{Post}_t \times T_i (+\gamma_j \times \theta_t) + \epsilon_{ijt} \tag{1}$$

where i denotes the plots, j denotes the blocks, t denotes the years, and $Sole$ is the share of establishments that were sole proprietorships. T_i is the treatment dummy: $T_i = 1$ indicates that i is a connected plot, and $T_i = 0$ indicates that i is a neighboring unconnected plot. $Post_t = 1$ indicates a post-electrification period, and $Post_t = 0$ otherwise. $\gamma_j \times \theta_t$ are block-by-year fixed effects. When these fixed effects are controlled for, the identification assumption is that the pair of plots within each block would have undergone similar time trends in the absence of the electrification of the streetcar system. Finally, β_1 measures the average difference in outcome between the connected plots and unconnected plots before the treatment. β_2 is the coefficient of interest, which measures how much more the outcome changed between the connected plots and unconnected plots after the treatment.

I estimate equation (1) using only the 1885 and 1905 data to capture the cumulative impact of the streetcar electrification. I do not use intermediate years because the 1890 data

[12] A small block size increases the number of observations and the significance of the statistical inferences, but the number of establishments in some blocks could fall to zero, which would result in an unbalanced panel data set. I choose 200 m as the block size to balance the trade-off. In robustness checks, I also try block sizes of 300 m and 400 m.

could reflect people's expectations about the progress of the streetcar electrification. (This project was announced in 1888.) In all specifications, the standard errors are clustered by block to adjust for serial correlation and within-block spatial correlation. The regressions weight each plot by the number of establishments in 1885.

4.2 Evolution of Outcomes

I illustrate my main findings in Figures 5 and 6. Figure 5 depicts the time trends in the weighted average of the share of sole proprietorships across rail-connected plots and unconnected plots in dashed lines and solid lines, respectively, only for food establishments. The two vertical dashed lines indicate the time window when the electrification took place. By visual inspection, we see that both the levels and trends in outcome were very similar between the two groups of plots before the completion of the electrification. In Table 2 in the online appendix, I confirm that the differences in the levels and trends in outcome are indeed close to zero and statistically insignificant. Figure 6 depicts the same time trends, restricting the sample to nonfood establishments. We observe that the pre-trends were parallel between the two groups of plots until 1890. There was a 3.5-percentage point difference in outcome in 1885, but this difference was statistically insignificant, as shown in the third column of Panel B in Table 2 in the online appendix. Overall, the evidence supports my assumption that the rail-connected plots and the unconnected plots would have changed similarly in the absence of the streetcar electrification.

The model predicts that average establishment size will diverge between rail-connected plots and unconnected plots after the electrification for food establishments, while the impact on nonfood establishments is ambiguous. The trends in Figures 5 and 6 are consistent with this prediction. In Figure 5, we can see that prior to the electrification, the gap in the outcome between the two groups of locations was almost 0. At the end of the study period, this gap had widened to 8.8-percentage points. Considering that the rail-connected plots were, on average, within 25 meters of the rails, while the unconnected plots were, on average, between

25 meters and 100 meters away from the rails, this magnitude of relative drop implies that the commuting costs for consumers to purchase food must have been very significant. In Figure 6, the time trends suggest no treatment effect on nonfood establishments. The gap in outcome between the two groups of locations had narrowed from 3.5-percentage points to 0. At the aggregate level, which is not shown in the figures, the share of sole proprietorships in the whole city had declined from 82.5% in 1885 to 66.7% in 1905 among food establishments, and had declined from 54.6% in 1885 to 48.7% in 1905 among nonfood establishments.

4.3 Benchmark Regressions

Table 4 reports estimated impacts on the plot-level share of sole proprietorships in the rail-connected areas relative to the plots in the unconnected areas under specification (1). Columns (1) and (2) report estimates for food establishments, and columns (3) and (4) report estimates for nonfood establishments. Columns (1) and (3) do not include controls, and columns (2) and (4) include block-by-year fixed effects. I examine estimated coefficients column by column.

In column (1), the coefficient on $Treatment$ is 0.007, suggesting that the average shares of sole proprietorships in 1885 were almost identical between the rail-connected plots and the unconnected plots. The coefficient for $Post$ reflects that over the 20 years, there was an 11.1-percentage point overall drop in outcome in the control. The coefficient on $Treatment * Post$ is -0.088, which shows that the share of sole proprietorships in the treatment experienced an 8.8-percentage point relative drop, or an $11.1 + 8.8 = 20$-percentage point overall drop between 1885 and 1905. Column (2) includes block-by-year fixed effects to capture differential time trends in each block. Under this preferred specification, the estimated coefficient on $Treatment * Post$ is -0.121, meaning a 12.1-percentage point relative drop in the treatment. All the coefficients for $Post$ and $Treatment * Post$ in columns (1) and (2) are significant at the 1% level. Overall, these results suggest that there exists a strong treatment effect among food establishments.

Columns (3) and (4) repeat the same estimates for nonfood establishments. In column (3), the coefficient on $Treatment$ suggests that the rail-connected plots have a 3.5-percentage point higher share of sole proprietorships in 1885. Between 1885 and 1905, the share of sole proprietorships experienced a 3.7-percentage point drop in the unconnected plots, and a $3.7 + 3.6 = 7.3$ percentage point drop in the rail-connected plots, as suggested by the coefficients on $Post$ and $Treatment * Post$. In the end of this period, the gap in outcome between the rail-connected and unconnected plots become close to zero, confirming the patterns in Figure 6. In column (4), we observe that the coefficient for $Treatment$ exhibits the opposite sign as in column (3), and the coefficient on $Treatment*Post$ has the same sign and a similar magnitude as in column (3). However, none of these coefficients is precisely estimated. In summary, there is no evidence suggesting a treatment effect of the streetcar electrification on the presence of sole proprietorships among nonfood establishments.

4.4 Robustness to Block Size and Treatment Threshold

Table 5 examines the robustness of the benchmark results to different block sizes and distance thresholds to define the treatment group. From columns (1) to (4), I vary the size of blocks between 200, 300, and 400 meters. In column (4), I include two bins of treatment in the regressions–the first bin is between 0 and 25 meters of the rails, and the second bin is between 25 meters and 100 meters of the rails. I include these two bins only when the block sizes are $400m \times 400m$ in order to allow enough establishment observations in the area 100 meters or farther away from the rails.

In the upper panel of Table 5, which reports results for food establishments, I find that the key coefficients of interest, those on $Treatment(0 - 25m)$, are consistently negative and significant at the 1% or 5% level. From columns (1) to (3), the magnitude of these coefficients ranges from 0.108 to 0.121 as the block sizes increase from 200 to 400 meters. The results in column (4) reveal the spatial decay rate of the treatment effect: compared to the area 100 meters or farther away from the rails, the area within 25 meters of the rails experienced a 13.5-percentage point relative drop in outcome, while the area between 25 meters and 100 meters away from the rails experienced only a 2.8-percentage point relative drop. This suggests a very fast spatial decay rate of the treatment effect for food establishments. On the other hand, the results in the lower panel of the table indicate that when we vary the block sizes and distance thresholds of the treatment, the coefficients are consistently imprecisely estimated and smaller in magnitude.

To best visualize the results, I plot the average changes in the share of sole proprietorships by product and geography in Figure 7. The vertical axis represents percentage point changes in outcome. The horizontal axis represents distance from the city center. The bars in different colors indicate different distances from the streetcar rails. The left subfigure of Figure 7 again reveals a fast spatial decay rate of the treatment effect: the decline is sharpest within 25 meters of the rails, and then becomes much smaller between 25 and 100 meters away from the rails. Moreover, the treatment effect for food takes place at every distance from the city center. In contrast, in the right subfigure, we find that the patterns for nonfood products are mixed. This explains why we have imprecisely estimated treatment effect for nonfood products in the regressions in Tables 4 and 5.

Taken together, Tables 4 and 5 and Figure 7 suggest that there exists a strong treatment effect of the streetcar electrification on the presence of sole proprietorships for food retail/wholesale establishments, which decays fast as one moves away from the streetcar rails. On the other hand, there is no evidence for the existence of treatment effect among nonfood retail/wholesale establishments.

5 Mechanisms

In this section, I examine the mechanism behind the treatment effect. In Section 5.1, I examine explanations for the heterogeneous treatment effects by product. In Section 5.2, I provide further evidence for the market segmentation hypothesis.

5.1 Explanations for the Heterogeneous Treatment Effects by Product

In Section 3.2, I mentioned two reasons why we expect to see a stronger treatment effect among food products. In this subsection, I provide evidence which supports both reasons. The first reason is that consumers are more sensitive to commuting costs to shop for food. I used τ–the number of trips the consumers made for purchasing every \$100 of a product– to measure this sensitivity at the product level. In Table 3, I showed that food products feature a high τ compared to the other products. While there is a high correlation between τ and the food/nonfood status, such a mapping is not one-to-one. To lend further support to this hypothesis, I reclassify the products into two groups according to τ instead of the food/nonfood status, and rerun the benchmark regressions in Table 4.

The regression results by τ are reported in Table 6. Columns (1) and (2) report estimates for high τ products, and columns (3) and (4) report estimates for low τ products. Columns (1) and (3) do not include controls, and columns (2) and (4) include block-by-year fixed effects. Columns (1) and (2) show that the coefficients on the interaction term are -0.111 and -0.122, respectively. The magnitude of both coefficients is greater than their counterparts in Table 4. (0.111 v.s. 0.088 in column (1), and 0.122 v.s. 0.121 in column (2).) In columns (3) and (4), the coefficients on the interaction term are smaller and imprecisely estimated. These results suggest that τ is an important product characteristic that determines the magnitude of the treatment effect.

I also visualize the average changes in the share of sole proprietorships by τ and geography in Figure 8. The left subfigure plots the outcome among high τ products. We see that there is a strong treatment effect within 25 meters of the rails and it decays rapidly with distance from the streetcar rails. This is consistent with the explanation that consumers are sensitive to commuting costs to shop for high τ products. For low τ products, the right subfigure shows very heterogeneous changes in outcome across different distances to the rails. A possible interpretation of this result is that consumers are insensitive to commuting costs to shop for low τ products, so distance from the rails does not matter.

The second possible reason why there is a stronger treatment effect among food is that food firms had a thicker left tail in their size distribution. As land rents rose in response to the upgrade in the transit system, small businesses were more likely to be priced out of the rail-connected areas. To test this hypothesis, I divide the benchmark regression data into two samples of locations. The first sample has an 1885 share of sole proprietorships above the median, and the second sample has a share below the median.[13] The first sample is supposed to contain a larger share of small firms. If this mechanism is at work, we expect to see a stronger treatment effect in the first sample.

Table 7 presents results of this exercise both for food products (the upper panel) and for nonfood products (the lower panel). Columns (1) and (2) use the sample of locations with the share of sole proprietorships in 1885 above the median, and columns (3) and (4) use the sample of locations below the median. Again, columns (2) and (4) include block-by-year fixed effects. Comparing the coefficients on $Treatment \times Post$ in columns (1) (2) to those in columns (3) (4) respectively in the upper panel, we see that under both specifications, there is a much larger treatment effect in the first sample. This result indicates that the initial share of small businesses does matter for the magnitude of the treatment effect for food. Because Figure 3 shows that food firms had a much thicker left tail in their size distribution, one might conjecture that the differences in treatment effect between food and nonfood could have been mainly explained by the differences in the firm size distribution. However, the lower panel of Table 7 suggests this is unlikely to be the case. When I divide the locations into two samples according to the 1885 share of sole proprietorships in all nonfood businesses, the treatment effect does not show any substantial difference in these two samples. The nature of the product appears to be important in the first place.

[13] Here the locations refer to the blocks.

In summary, the evidence in this subsection supports the two reasons why there is a stronger treatment effect among food: food products feature a higher τ, and food firms had a thicker left tail in the size distribution. The first reason is plausibly more critical. Because if τ is sufficiently large, then being located a short distance away from the rails made a significant difference in market access for firms. This difference in market access resulted in a firm sorting. Better market access coupled with higher firm productivity led to a larger average firm size in the rail-connected area. A thick left tail in the firm size distribution potentially magnified the treatment effect because small firms were more affected by the sorting process. On the other hand, if τ is very small, then distance from the rails did not matter for market access. Firm sorting would not occur. Consequently, we do not observe any treatment effect for this type of product.

5.2 Further Evidence for the Market Segmentation Hypothesis

Market access has been the key factor to explain the estimated treatment effects. The previous analysis equalizes proximity to the streetcar rails to better market access for firms. Yet we know little about how proximity to the streetcar rails improved market access. There are two interpretations. The first interpretation is that the streetcar system allowed nearby firms to get access to consumers from nonlocal neighborhoods. After the upgrade in this system, previously segmented neighborhoods were better connected, and the firms in rail-connected areas were able to reach more distant markets. A second possible interpretation is that wealthier residents highly gravitated toward the streetcar rails. If the consumption of retail goods was highly localized, proximity to the streetcar rails implied proximity to a wealthier local consumer base for firms. The electrification of the streetcar system could have caused gentrification near the rails, which would have enhanced such an advantage. The first interpretation of market access is more consistent with the market segmentation hypothesis described in the introduction.

The fundamental difference between these two interpretations lies in how localized the consumer markets were. The specific geography of Boston provides a useful case to tell which interpretation is more likely to be true. In Boston, there are only two peninsulas, Charlestown and East Boston. (Their precise locations are shown in Figure 2.) These two peninsulas were similar in population size, geographic area, and distance to the city center. Since the late-eighteenth century, Charlestown was connected to central Boston by bridges,[14] and the streetcar electrification included the portion of the streetcar rails on the bridges. However, East Boston was not connected to central Boston by any walkable roads until the opening of the East Boston (streetcar) Tunnel in 1904. Thus, the streetcar electrification in the early 1890s shortened the distance between Charlestown and central Boston, while East Boston remained largely isolated from the city center. Therefore, we expect that the treatment effect of the streetcar electrification should be stronger in Charlestown than in East Boston.

Figure 9 shows the overall trends in the share of sole proprietorships in these two neighborhoods. Between 1885 and 1905, this share declined by 12.5-percentage points in Charlestown, while there was only a 3.5-percentage point drop in East Boston. Taking the share of sole proprietorships as an inverse measure of average establishment size, it suggests that the average establishment size grew much more in Charlestown than it did in East Boston.

Next, I rerun the benchmark regressions for food in Table 4, dividing the sample into three areas: Charlestown, East Boston, and central Boston. I show the results for each area in Table 8, respectively. Again, the regression results reveal a stark contrast between Charlestown and East Boston. Comparing column (1) to column (3), and column (2) to column (4), the coefficients on $Treatment * Post$ are much larger in Charlestown than in East Boston. (0.182 v.s. 0.039 without fixed effects, and 0.204 v.s. 0.052 with fixed effects). Quite plausibly, the bridges enabled Charlestown businesses to reach consumers from central Boston, and rail connections were particularly important to reach such a consumer base. For

[14]The first bridge in this area was the old Charles River Bridge, chartered in 1785 and opened on June 17, 1786

businesses located in East Boston, the streetcar rails could not reach nonlocal markets, and thus, they were less important there.

So far I have shown evidence consistent with the first interpretation of market access. In the rest of this subsection, I also show that there is evidence inconsistent with the assumption of the second interpretation, that is, I show the upgrade of the streetcar system did not cause gentrification along the streetcar rails. Therefore, proximity to the rails was not associated with access to a wealthier consumer base.

To determine whether gentrification occurred, I constructed a small panel data of individuals with information on their residence and income. Because the Boston Directories do not contain information on income, I merged a random sample of individuals from the 1900 census micro data to the 1900 Boston Directory.[15] These individuals' occupation income score from the census data was used as the proxy for income.[16] Then, from these matched individuals in 1900, I traced them back to the 1887 Boston Directory, obtaining their residence in that year.[17] I chose 1887 as the beginning year because at that time, the electrification of the streetcar system was almost unpredictable, and therefore we can avoid the possibility that people might have sorted in anticipation of this event. The final data product is a panel of 471 individuals who lived in Boston both in 1887 and 1900, with information on their exact locations of residence, occupations, and occupation income scores.

In Figure 10, I examine whether gentrification occurred along the streetcar rails. Each dot in the figure represents an individual. The horizontal axis stands for distance between the individuals' residences and the streetcar rails in 1887, and the vertical axis stands for this distance in 1900. The left subfigure contains the individuals whose occupation income score was above the median, and the right subfigure contain those whose occupation income score was below the median. If gentrification occurred along the rails, we should observe that the dots in the left subfigure concentrate to the lower-right of the 45 degree line–indicating that

[15] These individuals were male, household heads, aged between 30 and 50 in 1900 in Boston. I merged individuals in these two data sources by name, occupation, and residence. The matching rate is 65%

[16] See Abramitsky et al. (2014) for a discussion of this variable as a proxy for personal income.

[17] The overtime matching rate is around 50%.

the relatively rich individuals moved toward the rails, and the dots in the right subfigure concentrate to the upper-left of the 45 degree line or scatter over the figure–indicating that the relatively poor individuals moved farther away from the rails or moved randomly in terms of distance from the rails. In fact, visual inspection suggests that the dots scatter very randomly in both subfigures. Using a regression line to fit each scatter plot, we see that in both subfigures the fitted lines have a slope of slightly less than 45 degrees. Moreover, the fitted line in the right subfigure is farther away from 45 degrees. These patterns imply that both the rich and the poor moved a little closer to the streetcar rails after the upgrade, and on average, the poor moved even closer to the rails. Therefore, there was no gentrification along the rails. [18]

6 Conclusion

In this paper, I use a natural experiment–the electrification of the streetcar system in Boston between 1889 and 1896–to provide the first causal evidence that an upgrade of transport infrastructure leads to a decrease in the share of sole proprietorships. To do so, I digitized and geocoded business data for the universe of the top 25 retail/wholesale products, as well as the city transit network data in Boston between 1885 and 1905. The identification strategy exploits the fact that the new electric system was quickly upgraded, while keeping the preexisting horse-drawn streetcar routes almost unchanged.

Using a difference-in-differences estimator, I find that rail-connected locations experienced a sharp relative decline in the share of sole proprietorships among food establishments after the electrification, and this effect did not exist for nonfood establishments. The magnitude of the treatment effect among food is big and decays quickly as one moves away from the rails–compared to the area 100 meters or farther away from the rails, the area within 25

[18] In Figure 7 in the online appendix, I also show residential sorting patterns in terms of distance from the city center. I find that both the rich and the poor moved farther away from the city center after the streetcar electrification. However, there was no substantial difference between the two income groups. Therefore, gentrification did not occur in the "suburbs" either.

meters of the rails experienced a 13.5-percentage point relative drop in outcome, while the area between 25 meters and 100 meters away from the rails experienced only a 2.8-percentage relative drop. Further analysis reveals that this treatment effect for food can be understood as a combination of two effects. The first is that the consumers of food are sensitive to commuting costs. The second is that the streetcar system enabled the establishments to get access to a large consumer base from nonlocal neighborhoods. Because of the combination of these two effects, being located a short distance away from the rails made a significant difference in market access for firms.

The results of this paper have implications for the theories of the firm size distribution. Existing explanations for the prevalence of micro and small enterprises in the process of economic development emphasize regulatory and institutional barriers, which distort the firm size distributions by disfavoring either small or large firms. In my study context–historical Boston between 1885 and 1905–institutions had been quite stable, but we still observe a quick shift in the firm size distribution. The evidence in this paper points to the important role played by transport infrastructure improvements, which lends support to Chandler (1977) and Lagakos (2016).

The results of this paper also have implications on resource (mis)allocation across firms. Hsieh and Klenow (2009) document that there exists a higher degree of resource misallocation across firms in China and India than in the US. This paper suggests a potential source of misallocation at a low level of economic development: the geographic segregation of markets, which enables a large number of low-productivity entrepreneurs to stay away from competition with more productive, larger firms. An improvement in transport infrastructure could improve the resource allocation across firms by inducing more productive firms to move into more advantageous locations, which would enlarge their market shares.

References

Abramitzky, Ran, Leah Platt Boustan, and Katherine Eriksson, "A Nation of Immigrants: Assimilation and Economic Outcomes in the Age of Mass Migration," *Journal of Political Economy*, June 2014, *122* (3), 467–506.

Ahlfeldt, Gabriel M., Stephen J. Redding, Daniel M. Sturm, and Nikolaus Wolf, "The Economics of Density: Evidence From the Berlin Wall," *Econometrica*, November 2015, *83* (6), 2127–2189.

Atack, Jeremy, "Returns to Scale in Antebellum United States Manufacturing," *Explorations in Economic History*, November 1977, *14* (4), 337–359.

_ , "Industrial Structure and the Emergence of the Modern Industrial Corporation," *Explorations in Economic History*, January 1985, *22* (1), 29–52.

_ , "Firm Size and Industrial Structure in the United States During the Nineteenth Century," *The Journal of Economic History*, June 1986, *46* (02), 463–475.

_ **, Fred Bateman, and Robert A. Margo**, "Steam power, Establishment Size, and Labor Productivity Growth in Nineteenth Century American Manufacturing," *Explorations in Economic History*, April 2008, *45* (2), 185–198.

_ **, Matthew Jaremski, and Peter L. Rousseau**, "American Banking and the Transportation Revolution before the Civil War," *The Journal of Economic History*, December 2014, *74* (04), 943–986.

Barr, Jason and Troy Tassier, "The Dynamics of Subcenter Formation: Midtown Manhattan, 1861-1906," *Journal of Regional Science*, 2016.

Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum, "Plants and Productivity in International Trade," *The American Economic Review*, September 2003, *93* (4), 1268–1290.

Billings, Stephen B., "Estimating the Value of a New Transit Option," *Regional Science and Urban Economics*, November 2011, *41* (6), 525–536.

Bowes, David R. and Keith R. Ihlanfeldt, "Identifying the Impacts of Rail Transit Stations on Residential Property Values," *Journal of Urban Economics*, July 2001, *50* (1), 1–25.

Brooks, Leah and Byron Lutz, "Vestiges of Transit: Urban Persistence at a Micro Scale," *Working Paper*, 2016.

Chandler, Alfred D., *The Visible Hand: The Managerial Revolution in American Business*, Harvard University Press, 1977.

_ **and Takashi Hikino**, *Scale and Scope: The Dynamics of Industrial Capitalism*, Belknap Press, January 1990.

DeSoto, Hernando, *The Other Path: the Invisible Revolution in the Third World*, Harper & Row, 1989.

Donaldson, Dave and Richard Hornbeck, "Railroads and American Economic Growth: A "Market Access" Approach," *The Quarterly Journal of Economics*, February 2016.

Gibbons, Stephen and Stephen Machin, "Valuing Rail Access Using Transport Innovations," *Journal of Urban Economics*, January 2005, *57* (1), 148–169.

Gollin, Douglas, "Nobody's Business but My Own: Self-Employment and Small Enterprise in Economic Development," *Journal of Monetary Economics*, March 2008, *55* (2), 219–233.

Guerra, Erick, Robert Cervero, and Daniel Tischler, "Half-Mile Circle: Does It Best Represent Transit Station Catchments?," *Transportation Research Record: Journal of the Transportation Research Board*, December 2012, *2276*, 101–109.

Harris, John R. and Michael P. Todaro, "Migration, Unemployment and Development: A Two-Sector Analysis," *The American Economic Review*, 1970, *60* (1), 126–142.

Hewitt, Christopher and W. E. Hewitt, "The Effect of Proximity to Urban Rail on Housing Prices in Ottawa," *Journal of Public Transportation*, December 2012, *15* (4).

Holmes, Thomas J. and John J. Stevens, "An Alternative Theory of the Plant Size Distribution, with Geography and Intra- and International Trade," *Journal of Political Economy*, 2014, *122* (2), 369–421.

Hornbeck, Richard, "Barbed Wire: Property Rights and Agricultural Development," *The Quarterly Journal of Economics*, May 2010, *125* (2), 767–810.

_ **and Daniel Keniston**, "Creative Destruction: Barriers to Urban Growth and the Great Boston Fire of 1872," *The American Economic Review*, 2017, *107* (6).

Hsieh, Chang-Tai and Benjamin A. Olken, "The Missing "Missing Middle"," *The Journal of Economic Perspectives*, July 2014, *28* (3), 89–108.

_ **and Peter J. Klenow**, "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, November 2009, *124* (4), 1403–1448.

_ **and** _ , "The Life Cycle of Plants in India and Mexico," *The Quarterly Journal of Economics*, May 2014, p. qju014.

Jensen, Anders, "Employment Structure and the Rise of the Modern Tax System," *Working Paper*, 2016.

Kahn, Matthew E., "Gentrification Trends in New Transit-Oriented Communities: Evidence from 14 Cities That Expanded and Built Rail Transit Systems," *Real Estate Economics*, June 2007, *35* (2), 155–182.

Ko, Kate and Xinyu Cao, "The Impact of Hiawatha Light Rail on Commercial and Industrial Property Values in Minneapolis," *Journal of Public Transportation*, March 2013, *16* (1).

Krugman, Paul, "Increasing Returns and Economic Geography," *Journal of Political Economy*, June 1991, *99* (3), 483–499.

Lagakos, David, "Explaining Cross-Country Productivity Differences in Retail Trade," *Journal of Political Economy*, March 2016, *124* (2), 579–620.

LaPorta, Rafael and Andrei Shleifer, "The Unofficial Economy and Economic Development," *Brookings Papers on Economic Activity*, 2008, *2008*, 275–352.

_ **and** _ , "Informality and Development," *The Journal of Economic Perspectives*, July 2014, *28* (3), 109–126.

Levy, Santiago, *Good Intentions, Bad Outcomes: Social Policy, Informality, and Economic Growth in Mexico*, Brookings Institution Press, 2008.

Lewis, W. Arthur, "Economic Development with Unlimited Supplies of Labour," *The Manchester School*, May 1954, *22* (2), 139–191.

Lucas, Robert E., "On the Size Distribution of Business Firms," *The Bell Journal of Economics*, 1978, *9* (2), 508–523.

Margo, Robert A., "Economies of Scale in Nineteenth Century American Manufacturing Revisited: A Resolution of the Entrepreneurial Labor Input Problem," *NBER Working Paper*, 2013.

McCaig, Brian and Nina Pavcnik, "Informal Employment in a Growing and Globalizing Low-Income Country," *The American Economic Review*, May 2015, *105* (5), 545–550.

McKenzie, David, "Identifying and Spurring High-Growth Entrepreneurship: Experimental Evidence from a Business Plan Competition," *The American Economic Review*, 2017, *107* (8).

Melitz, Marc J., "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, November 2003, *71* (6), 1695–1725.

Michaels, Guy, "The Effect of Trade on the Demand for Skill: Evidence from the Interstate Highway System," *Review of Economics and Statistics*, October 2008, *90* (4), 683–701.

Morris, Eric, "From Horse Power to Horsepower," *Access*, 2007.

Most, Doug, *The Race Underground: Boston, New York, and the Incredible Rivalry That Built America's First Subway*, Macmillan, February 2014.

Rauch, James E., "Modelling the Informal Sector Formally," *Journal of Development Economics*, January 1991, *35* (1), 33–47.

Redding, Stephen J. and Matthew A. Turner, "Transportation Costs and the Spatial Organization of Economic Activity," *NBER Working Paper*, 2014.

Sarada and Nicolas L. Ziebarth, "Distance and the Informativeness of Credit Ratings," *Working Paper*, 2015.

Siodla, James, "Razing San Francisco: The 1906 Disaster as a Natural Experiment in Urban Redevelopment," *Journal of Urban Economics*, September 2015, *89*, 48–61.

Slemrod, Joel, "Cheating Ourselves: The Economics of Tax Evasion," *Journal of Economic Perspectives*, March 2007, *21* (1), 25–48.

Sokoloff, Kenneth L., "Was the Transition from the Artisanal Shop to the Nonmechanized Factory Associated with Gains in Efficiency?: Evidence from the U.S. Manufacturing Censuses of 1820 and 1850," *Explorations in Economic History*, October 1984, *21* (4), 351–382.

Tybout, James R., "Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?," *Journal of Economic Literature*, 2000, *38* (1), 11–44.

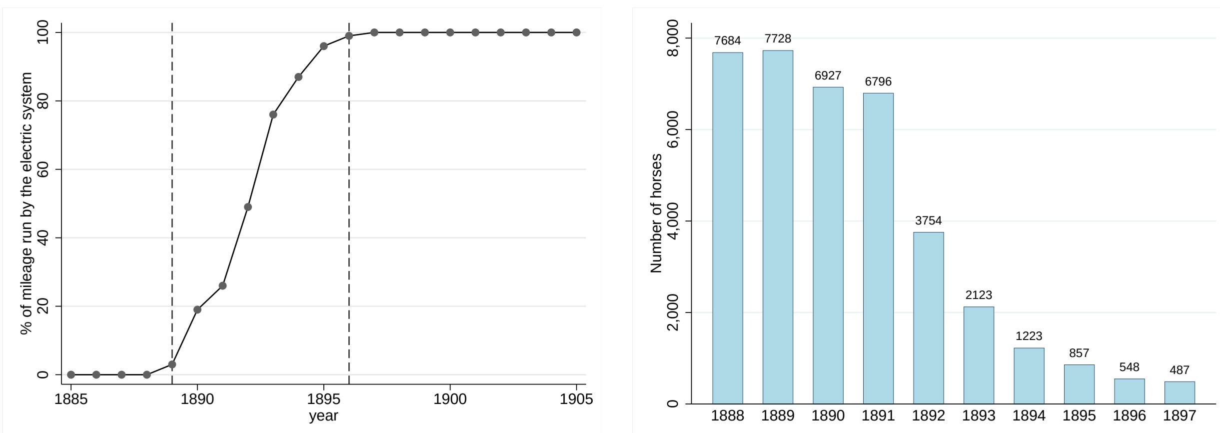
Vessali, Kaveh V., "Land Use Impacts of Rapid Transit: A Review of the Empirical Literature," *Berkeley Planning Journal*, January 1996, *11* (1).

Vuchic, Vukan R., *Urban Transit Systems and Technology*, John Wiley & Sons, February 2007.

Warner, Sam B., *Streetcar Suburbs: the Process of Growth in Boston, 1870 - 1900*, Harvard University Press and The M.I.T. Press, 1962.

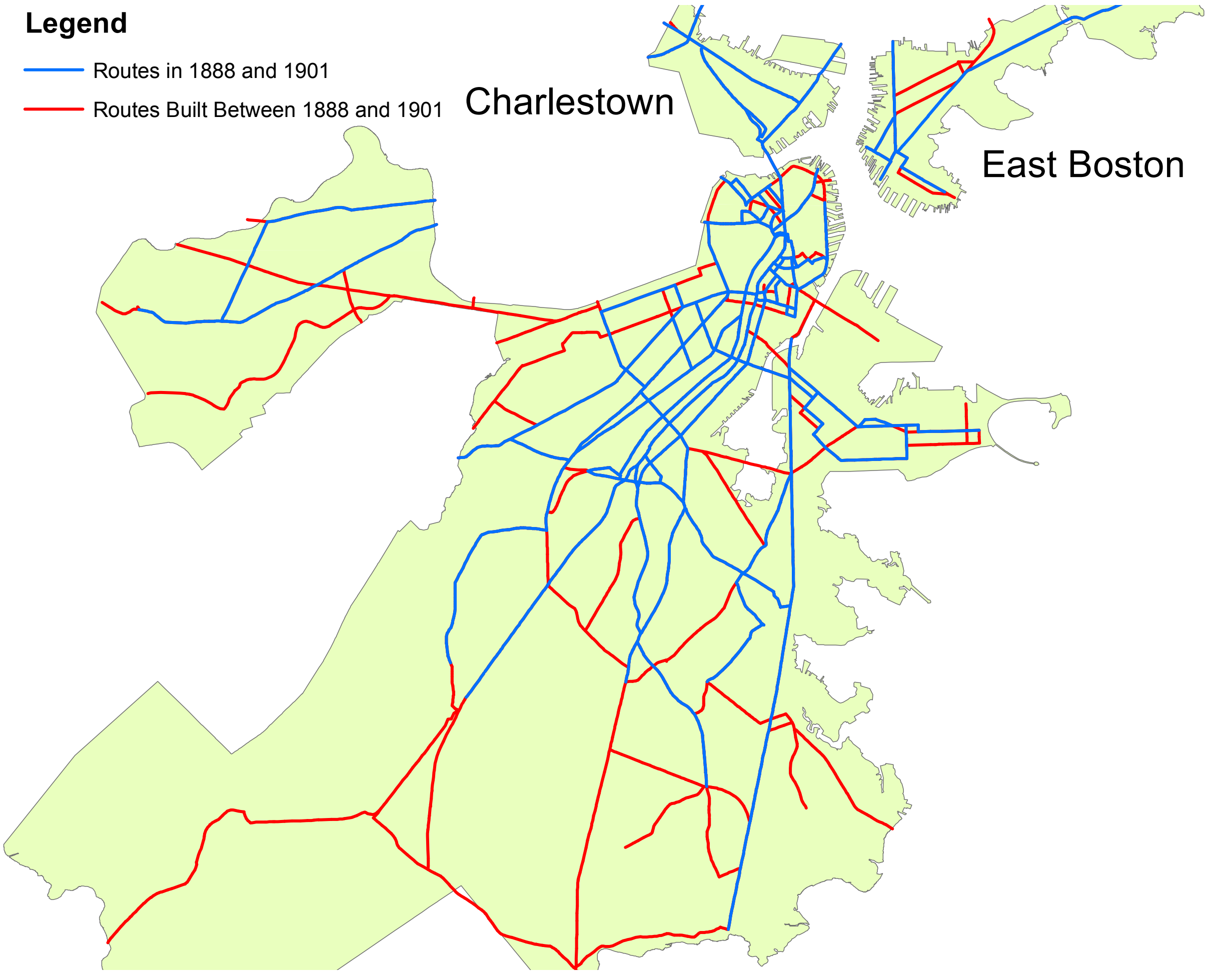
Ziv, Oren, "Geography in Reduced Form," *Working Paper*, 2017.

Figure 1: Pace of the Electrification



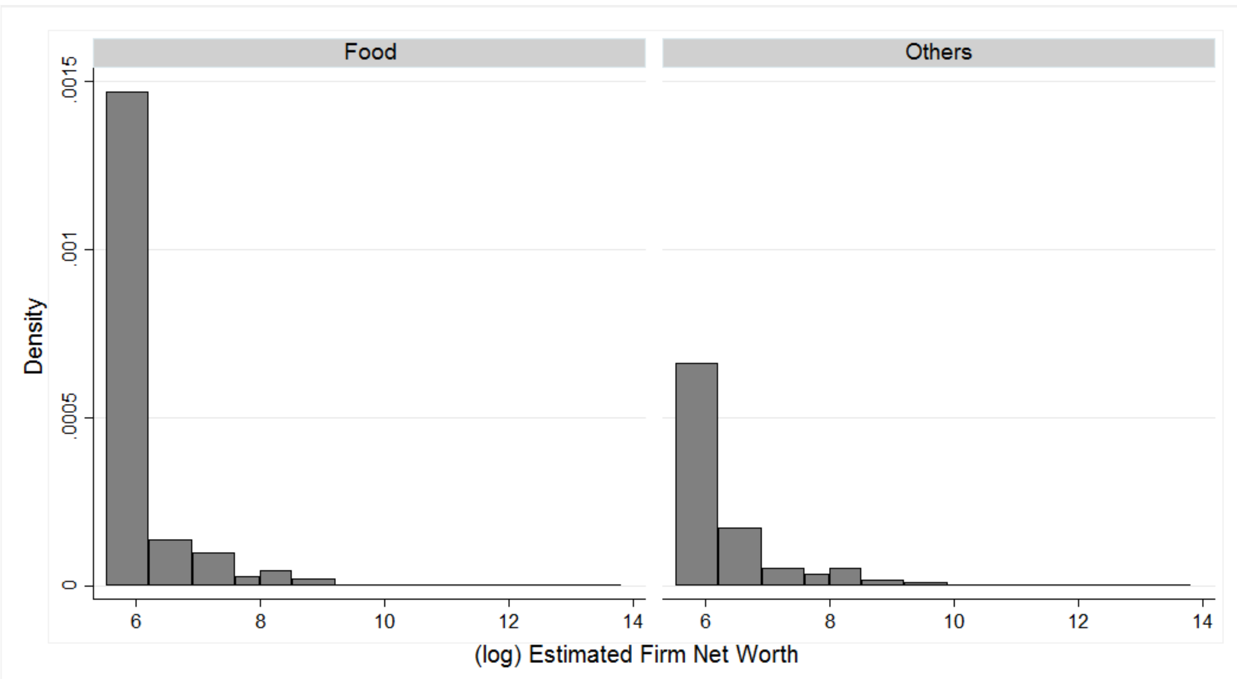
Source: The Annual Reports of the West End Street Railroad Company.

Figure 2: The Streetcar Routes in 1888 and 1901



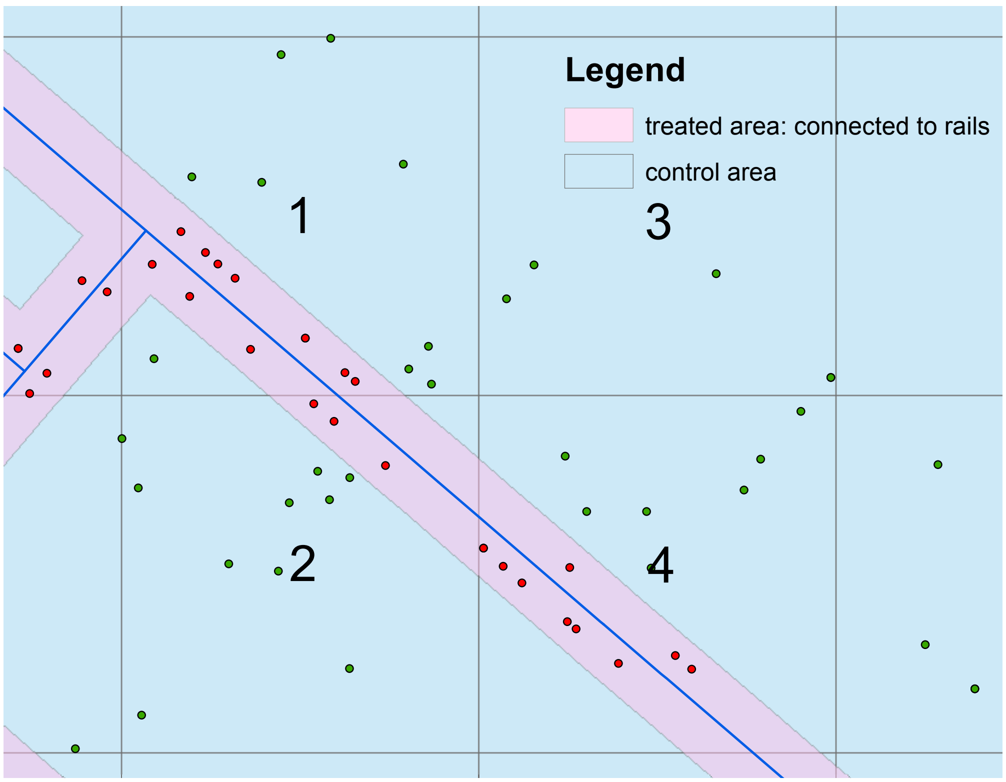
Source: Digitized Boston city maps.

Figure 3: Firm Size Distribution by Product



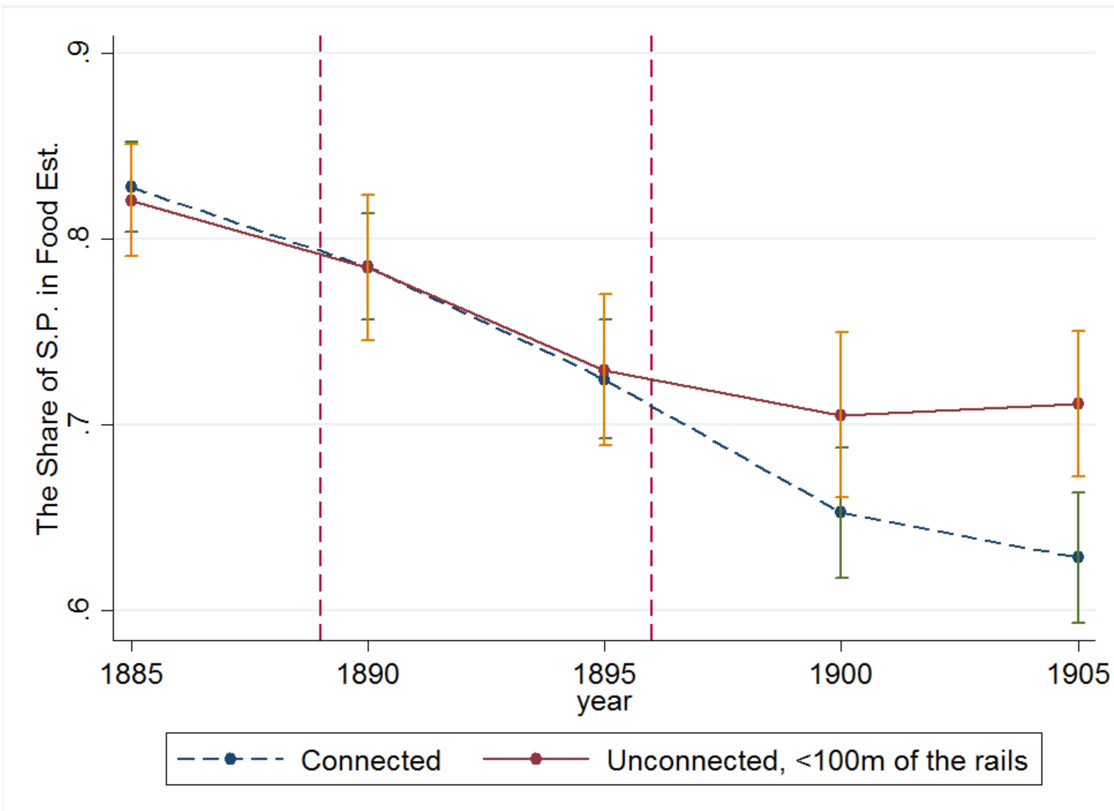
Sources: Matched firms between the 1885 and 1899 Boston Directories and R.G. Dun & Co's credit reference books. Firm size is measured by net worth (pecuniary strength) in dollars in the credit reference books.

Figure 4: Illustration of Treatment and Control "Plots", and "Blocks"



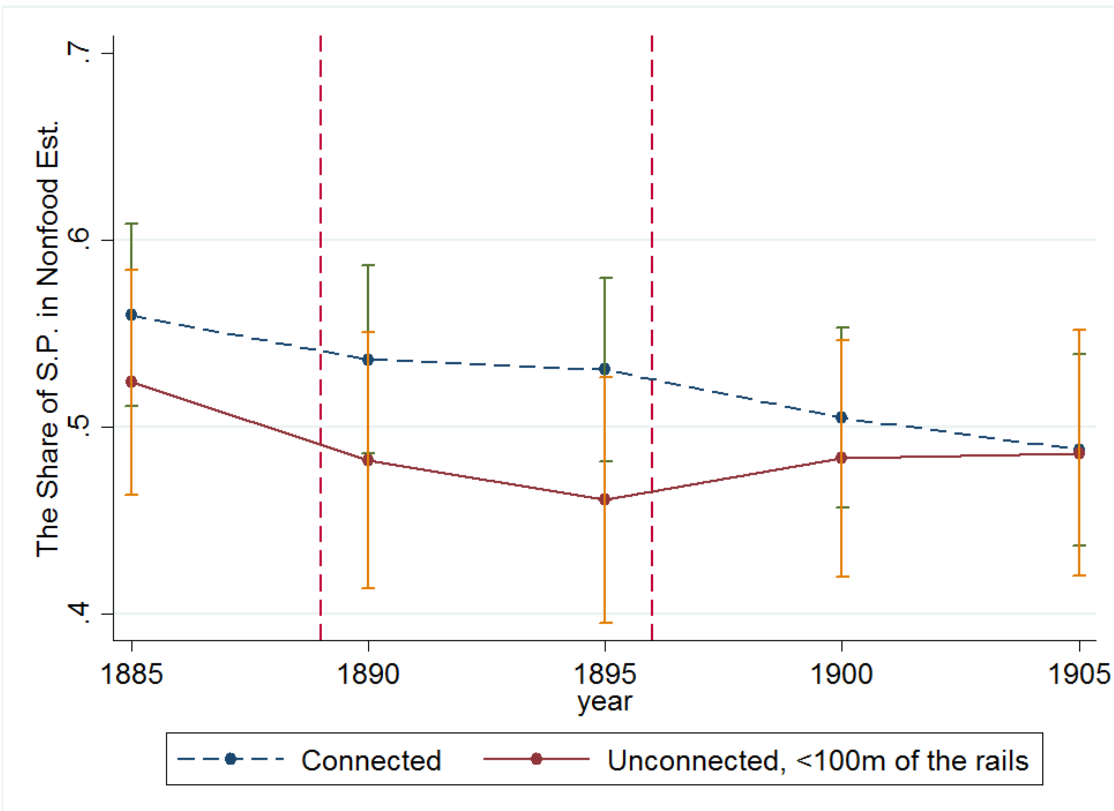
Notes: The above figure illustrates the definition of the treatment plots and control plots, as well as the blocks. The grids in this figure are $200m \times 200m$, called blocks. If a block is passed through by a streetcar rail, such as blocks 1, 2, and 4, it is then separated into two plots: the rail-connected plot, indicated by the purple areas, and the unconnected plot, indicated by the light blue areas. I define the rail-connected plots as the treatment locations, and the unconnected plots as the control locations. Block 3 is dropped from the regressions.

Figure 5: Trends in Outcome between the Treatment and the Control Plots, Food Products



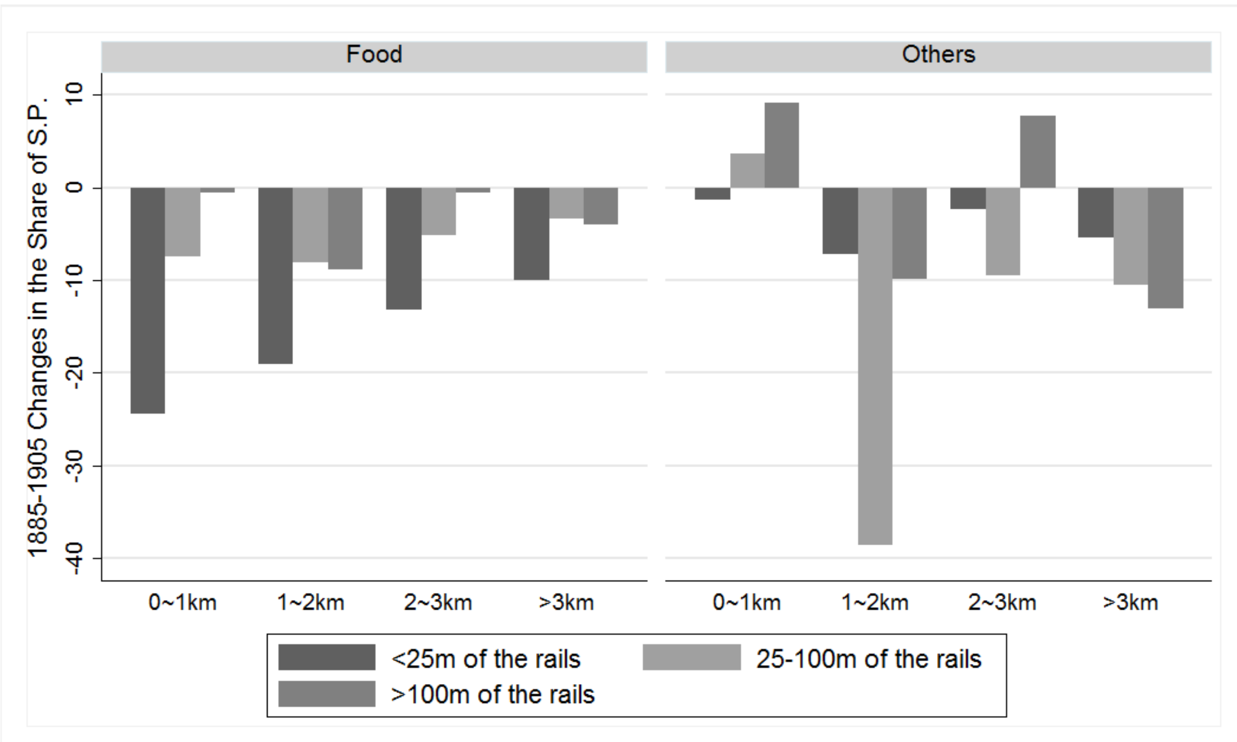
Notes: The time trends in the weighted average of the share of sole proprietorships across the rail-connected plots and the unconnected plots are plotted here in dashed lines and solid lines, respectively. The average for a group of plots is weighted by the number of establishments in 1885 in each plot. The vertical bins indicate the 95% confidence intervals. All statistics were calculated using food establishments only.

Figure 6: Trends in Outcome between the Treatment and the Control Plots, Other Products



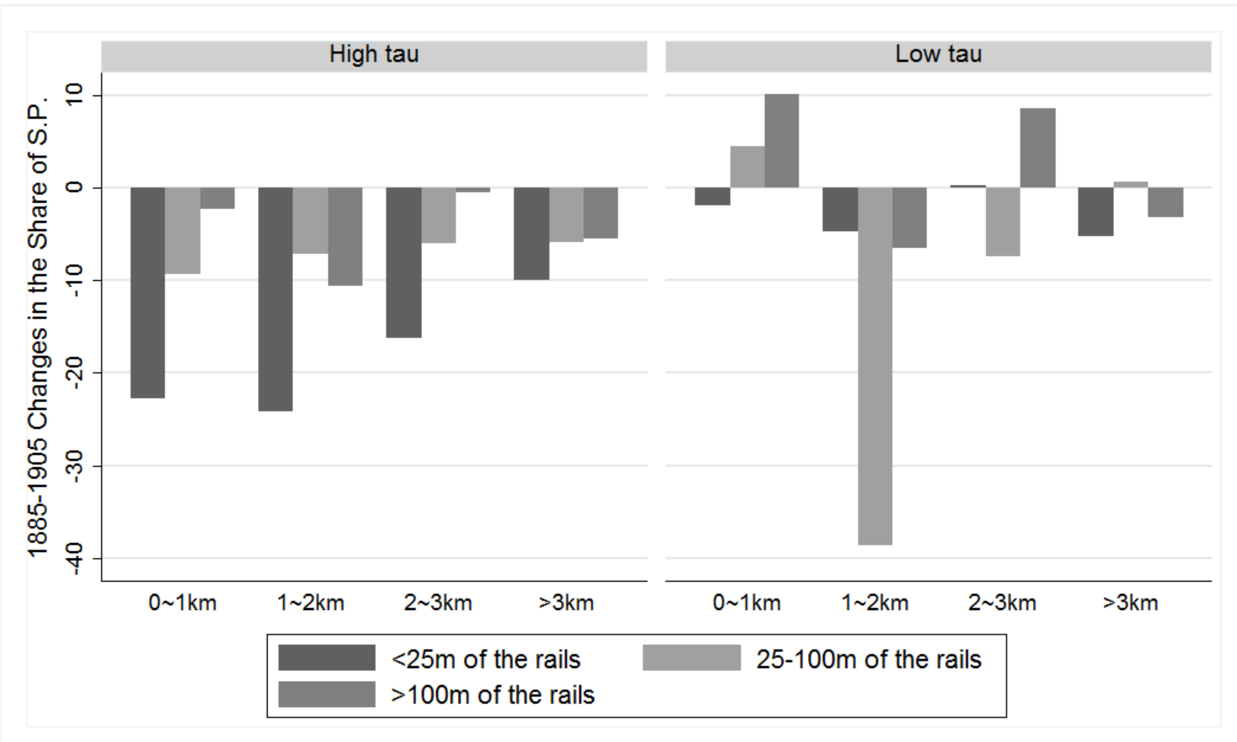
Notes: The time trends in the weighted average of the share of sole proprietorships across the rail-connected plots and the unconnected plots are plotted here in dashed lines and solid lines, respectively. The average for a group of plots is weighted by the number of establishments in 1885 in each plot. The vertical bins indicate the 95% confidence intervals. All statistics were calculated using nonfood establishments only.

Figure 7: 1885-1905 Changes in the Share of Sole Proprietorships by Product and Geography



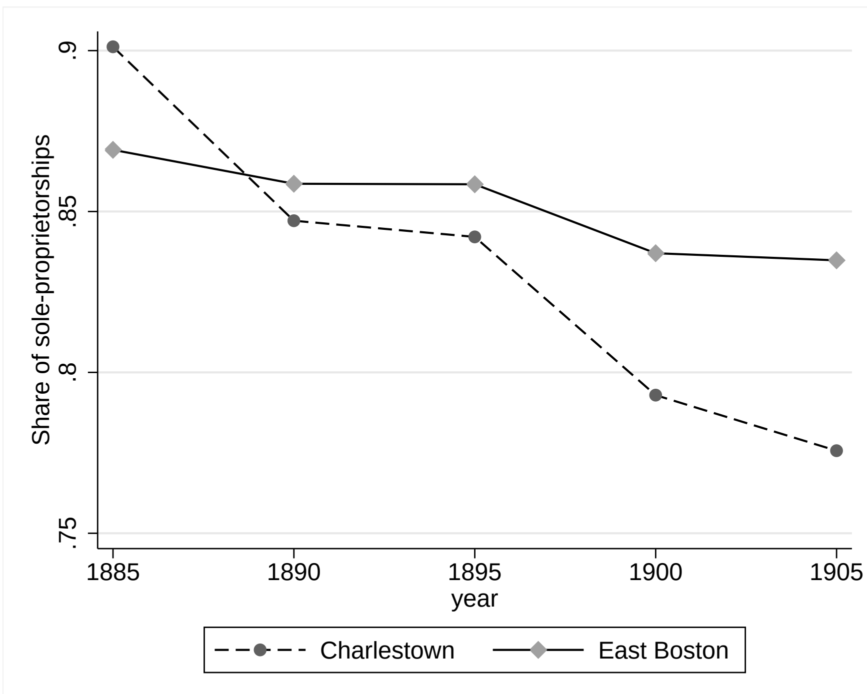
Notes: The horizontal axis represents the distance from the city center (City Hall). The bars of different colors indicate different distances from the 1888 streetcar rails. The outcome is the percentage point changes in the share of sole proprietorships (S.P.) in the corresponding area between 1885 and 1905.

Figure 8: 1885-1905 Changes in the Share of Sole Proprietorships by Product and Geography



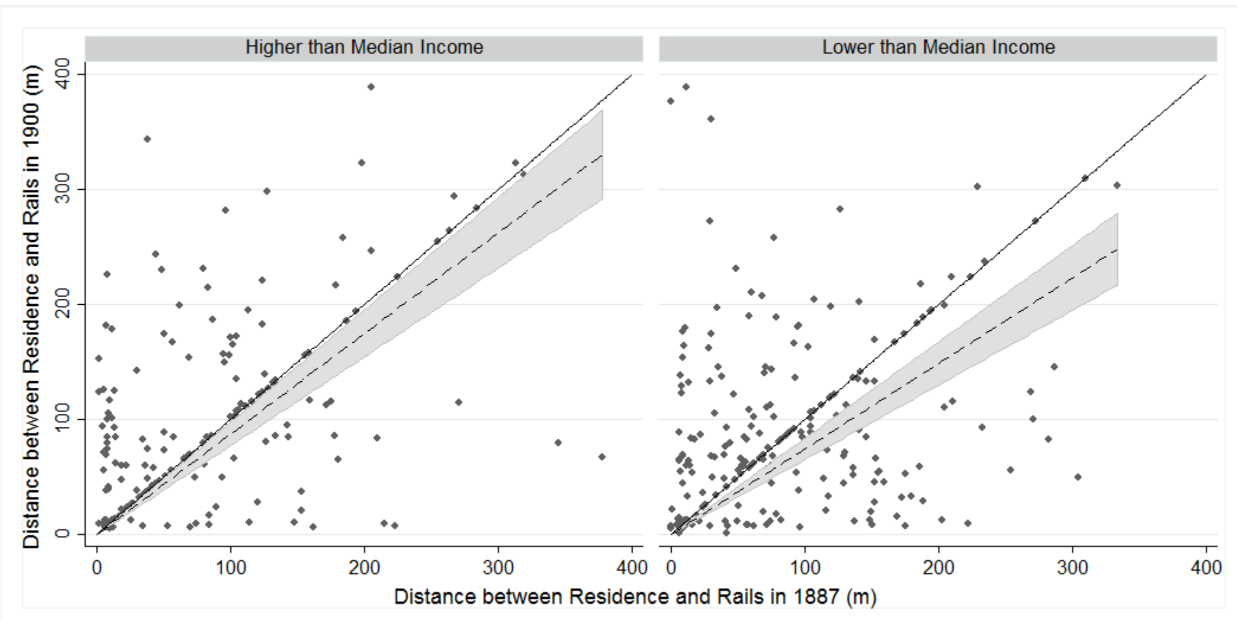
Notes: The horizontal axis represents the distance from the city center (City Hall). The bars of different colors indicate different distances from the 1888 streetcar rails. The outcome is the percentage point changes in the share of sole proprietorships (S.P.) in the corresponding area between 1885 and 1905. τ measures the sensitivity of consumers to commuting costs for each product. The left subfigure and the right subfigure report the outcome using the products (establishments) with a τ above and below the median, respectively.

Figure 9: Comparison of Charlestown and East Boston



Notes: Author's calculation from the *Boston Directories*. The sample includes both food and nonfood establishments.

Figure 10: Residential Sorting by Income



Sources: Matched 471 indiduals between the Boston Directories and census micro data.
Notes: Each dot represents an individual. The solid lines are the 45 degree lines. The dashed lines are the linear fitted lines without the constant term. The shaded areas are the 95% confidence intervals of the linear fit.

Table 1: Estimated Net Worth by Type

Type	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

Notes: The statistics were calculated using the 1,736 firms matched between the Boston Directories and the credit rating reference books. Year 1885 and year 1899 each account for half of the sample. The estimated net worth refers to the pecuniary strength in the credit rating reference books. The value is measured by current-price USD.

Table 2: Statistics on the Streetcar Network

Distance to City Hall	0-1 km	1-2 km	>2 km	Whole City
Distance to rails from random points (m)	281	710	4369	4075
Distance to rails from firms (m)	60	32	101	69
Share of firms within 25m of rails (%)	40	63	60	51
Share of firms within 100m of rails (%)	79	92	77	81

Notes: Author's calculation from digitized streetcar network and firm data. The streetcar network is 1888. The firm data pool years from 1885 to 1905. To calculate distance to rails from random points, I created evenly distributed points within the boundary of Boston, each of which is 50 meters away from the closest point. I then calculated distance between each point to the nearest streetcar route. Each cell in the first row is the average of the distances between the rails and the points in that area. In the second row, I replaced the points by the locations of the firms, and repeated the exercise.

Table 3: Consumption Behavior Statistics

Pshr	costs($)/item	items/week	trips/week	trips/$100
Confectioners^F	2.30	1.02	0.68	28.74
Bakers^F	1.99	2.87	1.28	22.45
Fruits^F	1.72	4.76	1.29	15.70
Fish^F	5.03	0.36	0.28	15.38
Cigars & Tabaccos	6.46	0.61	0.54	13.78
Produce^F	2.25	5.32	1.56	13.06
Books & Publishers	6.79	0.58	0.46	11.72
Liquors^F	5.85	0.97	0.48	8.44
Restaurants^F	4.76	6.09	2.44	8.43
Provisions^F	3.06	8.84	1.77	6.56
Hats, Caps, & Furs	14.45	0.06	0.05	5.83
Milliners	17.52	0.08	0.07	4.81
Apothecaries & Drugs	15.64	0.63	0.43	4.30
Dry Goods	18.57	0.12	0.09	3.82
Hardware	19.52	0.18	0.11	3.20
Boots & Shoes	34.52	0.18	0.14	2.29
Clothing	21.28	0.98	0.44	2.10
Jewelry & Watches	48.66	0.07	0.06	1.62
Leather	70.99	0.04	0.03	1.20
Furniture	191.40	0.04	0.03	0.38
Piano	>93.43	0.00	0.00	1.07

Source: 1996 Consumer Expenditure Survey from the Bureau of Labor Statistics.
Notes: Statistics on grocers, tailors, and men's furnishings are not reported because of the lack of correspondence in the product categories in 1996 Consumer Expenditure Survey. A superscript F indicates that this product is food-related. "trips/week" is defined as the number of trips consumers took each week to purchase any item of this product. "trips/$100" is defined as the number of trips the consumers made for purchasing every $100 of this product.

Table 4: Benchmark

Dependent Variable: Share of S.P. in total est.	(1) Food Products	(2)	(3) Nonfood Products	(4)
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

Notes: Each observation is a plot. For all specifications, the outcome variable is the share of sole proprietorship (S.P.) establishments of the plot. Every plot is weighted by its number of establishments in 1885. The regressions use only the 1885 and 1905 data. *Post* is a dummy for the post-electrification period, i.e. year 1905. The treatment and control plots and the blocks are defined in Figure 4. In columns (1) (2) and (3) (4), I calculated all the statistics using food and nonfood products (establishments), respectively. Standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Table 5: Regressions by Different Block Size and Treatment Definitions

Dependent Variable: Share of S.P. in total est.	(1)	(2)	(3)	(4)
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)
Block*Year FE	YES	YES	YES	YES
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)
200m-Block*Year FE	YES	YES	YES	YES
Observations	276	232	188	126
R-squared	0.908	0.906	0.930	0.886

Notes: Each observation is a plot. For all specifications, the outcome variable is the share of sole proprietorship (S.P.) establishments of the plot. Every plot is weighted by its number of establishments in 1885. The regressions use only the 1885 and 1905 data. *Post* is a dummy for the post-electrification period, i.e. year 1905. The treatment and control plots and the blocks are defined in Figure 4. Standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Table 6: Regressions by τ

Dependent Variable: Share of S.P. in total est.	(1) High τ Products	(2)	(3) Low τ Products	(4)
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

Notes: Each observation is a plot. For all specifications, the outcome variable is the share of sole proprietorship (S.P.) establishments of the plot. Every plot is weighted by its number of establishments in 1885. The regressions use only the 1885 and 1905 data. *Post* is a dummy for the post-electrification period, i.e. year 1905. The treatment and control plots and the blocks are defined in Figure 4. τ measures the sensitivity of consumers to commuting costs for each product. In columns (1) (2) and (3) (4), I calculated all the statistics using the products (establishments) with a τ above and below the median, respectively. Standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Table 7: 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)
200m-Block*Year FE		YES		YES
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

Notes: Each observation is a plot. For all specifications, the outcome variable is the share of sole proprietorship (S.P.) establishments of the plot. Every plot is weighted by its number of establishments in 1885. The regressions use only the 1885 and 1905 data. *Post* is a dummy for the post-electrification period, i.e. year 1905. The treatment and control plots and the blocks are defined in Figure 4. Columns (1) (2) use the blocks with 1885 share of sole proprietorships above the median for the regressions, and columns (3) (4) use the blocks with the share below the median for the regressions. Standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Table 8: Regressions by Geography

Dependent Variable: Share of S.P. in total est.	(1) Charlestown	(2)	(3) East Boston	(4)	(5) Central Boston	(6)
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)
200m-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

Notes: Each observation is a plot. For all specifications, the outcome variable is the share of sole proprietorship (S.P.) establishments of the plot. Every plot is weighted by its number of establishments in 1885. The regressions use only the 1885 and 1905 data. *Post* is a dummy for the post-electrification period, i.e. year 1905. The treatment and control plots and the blocks are defined in Figure 4. Columns (1) and (2) use the plots from Charlestown. Columns (3) and (4) use the plots from East Boston. Columns (5) and (6) use the plots from the rest of Boston. All statistics were calculated using food-related establishments only. Standard errors clustered by block are reported in parentheses: *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level.