Working Paper

Vestiges of Transit: Urban Persistence at a Micro Scale

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Vestiges of Transit: Urban Persistence at a Micro Scale

In this paper, we document spatial persistence at a micro scale and explore its causes. The streetcar dominated urban transit in Los Angeles County from the 1890s to the early 1910s, and was off the road entirely by 1963. However, we find that its influence remains readily visible in the current pattern of urban density. Further, we show that this pattern has reinforced, not muted, over the nearly 60 year since the streetcar's removal. Our evidence is most consistent with the defunct streetcar influencing modern behavior by serving as a focal point, coordinating both land use regulation and agglomerative clustering.

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> If there is one single area of economics in which path dependence is unmistakable, it is in *economic geography* – the location of production in space. The long shadow cast by history over location is apparent at all scales, from the smallest to the largest....
>
> Krugman (1991)

How persistent is the past? If the past is persistent, why? And what does a persistent past mean for economic outcomes today? From the location of the slave trade in Africa (Nunn, 2008) to the impact of legal form (La Porta et al., 1998), economists find that century- and decade-old decisions determine modern economic outcomes.[2] Spatial persistence is particularly well documented. Davis and Weinstein (2002) find that the centuries-old regional distribution of economic activity in Japan persists even in the face of nuclear attack. In the US, Bleakley and Lin (2011a) document that cities that formed at canoe portage sites persist long after portage's obsolescence.[3]

Previous examinations of spatial persistence have mostly focused on broad geographies – the "largest" in the Krugman (1991) epigraph above. Yet the available evidence suggests that the highly localized, intra-city distribution of individuals and firms is a key input into economic activity and growth (Glaeser et al., 2001; Arzaghi and Henderson, 2008; Rosenthal and Strange, 2003, 2001, 2004). To address whether persistence is important within cities, we provide evidence of historical persistence at the "smallest" scale. We do so by examining whether long-extinct Los Angeles streetcars continue to influence modern land use decisions, and if so, why.[4]

[2] See Nunn (2014) for a thorough overview.

[3] See also Redding et al. (2011), Miguel and Roland (2011), Hanlon (2015) and Michaels and Rauch (2013).

[4] The literature on inter-urban persistence is extremely limited. (Ambrus et al., 2015) explore the long-run effect of a disease outbreak in 19th century London on house prices. Like the work here, the paper examines micro-level spatial persistence using property level data, but explores very different initial treatments, mechanisms and outcomes. Also related is Redfearn (2009), which examines intra-urban persistence in employment centers but provides no evidence on mechanism. Finally, two recent papers have implications

Streetcars were built between 1890 and 1910 in many cities around the world. We focus on Los Angeles County, which had the world's most extensive system, and where streetcars were particularly influential due to the coincidence of their technological dominance and the initial era of extremely rapid population growth (Crump, 1962). Due to the rise of alternative technologies, streetcar ridership was in decline by the late 1910s, buses began replacing streetcar routes in the 1920s, and the very last Los Angeles streetcar ran in 1963.

To examine whether these vestiges of transit impact the modern city, we present a simple theoretical framework. The framework predicts that in streetcars' heyday, when areas near streetcars had faster and cheaper access to the central business district, streetcar areas are more dense. After streetcars are replaced by the speed and convenience of the car, and assuming that urban congestion imposes costs on workers and residents, the framework predicts that density near streetcars should converge to that of other urbanized locations.

We test this convergence hypothesis using digitized historical maps and data on the 2.3 million properties in Los Angeles County. Despite the fact that streetcars have been gone entirely for over fifty years, and replaced as a primary means of transit for much longer, we document that the streetcar's imprint remains readily visible in current day Los Angeles. Areas near streetcar stops are substantially more dense now, both in people and buildings, than areas farther from the extinct streetcar.

While this correlation is compelling, such an unconditional relationship between distance to the streetcar and density could easily be driven by features that determine both historic streetcar location and modern density. To exclude this possibility, we use a more nuanced empirical strategy. We compare parcels in a small circle (0.5 km radius) around the stop, the treatment area, to parcels in an equally sized concentric ring, the control area. This method

for inter-urban persistence (although they are not explicitly focused on this topic). (Hornbeck and Keniston, 2014) explores how the Great Boston Fire of 1872 affected land values and emphasizes the influence of cross-plot externalities on redevelopment decisions. Ahlfeldt et al. (2015) examines intra-city density patterns and explores agglomerative and dispersive forces as mechanisms behind the density.

nets out many features common to parcels in both the treated and control areas and finds that the areas close to the streetcar are more dense than the control areas. Further, these results hold even when we restrict the analysis to areas undeveloped before the streetcar's arrival, where we can be sure that no pre-existing features determine later outcomes. Thus, we decisively reject the theoretical prediction that the density near streetcars converges to the average density in the post-streetcar era.

Given this, we explore two mechanisms to explain the rejection of the convergence prediction. The first mechanism is the durability of streetcar era capital, both private and public. The second mechanism is the streetcar as focal point: the initial investment in the streetcar provides a focal point for coordinating the substantial urban evolution and growth of the post-streetcar era. This coordination may work through both market-driven agglomerative forces and the institution of land use regulation.

We test for these two mechanisms by marshalling a wealth of additional data on building age, proximity to modern and historic public investments, and property-level land use regulation, both historic and modern. In particular, our granular data on property-level zoning, combining modern and historic attributes, is new to the literature.[5]

To examine the first hypothesized mechanism, that density near the streetcar is due to initial investments in durable capital that have not yet depreciated sufficiently to be replaced, we begin with an analysis of private investment in structures. Indeed, there is substantial evidence that durable private capital inhibits cities' ability to adapt to economic changes (Hornbeck and Keniston, 2014; Glaeser and Gyourko, 2005; Siodla, 2015). In addition, persistent density near streetcars could be due to public investments in infrastructure. For instance, roads placed alongside streetcars could be the true anchor for modern density, rather than the streetcar itself.

[5] Gyourko and Molloy (2015) note that data on land use regulation is quite limited, and that parcel level panel data–like ours–is virtually non-existent.

We test empirically for the importance of such durable capital on persistent density near streetcars and find only a limited role. Considering private durable capital, we find that structures built in the post-streetcar era are constructed as relatively densely as were the streetcar-era structures. Thus, construction in the post-streetcar era has reinforced, rather than muted, the greater density around the defunct transit nodes. Considering public durable capital, we find that public infrastructure accounts for, at most, ten percent of modern density near streetcars. Thus, while initial private and public investments play a role, they are insufficient to explain the historical persistence we document.

The second hypothesized mechanism for the failure of density convergence is that the initial streetcar location creates a focal point, which then serves to coordinate public and private choices. Considering public choices, we focus our attention on the institution of land use regulation, specifically zoning.[6] Zoning regulates the permissible density on individual parcels of land. Assuming this regulation binds, density near the extinct streetcar may reflect the regulatory choices of policymakers. If zoning does serve to coordinate density near the streetcar, it must be the case that zoning allows more density near the extinct streetcar.

Using fine-grain data on zone code characteristics, we test these claims and find that zoning does indeed permit more density near the streetcar. Moreover, controlling for zoning eliminates the density premium associated with streetcar proximity. In other words, properties near the streetcar are constructed no more densely, given their zoning designation, than any other properties. Thus, our evidence is consistent with zoning causing persistent density around the streetcars.

Today's zoning pattern could be a result of changes in the zoning code over the past

[6]Land use regulation is of significant interest to economists because it has been viewed both as a value-destroying restraint on trade (Turner et al., 2014; Glaeser et al., 2005), and as a welfare-enhancing regulation solving problems of collective action and externalities in the location of economic activity (Lucas and Rossi-Hansberg, 2002; Rossi-Hansberg et al., 2010; McMillen and McDonald, 2002). Fischel (2005) argues that, in the absence of a market for home value insurance, zoning serves as a de facto substitute. Modern day land use regulation in Los Angeles is widely considered to be among the most stringent in the U.S. (Glaeser et al., 2005; Saiz, 2010).

century, or simply an ossification of the initial zoning designation. We use our digitization of Los Angeles's initial 1922 zone code – adopted just after the streetcars' heyday – to discriminate between these explanations. We find that zoning changed over the century in a manner that reinforced the initial permissiveness of zoning near the streetcar.[7] Specifically, zoning designations were quite malleable over the century following their introduction: Approximately one out of every three parcels of land changed the broad type of permitted use (e.g., single-family or commercial). Furthermore, we document that parcels of land near the streetcar were substantially more likely to experience a change from residential to non-residential designation—a change that generally increases permissible density. Perhaps most telling, unlike controlling for modern zoning, controlling for 1922 zoning does not erase the modern density premium to streetcar proximity. Thus, we conclude that the streetcar has served as a focal point, coordinating century-long changes in regulatory permissiveness.

Finally, we examine the streetcar as a focal point for agglomerative externalities. Our theoretical framework demonstrates that, in the presence of increasing returns to density, the historical accident of the streetcar stops may help resolve a multiple equilibria environment by selecting locations for density to form.

Empirically, we marshal several pieces of evidence consistent with this hypothesis. Agglomerative forces should be particularly important for non-residential land uses, as intra-city density can generate substantial positive externalities in the production of both tradeable goods and services (Arzaghi and Henderson, 2008; Rosenthal and Strange, 2003) and local consumer amenities such as retail and restaurants (Glaeser et al., 2001). Consistent with this theory, we find that land near the streetcar is substantially more likely to be in non-residential use than other land and that non-residential properties are more spatially concentrated near the streetcar. In addition, in the absence of agglomerative externalities

[7] At its inception, zoning was heavily demanded by the development industry, which viewed it as a guarantee against negative externalities on their properties for sale.

but in the presence of congestion costs, our framework predicts that the more congested land near streetcars should be lower valued than less congested land farther away. In contrast, we find that land near the streetcar is valued nearly identically to otherwise similar land farther away, consistent with the existence of positive agglomerative externalities offsetting higher congestion costs.

Overall, we believe the evidence suggests that the defunct streetcar serves as a focal point to anchor agglomerative externalities and coordinate the evolution in land use regulation. Moreover, we view it as reasonably likely that these channels are mutually reinforcing.

In addition to furthering our understanding of historical persistence and the mechanisms behind it, our findings contribute to several other literatures. At least since North and Thomas (1973), economists have viewed institutions as a fundamental input into economic growth, and institutional change as therefore of central concern (see, for example, Acemoglu et al. (2001)). By examining the historical origins and evolution of zoning, we contribute to our understanding of the determinants of institutional change. In addition, we add to the specific literature on the determinants of land use regulation—a subject where the existing empirical evidence is thin (Saks, 2008; Hilber and Robert-Nicoud, 2013). We also contribute to the voluminous literature on agglomeration by testing for agglomeration forces over an unusually small geographic area (for a review of empirical agglomeration literature see Rosenthal and Strange (2004); Combes and Gobillon (2015)).

In the next section, we briefly provide details on the historical development of streetcars in Los Angeles. Section 2 outlines a theoretical model of population density's response to streetcar development and obsolescence, and Section 3 describes our data and provides descriptive statistics. Section 4 documents the correlation between modern density and the distance to the streetcar. Section 5 tests whether this correlation is explained by features that pre- or post-date the streetcar, and whether it is driven by old structures. Section 6 explores the focal point hypothesis, and Section 7 concludes.

1 Historical Context

To ground the theoretical framework, we begin by discussing five key facts about Los Angeles in the era of streetcar development. First, Los Angeles was relatively unpopulated before the arrival of the streetcar. Second, the streetcar was the dominant mode of transit in its heyday. Third, the interurban rail was developed in a way that make it particularly useful for analysis: built largely to unpopulated areas, and built in a manner not overly concerned with direct profitability. Fourth, the system was in decline as early as the late 1910s. Fifth, land use regulation post-dates streetcar investment.

Before the arrival of streetcars, the population in the Los Angeles basin was quite small. Appendix Figure 1 (a) presents the populations of the city and county from 1890 to 1950. At the dawn of the streetcar era in 1890, the city of Los Angeles had a population of about 50,000, and the county 100,000. As the streetcars multiplied, so did Angelenos. By 1930, at the close of the streetcar era, the city had grown over 20 times to 1.2 million inhabitants; the County grew at roughly the same proportional pace to 2.2 million people.

From the 1890s to the late 1910s, as the Los Angeles area population blossomed, the streetcar was the dominant mode of urban transit; as such, it played a key role in determining land use patterns. Electric streetcars were first successfully employed in Richmond, Virginia in 1888. Relative to their immediate predecessors—horsecars, cable cars and human locomotion—they were a quantum leap forward in speed and cost.[8] As cities grew, streetcars created a land use pattern that mirrored their delivery of speed. It was well understood that proximity to the streetcar raised value. Advertising commonly highlighted proximity to the streetcar, as in "all lots [are] within 600 feet of the new car line" (Post, 1989, p. 22; Fogleson,

[8]Motorized public transit in Los Angeles County actually began in 1885 with the cable car, which was propelled by gripping and ungripping a continuously moving underground cable (Walker, 2007, p. 7). The cost of the cable and the construction necessary to lay it made cable cars very capital intensive to build. The cars could climb steep grades, but ran at a maximum speed of roughly eight miles per hour (Post, 1989, p. 96). Before the cable car was the horsecar, a train pulled along a train-like track by a horse. Horsecars were even slower, less reliable, and subject to stoppage due to equine infection.

1967, p. 87; Jackson, 1985). It was not until the early 1920s that contemporaries began to acknowledge the threat that auto and bus posed to urban passenger rail (Hilton and Due, 1960, p. 236).[9]

Los Angeles had two distinct types of urban rail. The Los Angeles Railway, known as the "yellow cars," provided service in the downtown core and surrounding neighborhoods. The yellow cars had no discrete stops: "up to the advent of the automobile [the cars] stopped anywhere for a lady; in the middle of the block, in the intersection of streets, as well as at corners. ... [T]he active man seldom stopped the car to board it, or to get off" (Cowan, 1971, p. 2). The Pacific Electric, known as "red cars," provided interurban service, similar in some locations to a urban system and in other locations to "a suburban electrified main-line service" (Hilton and Due, 1960, p. 406). At its peak of 1,164 miles, the Pacific Electric – just the interurban half of the Los Angeles rail network – was "the largest electric railway in the world" and constituted roughly five percent of the total track in the entire country (Crump, 1962; Post, 1989, p. 141; Fischel, 2004). Unlike the yellow cars, the Pacific Electric had discrete stops for entry and exit.

The Pacific Electric was built largely to unoccupied areas and in a pattern not necessarily directly concerned with rail profitability. These features make the Pacific Electric, from an empirical standpoint, a particularly useful case to analyze. In particular, because the system was built largely to unoccupied areas, it makes it easier to pinpoint the red cars as a causal mechanism for development. In their comprehensive history of interurban railroads, Hilton and Due (1960, p. 407) write that "No other area of the country ever had such an intensive network of lines built largely ahead of the growth of population." This pattern of development was made possible by the fact that the system was built largely by Henry E. Huntington. Huntington was the nephew of one of the great railroad robber barons, the inheritor of the bulk of his uncle's fortune, and a railroad financier in his own right. About

[9]Gin and Sonstelie (1992) and Fischel (2004) describe the spatial income pattern this speed delivers.

his investment strategy he wrote, “It would never do for an electric line to wait until the demand for it came. It must anticipate the growth of communities and be there when the builders arrive – or they may very likely never arrive at all, but go to some other section already provided with arteries of traffic” (Friedricks, 1992, p. 7).

Huntington turned his attention to urban rail in Los Angeles when personal disputes prevented him from ascending to the presidency of his uncle’s railway (the Southern Pacific). Huntington’s deep pockets and business acumen yielded two anomalous conditions for development. First, Huntington’s large personal fortune made him less dependent on the demands of the capital markets than other investors, and more able to build to suit his personal tastes. Second, Huntington controlled three tightly interwoven companies. In addition to the rail assets of the Los Angeles Railway and the Pacific Electric, he also owned a land development company (Huntington Land and Improvement) and a power company (Pacific Light and Power Company). From Huntington’s perspective, it was sufficient to maximize profits across these three enterprises. The location of the streetcar lines should therefore be responsive to Huntington’s total portfolio, rather than to specific interurban profitability (Friedricks, 1992). In fact, the Pacific Electric was almost never profitable, whereas the Los Angeles Railway (also Huntington controlled, but only after its major development) was profitable for much longer (Friedricks, 1992).

Streetcars were in decline as the dominant mode of transit at least as early as the late 1910s. Streetcar construction peaked nationally in 1906 (Fischel, 2004, p. 321). Appendix Figure 1 (b) shows ridership on the Pacific Electric (in red) and the Los Angeles Railway (in yellow) between 1910 and 1940. In Los Angeles, rides per capita were surely declining by 1920 – in an era of great population growth – and possibly even earlier. As early as 1922, Los Angeles Railway was using “motor coaches” (buses) for new routes (Walker, 2007, p. 30). By the late 1920s, new lines were exclusively bus and not streetcar (Post, 1989, p. 152), and riders were abandoning urban rail for the automobile (Walker, 2007, p. 41).[10] The final streetcar trip in Los Angeles took place in 1963, though the vast majority of the system had been already been dismantled. Thus, streetcars were both dominant and short-lived.

Finally, it is important to note that the institutions of land use regulation post-date the introduction of streetcars. Fischel (2004, p. 318) defines modern zoning as the restriction of uses or building on all land, rather than an ad hoc approach for industries or structures.[11] Defined in this way, zoning arrived in Los Angeles in 1922, when the city delineated five zoning districts: single family, multi-family, commercial, limited industrial, and unlimited (Whittemore, 2010, p. 14, 58).[12] Zoning generally, and in Los Angeles specifically, grandfathers in old uses and structures.[13] Therefore, initial zoning reflects contemporary land use and not vice-versa.[14]

2 Theoretical Framework

With this historical background in mind, we now present a simple theoretical framework to motivate our empirical work. We first show how transit costs influence initial density patterns. We then examine how a shock to transit costs changes density patterns when returns

[10]Interestingly, an earlier challenge was posed to the streetcar system by buses know as jitneys in 1914. The city responded with a 1917 ordinance banning the jitneys from the downtown core, and they ceased to compete (Walker, 2007, p. 27).

[11]Historians date zoning to the late 1800s in Germany, and the passage of a zoning law in Frankfurt in 1891 (Burgess, 1994, p. 63-4).

[12]At the end of the first decade of 1900s, Los Angeles was a patchwork of districts outlawing specific industries, such as brickyards, or horse and mule keeping (Whittemore, 2010, p. 33).

[13]With the exception of a minimum lot width and a limit of one family per lot, both in the single family zone, density and bulk were not regulated (Whittemore, 2010, p. 58-9). McMillen and McDonald (1999) document that the initial zoning code in Chicago grandfathered in old uses and structures.

[14]The historic record suggests the waning of the streetcar era sparked the introduction of zoning in Los Angeles. Fischel (2004, p. 320) argues that zoning was actually unnecessary until after the decline of the streetcar. Streetcars yielded homogeneous suburbs without the necessity of zoning. They kept out noxious commercial uses, as producers would have been hard put to transport inputs and finished goods via the streetcar in and out of outlying neighborhoods. Fischel blames the truck, which "liberated heavy industry from close proximity of downtown railroad stations and docks," thereby threatening residential areas (Fischel, 2004, p. 321). Buses, with their flexible routes, posed a later, similar threat to higher income areas by lower income interlopers.

to density are decreasing.[15] Finally, we discuss factors that may influence the evolution of density in the wake of transit cost changes.

2.1 Transportation Costs and Population Density When Returns to Scale are Decreasing

We posit a city with a fixed population of identical individuals, each of whom commutes to the central business district.[16] This city has two residential locations l called S and NS, denoting "streetcar" and "no streetcar." Both locations are equidistant from the central business district, as shown in Figure 1a, and are equivalent in locational amenities, such as parks and access to freeways. Indeed, the lone difference between the locations is that at some point in time location S has a streetcar stop. Locations S and NS can be arbitrarily dense; there are no regulatory or technical constraints on density.

We assume individual utility is quasi-linear, $U(D_l, c_l) = \Gamma(D_l) - c_l$, where l denotes discrete locations S and NS. The first term, $\Gamma(D_l)$, measures the net effect of population density on utility at location l and captures the trade-off between the positive amenity value of density and the disutility from congestion: $\Gamma(D_l) = \delta(D_l) - \mu(D_l)$. The amenity value of density is $\delta(D_l)$, where $\delta(D_l) > 0$ and $\delta'(.) > 0$. Density amenities could include a greater variety of shops or longer store hours. The disutility from congestion is $\mu(D_l)$, where $\mu(D_l) > 0$ and $\mu'(.) > 0$. Such undesirable aspects of density include noise, crowding, and congestion of publicly provided goods.

The second term in the utility function, c_l, is the cost of commuting to the central business district, equal to the sum of the opportunity cost of time and the monetary cost of transit. Residents choose only a residential location l, and they always have the option of residing

[15] A different route to considering the role of transportation cost and density is the canonical monocentric model of Alonso (1964); Mills (1967); Muth (1969). While predictions of this model are clearly relevant for our analysis, for our empirical purposes we prefer a model that abstracts from the focus on distance to the central business district.

[16] The theoretic framework draws on Bleakley and Lin (2011b) and Helpman (1998).

outside the city in a location providing a reservation level of utility U^*.

We use this framework to examine the effect of three transit regimes on density at locations S and NS: pre-streetcar, streetcar and autos. For the moment, we assume that returns to density are decreasing, which is equivalent to assuming that congestion costs increase with density more quickly than does amenity value ($\delta'(D_l) < \mu'(D_l)\ \forall D_l$).

Before the arrival of the streetcar, the dominant mode of commuting was walking, and transport from S and NS to the center was equally slow. Figure 1b plots utility in the walking era as a function of density in the two locations. As S and NS are equidistant from the city center, they are equally costly for commuters. With equal commuting costs and utility pinned down at U^*, density must be equal across locations at $D^*_{NS} = D^*_S$. If density at NS were greater than equilibrium density D^*_{NS}, utility for people at NS would be below U^* and they would depart for the reservation location, decreasing density at NS. Departures would continue until density fell to D^*_{NS}, at which point residents would no longer have an incentive to move. Thus, $D^*_{NS} = D^*_S$ is the only stable equilibrium in the walking era.

With the arrival of streetcars, the cost of commuting to the center from location S declines sharply, while commuting costs at NS are unchanged. Figure 1c shows that the streetcar utility curve U_S now lies above U_{NS} at any density, since the cost of commuting is lower from S. Individuals move to location S in order to obtain utility above U^*—increasing density at S—until the additional net disutility of density exactly equals the reduction in commuting costs at D^*_S.

After the arrival of the auto, the cost of commuting once again equalizes across locations S and NS. Equal commuting costs returns us to the situation in Figure 1b, where density at the two locations must equalize.

This framework demonstrates that given decreasing returns to density, and in the absence of other forces, density at S and NS should equalize after transit costs converge. The first half of the empirical work in this paper is devoted to testing this contention.

2.2 Causes of Reconverge Failure

We now turn to three explanations for why density may fail to reconverge after the streetcar's obsolescence: follow-on public investment, the persistence of initial durable capital, and the creation of focal points for public and private coordination.

The first hypothesis is that the initial streetcar location yielded successive public investment—in roads and other forms of public transit—and it is this later investment that causes density to persist. In other words, locations S and NS remain distinct today, and their difference is driven by post-streetcar public investments. We take this possibility seriously and aim to bound its magnitude in our empirical work.

Alternatively, density could persist near streetcars because the initial commuting advantage motivated the construction of large structures for dense living and these structures are still in existence (Brueckner, 1980b,a). This is analogous to the hypothesis that urban decline is not a mirror image of urban growth, as Glaeser and Gyourko (2005) argue. In this view, economic fundamentals now argue for less capital intensive structures, but the time for capital replacement has not yet arrived. If this hypothesis is true, new structures near defunct streetcars should be substantially less capital intensive than older structures; we test this contention empirically.

Finally, density may persist near streetcars because the streetcar has generated a focal point for coordinated action, or a "point of convergence for individual expectations" (Bosch-Domènsch and Vriend, 2013, p. 52). Game theorists argue that a focal point can help individuals coordinate, even when the focal point is not an equilibrium, and when it is Pareto dominated by other equilibrium outcomes (Bosch-Domènsch and Vriend, 2013).

If streetcars serve as focal points, we should observe evidence of coordinated outcomes, either public, private or both. Public coordination in land use takes the form of land use regulation, which we can observe with great detail in our data. Private coordination stems from external benefits that residents or firms exert on one another. Intuitively, if there are increasing returns – driven perhaps by consumers' ability to share consumption, or firms' ability to share inputs – an initial location decision can solve a multiple equilibrium problem. Appendix Section 11 further discusses agglomerative externalities in relation to the defunct streetcars in the context of our theoretical framework.

3 Data

Our data consist of four major components: cross-sectional property data, historical streetcar routes, geographically consistent historic census data and zoning information. The data cover Los Angeles County, which contains 88 incorporated cities and a large unincorporated area. The cross-sectional property data contain information on legally defined pieces of land, or parcels. We observe structure, lot size and other property information for each of the roughly 2.3 million parcels existing in Los Angeles County from 1999 to 2011.

To document historical streetcar routes, we digitized historical maps showing the red and yellow cars of Los Angeles County to approximate the fullest extent of the network.[17] Appendix Figure 2 gives a graphical representation of the extent of this work. Los Angeles Railway lines are in the center in yellow; Pacific Electric lines and stops are in red. The rest of the map shows how we placed the lines. The yellow cars are drawn on top of a georeferenced 1914 system map. Behind the system map are georeferenced topographic maps from the 1920s and 1930s. The lowest layer is modern major roads in blue. In addition to the streetcars, we also digitized the network of major roads c. 1925 and 1934. We list the specific maps and documents we use in the data appendix.

Any analysis of population density over time must consider consistent geographic units. Were we to use census tract boundaries as defined for each census year, our analysis would be confounded by the fact that the Census defines tract boundaries in part on the basis of

[17] "We" here means University of Toronto student Jordan Hale, who did marvelous work digitizing hard-to-read maps.

population. Therefore, we construct a panel of tract-level data consistent with 1940 census boundaries, the first year for which census data cover the entire county (the city was first tracted in 1930).[18] Using digital maps from the National Historic Geographic Information Systems Center, we allocate the land area of tracts from 1950 to 2010 to the 1940 borders (due to the demise of the decennial long form, "2010" is the American Community Survey, 2007-2011). We attribute consistent variables to these 1940-boundary tracts.

Our final major data collection is on land use regulation. The first part of this is our analysis of municipal zoning restrictions. Each parcel in each city is associated with a zone code, for example, R-1 or C-2, and this code is reported in the parcel data. These codes are not consistent across cities in the sense that the restrictions for R-1 in Los Angeles are not the same restrictions for R-1 in the city of Long Beach. Parcels in roughly 50 cities and the unincorporated area (covering approximately 70 percent of all parcels) have reliable information on zone codes in our cross-sectional parcel data. For those cities, we collected the "meaning" of each code from 2010 municipal documents. Specifically, for each code we collected maximum units allowed, maximum height allowed, maximum floor area ratio (structure square footage divided by lot square footage) allowed, minimum lot size required, and minimum covered and uncovered parking spots required. Not all cities require all of these elements for all codes. However, missing values in the zone code still contain information: when an element is not limited, behavior is unrestricted.

The second part of our land use regulation data collection is our digitization of a map of the earliest zoning designations in the county: the 1922 City of Los Angeles zone code. Appendix Figure 3 shows one page of the 1922 zoning map book. We use GIS techniques to connect 1922 zoning to modern parcels.

To find a measure of distance to the streetcar, we calculate the shortest distance from the

[18] Unfortunately, fine grain geographic data is either not available or not digitized before 1930. In the pre-streetcar era, Los Angeles 1880 census microdata are no longer available, and the 1890 Census manuscripts burned (leading to the founding of the National Archives.)

center of each parcel to the nearest streetcar. For the Los Angeles Railway, we very closely approximate the shortest distance to the rail line;[19] for the Pacific Electric we measure distance to the nearest stop.

Appendix Table 1 shows that being near a streetcar is not a historical anomaly that affects a small part of the county. The average distance to a Pacific Electric stop is about six and a half kilometers, and about one-fifth of all parcels in the County are within half a kilometer of a Pacific Electric stop. Almost seventy percent of county parcels are within three kilometers of a stop.[20] The Los Angeles Railway lines were not so widespread; the larger standard deviation in this row shows that there are many parcels very close to the yellow car lines, and many quite far away, for an average of 18 kilometers. The final row of the table presents the measure we will use in many of the figures in the paper: the minimum of the distance to either a yellow line or red car stop; figures in this row are mostly driven by variation in distance to the Pacific Electric stops.

We also calculate the shortest distance from each parcel to modern major roads, major roads circa 1925 and 1934 (from maps we digitized), major road intersections in 1934, modern inter- and intra-urban rail, the coast, downtown and highway entrance or exit.[21]

4 Establishing Persistence

In this section, we illustrate the strong correlation between the distance to the extinct streetcar and 2010 population density. We then demonstrate that this relationship is due to the density of structures, rather than the density of people per structure. Finally, we show that the pattern of density near the streetcar has reinforced, rather than muted, over time.

[19]Mechanically, we transform the line into discrete points at a distance of 200 feet and calculate the shortest distance to any one of these points.

[20]Stops are sufficiently close that if we re-do this table with distance to the line, rather than the stop, the results are quite similar.

[21]For features that are lines, we use the same technique as in the previous footnote.

Figure 2 presents the striking relationship between current density and distance to the now-extinct streetcar. Distance to the streetcar is on the horizontal axis, and population density, measured in thousands of people per square kilometer, is on the vertical axis.[22] The negative relationship between density and distance to the streetcar is clearly visible. The red line traces out a locally linear least squares regression.[23]

To make a legible figure from the county's 2.3 million parcels, this and all following similar figures present means by distance-to-streetcar bins. We sort parcels by distance to the streetcar and allocate an equal number of parcels into each of six thousand bins by distance to the streetcar. Each bin has slightly fewer than 400 parcels. This figure presents (as do subsequent ones) the mean of the vertical axis variable by bin.[24]

Population density is quite high near the extinct streetcar, and tapers off rapidly with distance. By about two kilometers from the streetcar, density is less than half of its streetcar location peak. The slope is particularly steep very close to the streetcar.

Are the areas near the streetcar densely populated because they have many housing units, or because the housing units are more densely occupied? To explore the source of population density, we note that population density is a function of people per housing unit, and housing units per land area:

$$\text{population density} = \left(\frac{\text{people}}{\text{housing units}}\right)\left(\frac{\text{housing units}}{\text{land area}}\right)$$

We plot each of these components in 2010 versus distance from the streetcar in Appendix Figure 4.

[22]This and all figures measure distance to the streetcar as the minimum of a parcel's distance to the Los Angeles Railway line or the Pacific Electric stop (the final row in Appendix Table 1).

[23]We use the tricube weight and a bandwidth of 0.3.

[24]Density is a feature of census tracts, not parcels (pictures using block group density are virtually identical; we use tract density to make historically consistent pictures). Instead of reporting the mean population density by distance to the streetcar, we could have reported the mean distance to the streetcar by census tract. We prefer to aggregate by distance to the streetcar, since it preserves the most variation in the key variable of interest.

Appendix Figure 4 (a) shows no negative association—and if anything a positive one—between people per housing unit and distance to the streetcar. In contrast, Appendix Figure 4 (b) shows a strong negative relationship between housing units per land area and distance to the streetcar. Comparing Figure 2 and Appendix Figure 4, it is clear that the relationship between population density and the streetcar is driven by the capital intensity of land use, and not by greater population per housing unit. This finding motivates our principal focus on structural capital for most of the remainder of the paper.

Finally, we consider how the relationship between streetcars and density has evolved over time using decennial census data from 1940 to 2010. In other words, we consider whether what we show is truly "persistent," or merely a muted echo of the past. Figure 3 summarizes the streetcar gradient over time. The top line in Figure 3 plots the density by decade at a distance of 0.3 km from the streetcar by decade from 1940 to 2010. Each subsequent line traces out the density at an additional 0.3 km from the streetcar (so the second line is 0.6 km, the third 0.9 km, etc).

This comparison yields two findings. First, in all decades, areas closer to the streetcar are more densely populated than areas far from the streetcar. Second, over time, density increases at all locations within the three kilometer radius of streetcar stops (recall that such locations account for 70 percent of county parcels). Stated differently, as the county became more dense at all locations, the greater relative density near the streetcar was preserved. Data allow us to go back one decade further for the city of Los Angeles only (see Appendix Figure 5), and the pattern for these data are very similar to what we see in Figure 2.

5 Causal Analysis of Streetcar Influence

The previous section shows that distance to the extinct streetcar is strongly associated with higher density, specifically structure density, and that the gradient has reinforced, rather than muted, over time. In this section, we adopt a more nuanced empirical strategy in order to establish that the streetcars are causally connected to modern density. We also use this strategy to test whether the durability of capital can explain streetcars' persistent impact on modern density.

5.1 Empirical Strategy

While the pattern in Figure 2 strongly suggests a relationship between extinct streetcars and modern population density, this relationship could simply be a correlation between pre-streetcar factors and streetcar location, rather than the effect of streetcars themselves. For example, streetcars may have been laid out near major roads, and these major roads, not the streetcars, drive the pattern we document. We view these pre-existing factors as an identification problem, as our theoretical framework assumes that initial density is caused by the streetcar.

In contrast, we view subsequent investments generated by streetcars as a potential mechanism for persistent streetcar density. We aim to quantify the importance of such investments.

To isolate streetcars' effect on density, we draw a circle around each red car stop—the dark shaded region in Appendix Figure 6. We compare the density within this circle to the ring surrounding the circle—the lightly shaded region in the figure. We call the circle the "treatment" area and the ring the "control." Our goal in this comparison is to hold most features that define the locational amenities of a small neighborhood—its location in the city, its distance to parks and businesses—constant and isolate the effect of the streetcar stop. We set the radius of the control ring—the distance from the streetcar stop to the outer edge of the control area—so that the treatment circle and control ring have equal areas. Thus, the strategy compares the area immediately surrounding a streetcar stop to the closest possible area of the same size.[25] Importantly, major roads running through the treatment area will

[25]The control radius equalizes the two areas in theory—i.e. $\pi r_c^2 = \pi r_t^2 - \pi r_c^2$, where r_t and r_c are the

almost always pass through the control region.

We implement this procedure by estimating

$$\text{outcome}_{is} = \gamma_0 + \gamma_1 \text{Treatment Circle}_{is} + \delta_s + \gamma_2 P_{is} + \gamma_3 D_{is} + \epsilon_i \quad (1)$$

where s denotes the nearest streetcar stop to parcel i. Our sample is limited to parcels in the treatment circle or control ring: we drop parcels in the grey area in Appendix Figure 6. Treatment Circle_{is} is a indicator variable equal to one if parcel i is located within the treatment circle s. The omitted category is the control ring. The fixed effect δ_s is specific to each streetcar stop and controls for differences across streetcar stop areas s. The coefficient γ_1 therefore measures the mean difference in outcome_{is} between the treatment and control regions.

We control for a robust set of parcel-specific distances to amenities. The vector P_{is} is streetcar predecessors—locational features that pre-date the arrival of the streetcar. We include ruggedness of terrain, and cubics in elevation, distance to the coast, distance to downtown, distance to a major road in 1925, and distance to a major intersection in 1934. We include elevation and ruggedness to control for the possibility that streetcars lines were laid out to avoid significant changes in elevation, and to control for any amenities, such as views, that are conveyed by elevation.[26]

We include distance to a 1925 major road to increase the odds that we isolate the historical influence of streetcar stops from the historical influence of major roads, which may independently affect both historical and modern density. Ideally, we would control for the road network circa 1890, since using 1925 roads likely controls for roads that were themselves

treatment and control radii, respectively. In practice, though, not all of the treatment and control areas contain equal areas. For instance, roads are not part of the sample. Moreover, streetcar stops that are closer together than 0.7 km will have truncated control (and possibly treatment) regions as we assign each parcel to its closest streetcar stop.

[26]Historically, streetcars need not have been laid out to avoid changes in elevation; one of the advantages of streetcars was their ability to traverse steep slopes.

determined by streetcar routes. Unfortunately, road maps as we know now them — with sufficient detail to locate major roads — are available only starting in the 1910s (Ristow, 1946; Redmill, 1932).[27] We also control for the distance to the nearest 1934 major intersection in case it is the intersection, rather than the road, that is the key determinant of density. Thus, we believe these variables "over control" for pre-existing roads and therefore yield lower bound estimates on streetcars' persistent effects.

The vector $D_{i,s}$ contains follow-on public capital, or streetcar descendants—variables that post-date the streetcar and could plausibly be streetcar-caused and themselves cause persistence. The vector consists of cubics in distance to a modern major road, distance to a Metro rail line, distance to a Metrolink line, and distance to a highway entrance.[28] This vector includes the key elements of the modern transit system, all of which may have roots in the system initially defined by the streetcar (we turn to controlling for bus stops—which is problematic in terms of the data required—at the end of this section).

We weight parcel observations by lot size, normalized so that weights within each streetcar stop treatment area and each streetcar stop control area sum to one. As a result of the normalization, we can interpret each streetcar stop as a separate "experiment" contributing equal weight to the estimation of γ_1. We cluster standard errors by streetcar stop s. Finally, we limit our sample to stops where both the treatment and control rings have at least ten parcels to ensure a sufficiently large sample for analysis.

This strategy focuses solely on red car stops. Yellow car lines did not have stops and are therefore not amenable to the circle estimation strategy which requires a focal point (the stop). As Appendix Figure 2 shows, the yellow cars operated very densely in the historic downtown. Because of this location pattern, our strategy might also struggle to distinguish between the effects of the downtown location and the yellow cars. It is also possible that the

[27] As a sign of streetcars' dominance, builders referred to building a streetcar line as "building a road."

[28] Metro Rail and MetroLink are Los Angeles's modern intra- and interurban rail systems. MetroRail formed in 1990, and MetroLink in 1991.

existence of nearby intra-urban rail reduced the locational advantage of red car stops. As a result, in most specifications we omit any red car stops that have a yellow car line running through either the treatment or control area.[29]

The key remaining choice in estimating the model is the radius of the treatment circle. The historical record tells us that a streetcar stop was valuable only to properties within walking distance. We therefore expect no effect outside of a treatment radius of roughly two kilometers (1.25 miles). The pattern of results at different radii is also a test of the validity of our approach. If structure density is influenced by distance to the streetcar, estimations using very small radii should have small and insignificant coefficients, because they compare the treated area with what is essentially another treated area. At very large radii, the estimation compares a mix of treated and control areas with control areas and should also yield small and insignificant coefficients. At some "middle" radius that maximizes the difference between treatment and control, the coefficients should be the largest. Theoretically, we expect this "middle" radius to be within easy walking distance to the streetcar stop. To test this prediction, and to hone in on what this "middle" distance is, we turn to the data and examine the effect at different radii.

5.2 Results

Figure 4a presents results from estimating Equation (1) 30 times, including both P_{is} and D_{is} (pre- and post-streetcar locational variables), and varying the radius of the treatment circle from 0.1 km to 3.0 km. The outcome variable is a parcel-specific measure of density: structure square feet divided by lot square feet. The radius of the treatment circle is on the horizontal axis and the estimate of γ_1 is on the vertical axis; the 95% confidence interval is in grey.

[29] We reproduce Figure 2, omitting parcels within 0.1 km of yellow car lines in Appendix Figure 7; the pattern is very similar to Figure 2's original relationship.

The effect of a streetcar stop on density increases rapidly as the treatment circle radius increases from 0.1 to 0.5 km. The effect reaches a maximum at 0.5 km, and there is a plateau in the effect from 0.5 to 0.7 km. These maxima are at the radii where the mean difference between the treatment and control densities is greatest, conditional on the covariates in Equation (1). The effect declines gradually as the treatment circle expands beyond 0.7 km. Around two kilometers from the streetcar stop, the density effect is no longer distinguishable from zero. This inverted U shape is consistent with an effect that peaks at a comfortable walking distance from the streetcar, and aligns with the historical narrative and the assumptions of our model about the importance of transportation costs.

We present results with and without controls in Figure 4b. Although the controls do attenuate the results somewhat over the first half kilometer or so, the results with and without controls are qualitatively similar in this range. Farther from the stop, the controls become progressively more important. For instance, at 0.5 km the estimate which controls for P_{is} and D_{is} is around 33 percent less than the unconditional estimate. This ratio grows to 50 percent at 1 km and 64 percent at 2 km.

The chart also makes clear that the D covariates, which measure follow-on public capital, have a very limited effect on the magnitude of our finding in a relevant range of distance to the streetcar. We leave the interpretation of this result to subsection 5.3. Given that the treatment radius of 0.5 km maximizes the density treatment effect (Figure 4a), is within the range where the effect is relatively less sensitive to the inclusion of controls (Figure 4b), and is well within the plausible walking distance to the stop, we present all remaining results based on a treatment circle radius of 0.5 km. Table 1 displays summary statistics for the treatment and control areas defined in this way. For comparison purposes, the first three columns display the same statistics for all County parcels. Columns (4) to (9) compare our outcome variables for the treatment and control areas. Relative to the control area, the control region has more dense capital, more valuable capital, is less likely to have residential properties, and is zoned more permissively.

Table 2 presents our main results. Panel A shows unconditional results (Equation 1 without P or D); Panel B shows results conditional on predecessor features (P), and Panel C presents results conditional on both predecessor and descendants (P and D). Column (1) includes the whole sample; results in Column (2) omit streetcar stops if any parcels in the treatment or control region are within 0.1 km of a Los Angeles Railway line (Figure 4 uses the specification in Column (2)).

Comparing estimates including and excluding parcels near yellow car lines (Columns (1) to (2)), the results are slightly larger when we exclude parcels near yellow car lines. This may be because red car lines exerted a more powerful influence on initial density when they were the only transport option available.

The estimates in Column (2), conditional on all covariates, suggest that being near a streetcar stop is associated with an increase in structure density of around 3.8, or about 12 percent of the control area mean (note that we multiply structure density by 100). The qualitative pattern of the results is consistent across columns: streetcar stops are associated with persistent effects on density. We interpret these results as a firm rejection of the reconvergence hypothesis.

5.3 Durable Capital and Persistence

One widely cited mechanism for the persistence of the past is the long life of capital, including roads and structures. Following this hypothesis, modern density is could be due exclusively to initial investments in durable capital – private structures, or public infrastructure – that have not yet depreciated sufficiently to be replaced. When replacement time arrives, the streetcar motivated density pattern may change.

Considering public infrastructure, we believe that the evidence in favor of the durability of public capital as the exclusive or predominant mechanism for the persistence of density is weak. Figure 4b shows that the addition of post-streetcar era public capital as controls has only a small impact on the coefficient. Comparing results conditional on pre-existing features to those additionally conditional on post-streetcar transit (Panel B to Panel C in Table 2), modern covariates related to roads and transit explain roughly 10 percent of the relationship between distance to the streetcar and modern density. We interpret this as evidence that a limited amount of streetcars' persistent effect is due to streetcars' influence on the geographic location of later transit. This portion of the persistent density could be due to market access, as in Redding and Sturm (2008). This is certainly not immaterial, yet a large majority of the streetcars' influence remains unexplained.

However, this leaves lingering private capital as a culprit. The first panel of Table 3 restricts the sample to parcels with structures built after 1963—the year the last streetcar was removed—in order to test the hypothesis that the persistent density around the streetcar stops is caused by old, dense structures that have not yet reached time for redevelopment. Column (1) in this table presents results without covariates, Column (2) with predecessor controls, and Column (3) with predecessor and descendant covariates (as in Table 2, Panels A, B, and C). Comparing the three estimates in the top panel to those in Column (2) of Table 2, the differences are small. On average, new structures near streetcars are as relatively dense as all structures near streetcar stops. We interpret this as a rejection of the hypothesis that the density near the streetcars is driven mostly by older structures that have not yet reached redevelopment.

In sum, we believe that durable capital cannot solely explain the persistence of density near the streetcar. Initial investments in durable capital surely play a role, but they are not sufficient.

5.4 Robustness

We now turn to addressing challenges to the circle estimation strategy. Despite the small radius for our analysis, properties in the circle may have been more likely than the control ring to host population centers pre-dating the streetcar. The simplest way to resolve this concern would be to restrict the analysis to areas unpopulated before the arrival of the streetcar. Such a strategy requires a map with detailed boundaries of populated areas. As we described above with the road maps, we have been able to find no sufficiently detailed map prior to 1925.

As a close substitute, we rely on the coverage by the Sanborn Map Company as a proxy for populated areas (for more details on these maps, see (Ristow, 1968)). The Sanborn Map Company produced city-level maps for fire insurance purposes that covered, to the best of our understanding, almost all populated places. We document this comprehensive coverage by comparing the number of cities in the Sanborn catalog with the number of cities and towns accounted for by the U.S. Census. In 1902, the earliest date for which we have a comprehensive number, the Sanborn catalog lists 273 cities in California. The 1900 Census reports 116 incorporated cities of any size in California (Census Office, Department of Interior, 1901; Sanborn Map Company, 1902, Table XVII, p. lxi). In other words, the number of cities in the Sanborn catalog is more than double the number of incorporated jurisdictions according to the Census. We therefore comfortably interpret the Sanborn map collection as a reasonably thorough catalog of places of any size.

Given this, we re-estimate on the sample of modern cities without Sanborn maps in 1898, the year in which Huntington first began to undertake major investment in the Los Angeles area. This is strigent along two dimensions. First, as streetcars began to appear in the early 1890s, using 1898 as a cut-off likely excludes some cities where development was truly influenced by the streetcar. Second, we omit the entire city when any part of that city was developed before the streetcar. Therefore, this method omits the entire City of

Los Angeles – and other large cities – although it had large portions that were undeveloped before the streetcar. Specifically, we drop 15 cities from our analysis, and they include the oldest and largest cities in the County: Los Angeles, Long Beach, Santa Monica, Pasadena, and Pomona.[30]

Although the sample decreases by more than one-third, the second panel of Table 3 shows that areas undeveloped before the streetcar have persistently higher density near extinct streetcar stops today. We find that, controlling for predecessor and descendant covariates, density is roughly seven percent higher near the streetcar. Thus, this best practicable empirical test argues against the hypothesis that density near streetcars is driven by pre-existing features.

As an alternative strategy to omit already-developed areas, we exclude the five dense clusters of red car stops, marked on Figure 2 with large asterisks (individual stops in these clusters are shaded pink). These locations correspond to stops in Pasadena, Long Beach, Santa Monica, San Pedro and Pomona. The third panel of Table 3 shows that, if anything, removing these clusters increases the results; density near streetcar stops is not exclusively due to these stop clusters.

The fourth panel of Table of 3 tests the contention that density near streetcar stops is driven by the major intersections, rather than the streetcar stops, at which some stops are located (recall that D already includes a cubic in distance to a 1934 major intersection). If a streetcar stop is situated at a major intersection, as in Figure 6, the treatment circle will mechanically have parcels with a lower average distance to the intersection and road, relative to the control ring.[31] In order to generate treatment and control areas with more similar average distance to the road or intersection on which the streetcar stop is placed, we

[30]The full list is Alhambra, Azusa, Compton, Downey, Inglewood, Long Beach, Los Angeles, Maywood, Monrovia, Pasadena, Pomona, Redondo Beach, Sierra Madre, South Pasadena and Whittier. See appendix subsection 9.7 for more details.

[31]Not all streetcar stops, however, were located at intersections.

define an alternative treatment area: the treatment ring. We construct the ring by removing a small concentric circle from the center of the treatment circle, creating a treatment ring with width equal to the control ring.

As expected given the gradient in Figure 2, these point estimates, reported in Column (1), are somewhat smaller than those from specifications with a treatment circle. However, the results remain quite large in economic terms and are precise, again suggesting the location of streetcar stops exert significant influence on modern density. Moreover, unreported results which limit the sample to stops with treatment and control regions lacking a major intersection are similar to the results on Table 2.

The fifth panel of Table 3 measures whether the density effect is economically meaningful. Are the structurally dense parcels more valuable? We replace the dependent variable of physical quantity of capital with the dollar value of capital, again measured per square foot of lot size. The results suggest that being near a streetcar stop boosts the assessed value of capital by roughly 4 dollars per square foot—an increase of 20 percent relative to the control area mean.[32] Thus, areas near the streetcar have more capital, and the market places positive value on this additional capital.

Although the D vector of post-streetcar public infrastructure controls for many forms of modern transport, it does not control for bus stops. The Los Angeles area is served by at least 20 bus services and we have not been able to locate a comprehensive digital map. However, controlling for bus stop locations (with a cubic, as we do other locations) from the Los Angeles Metropolitan Transit Authority (MTA)—the largest bus service in the county—has little effect on the results. See Appendix 10 for details.[33]

[32] We measure the dollar value of capital with the assessed value of improvements. Because of California's Proposition 13, assessed values may only be close to market values at sale, so we additionally control for a quartic in time since last sale.

[33] A remaining concern with our circle strategy is that it does not sufficiently distinguish between the effects of the streetcar stop and the streetcar line. While it is technically possible to include distance to the streetcar line in Equation (1), this distance is very highly correlated with distance to the streetcar stop, and our results are, not surprisingly, not robust to its inclusion. To address this issue, we use all County parcels

6 Streetcar as Focal Point

The previous section ruled out lingering durable capital as the primary explanation for the persistent impact of streetcars on density. In this section, we evaluate whether the evidence is consistent with the streetcar serving as a focal point for the coordination of economic activity after the streetcar's demise. Specifically, we define the focal point a la Schelling, as a salient location, perhaps deriving from precedent (Crawford and Haller, 1990), that guides coordinated actions that might fail to occur without guidance (Schelling, 1960). We consider both public coordination associated with the evolution and development of land use regulation and market-driven coordination due to agglomerative forces.

6.1 Land Use Regulation

Government can directly coordinate behavior through regulation. In the urban case, the institution of land use regulation constrains structure size, structure height and many other aspects of land use. In this subsection, we test whether modern zoning is consistent with the density pattern laid out by the streetcar. We then evaluate whether this modern pattern is an ossification of initial zoning choices, or whether institutional change acts to reinforce the density pattern.

We start by verifying a necessary condition for land use regulation to be an explanation for the density near the defunct streetcar stops: zoning near the stops must allow more density. To test this, we use our detailed zoning characteristic data. Table 4 reports whether the underlying attributes of zone codes vary by distance to the streetcar using the circle

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and estimate a linear or log-log model of structure density as a function of distance to the streetcar stop and streetcar line. (A log-log model is likely more sensible for the distances in the full sample, as parcels both 6 km and 12 km from the streetcar are equally unlikely be be affected by the streetcar.) Unlike our primary analysis sample, there is now substantial variation in both distance to the streetcar stop and streetcar line. We find that distance to the streetcar stop remains a robust predictor of density, even controlling for distance to the streetcar line. In fact, the coefficient on distance to the streetcar stop becomes larger and more precise when we include distance to the streetcar line as a control (results available upon request).

identification strategy. Parcels within 0.5 km of a streetcar stop are 3 percentage points more likely to be zoned for non-residential uses than are parcels in the control ring (Column (1)). This effect is large, equal to 25 percent of the control region dependent variable mean. A non-residential designation often allows for greater density than does a residential designation.

Similarly, residential locations near a streetcar stop are zoned significantly more permissively in terms of number of units allowed—see Columns (2). Specifically, parcels near the streetcar allow roughly $2\frac{1}{4}$ more units per parcel than more distant parcels, an increase of nearly 50 percent relative the control region dependent variable mean. Parcels within the streetcar circle also allow taller structures, although the size of this effect this modest—see column (3). Finally, relative to the control mean, parcels near streetcars are required to provide about a fifth of a parking spot less (per unit, for residential uses), or 7 percent of the control area requirement. Anecdotally, urban developers perceive minimum parking requirements to be substantial hindrances to development. Parking spots crowd out structure square footage and (or) increase the cost of a project. In sum, these results reveal that the regulatory environment permits substantially more density near the stops than farther away.

We next explore whether there is a density premium near streetcar stops when we control for parcel-specific zone codes. Panel A of Table 5 shows that in a strictly statistical sense, zoning explains almost all of streetcar's relationship to density. Panel A, Column (1) replicates our main results for the sample for which we observe detailed zoning information. Despite the change in sample, the coefficient estimate is very similar to our main result (Table 2, Panel C, Column (2); 4.3 vs 3.8). Column (2) limits the sample to parcels with zone codes that appear in both the treatment circle and control ring. Although this restriction drops less than 15 percent of the sample, the magnitude of the coefficient drops by roughly half. This indicates that about half of the density effect is driven by zones exclusive to either the treatment circle or the control ring.

Column (3) tests whether parcels with the *same* zoning designation have different densities near and far from the streetcar. To do this, we use the full sample from Column (1) and add municipality-specific zone code fixed effects (e.g., different fixed effects for Los Angeles R-1 and Pasadena R-1, which may have entirely different restrictions). The streetcar stop coefficient is now one-quarter of its original magnitude, and is only marginally significant. The final column controls for streetcar stop-specific zoning fixed effects (i.e. the effect of each zoning designation is allowed to vary by stop). Here we find no difference at all in the density near and far from the streetcar – the streetcar coefficient is less than ten percent of its initial magnitude, and insignificantly different from zero. Thus, the remainder of the density effect in Column (2) is driven by the differential distribution of the same zoning designations in the treatment circle and the ring, rather than by different density within zone designations.

Is this pattern driven exclusively by older structures? To test this possibility, the second portion of Panel A reports results from performing the previous analysis, but where the sample is limited to parcels with structures built after 1963. These results have roughly the same pattern as the sample of all structures.

Permissive modern zoning near the streetcar may be due to the ossification of the initial zoning designations. Alternatively, zoning may have modified over the century to perpetuate the streetcar pattern. These are very different institutional routes to greater density near the streetcar. To discriminate between these alternatives, we first evaluate whether initial zoning was motivated by streetcar-driven land use and then assess the extent to which the zoning code has changed over the nearly century since its inception. Finally, we explore initial zoning's ability to explain the modern density pattern around the streetcar.

To do this, we turn to our digitization of the 1922 City of Los Angeles zone code—the County's first zone code. The 1922 code had no limits on size or bulk and only five use categories: single-family, multi-family, commercial, manufacturing and "anything not prohibited by law."[34]

Unfortunately, the area of the city zoned in 1922 only partially overlaps with the estimation sample we use in prior estimates. Our previous estimates omitted parcels near yellow cars out of a concern that they could confound the estimation. However, a comparison of Columns (1) and (2) in Table 2 shows that omitting parcels near yellow cars has only a small effect on the estimated streetcar coefficient.

In order to obtain a reasonable sample size when using the 1922 data, we include areas near yellow car routes. To avoid the portion of the city built prior to the streetcar era, though, we omit all parcels within six kilometers of Los Angeles City Hall as a proxy for downtown. In the prior samples, we omitted these parcels when we excluded parcels near yellow car lines. The first set of rows of Table 5, Panel B show that we can roughly replicate the density and modern zoning findings (in the first set of rows of Panel A) in the much smaller sample of the 1922 city. Here again, controlling for modern zoning completely explains the density pattern near the streetcar in a statistical sense.

We begin by assessing the claim from the historical literature that initial zoning grandfathered in existing uses (Kolnick, 2008; Whittemore, 2010). Column 1 of Table 6 shows relatively more non-residential zoning near the streetcar in 1922. Being near the streetcar is associated with a 2.1 percentage point increase in the likelihood of being designated non-residential in 1922 – an extremely large increase of over 50 percent relative to the control region sample mean (displayed in the bottom row of the panel). This is consistent with an institutional ratification of the streetcar density pattern.

Next, we begin to assess the process of institutional change: is modern zoning a direct or nuanced descendant of 1922 decisions? Appendix Table 2 relates the 1922 zone code to its 2013 equivalent for parcels within the treatment and control areas. We find that roughly one

[34]It was not until the 1950s and 1960s that zoning as we know it today – with more elaborate restrictions on structure size and bulk – became widespread (Longtin, 1999, p.2).

in three parcels changed broad category of permitted use. Thus, over the long run, zoning around the stops has been malleable, not static.

Given this, we turn to analysis of how zoning changed. Table 6 Column (2) examines whether proximity to the stops affects the probability of zoning change. Although the estimate suggests that areas nears the streetcar were around 10 percent more likely to change zoning designations (relative to the control area mean), it is not precisely estimated. Column (3) examines the prevalence of changes from residential to non-residential and finds precise evidence that land near the streetcar was more likely to convert to a non-residential designation. Nonresidential uses are often quite dense. As a result, the shift from residential to non-residential should increase allowable density.

This pattern of changes suggests that 1922 zoning, relative to modern zoning, should be more limited in its ability to explain streetcar-related density. To test this idea, the second set of rows of Table 5, Panel B replaces modern zoning controls with 1922 zoning controls. Indeed, the 1922 zone code has very limited explanatory power for the modern density around the streetcar: Controlling for historic zoning causes the streetcar coefficient to decline by only about 20 percent (comparing columns 1 and 4).

Finally, we examine whether the lower explanatory power of the 1922 code, relative to modern zoning, is attributable to the coarse nature of the 1922 code. To do this, we collapse the modern zoning designations into the 1922 categories (as in Appendix Table 2). Comparing columns (1) and (4) in the the third set of rows of Panel B suggests that modern zoning, defined in 1922 terms, can statistically account for roughly half of the modern density near streetcars. The remaining greater explanatory power of the modern code relative to the 1922 code is, by inference, due to zoning's shift to finer gradations. In particular, modern zoning has a multitude of limits and restrictions—such as height limits and lot coverage limits—that allow for far more nuanced differences than permitted by the coarse 1922 use designations.

In sum, we conclude that the streetcar stops were focal points for coordinating the substantial change in land use regulation since 1922. Both parcel-specific changes in permitted use and an evolution toward more nuanced regulation have yielded more allowable density near defunct streetcars.

6.2 Agglomeration

In this section, we explore whether the evidence is consistent with agglomeration: Coordinated private activity near streetcar stops due to increasing returns to density. In line with much the literature on agglomeration, we anticipate that such benefits are likely to be particularly pronounced for non-residential land uses, and we focus our analysis in this section on such uses. We conclude with a test for agglomerative externalities using land prices.

We begin by testing whether land use near the streetcar — the actual use of the land, not the zoned use — is more likely to be non-residential. (Zoning designations are hierarchical; a parcel zoned non-residential can almost always be used for a residential purpose, but a residentially zoned parcel cannot be used for a non-residential purpose.) We use the basic specification from Equation 1 and find that land near the streetcar is more likely to be in non-residential use. The first column in Panel A of Table 7 reports that properties near streetcars are five percent more likely to be non-residential. This is a large effect, equal to over 20 percent of the control area dependent variable mean (at the bottom of the panel). Among residential properties, those near the streetcar are seven percent more likely to in multifamily use (Column (2)); this is equal to 20 percent of the control region dependent variable mean.

However, agglomeration is primarily about concentration. It is possible that the larger number of non-residential properties near the streetcar are no more concentrated than non-residential properties far from the streetcar. To test this possibility, for each parcel in our sample we count the number of parcels within a 50 meter radius in non-residential use. We then use this "number of non-residential parcels in close proximity" as our dependent variable and limit the sample to non-residential properties. Relative to the dependent variable mean, non-residential properties near the streetcar have about 2.5 percent more non-residential neighbors (Column (1)). When we expand the "nearby" radius to 100 and 200 meters (Columns 2 and 3), these results intensify, becoming 3.5 and 5.8 percent, respectively.

The presence of agglomeration near the streetcar also has implications for land values. Areas near the streetcar are more dense and therefore face higher congestion costs than other locations. In the absence of offsetting positive externalities from density (that is, agglomerative forces), land prices near the streetcar should be depressed to compensate for these congestion costs. Land values near the streetcar that are equal to or greater than land values far from the streetcar are therefore consistent with the presence of agglomerative forces.

However, differential zoning may confound an examination of the effect of streetcar proximity on land values. As documented above, areas near the streetcar are zoned more permissively—a fact which will tend to boost land values. As a result, when comparing land values near and far from the streetcar stops, we condition on each parcel's zoning designation. In doing so, we control for each lot's individual-specific zoning designation and allow the streetcar stop treatment coefficient to capture the effect of being surrounded by greater or lesser density (which may well reflect the zoning status of *neighboring* parcels).[35]

We examine land values using the circle identification strategy of Equation 1. Table 8

[35]Following Turner et al. (2014), the price effect of zoning on land values can be decomposed into an own lot effect and an external effect. The own lot effect is unambiguously negative—the more restrictive a parcel's zoning, the less it is worth. When we condition on parcel-specific zoning designations, we are controlling for the own lot zoning effect. The external zoning effect, which captures the spillover of neighboring zoning designations, is of ambiguous sign. Our estimates of the effect on land values of being located near a former streetcar stop will capture both the congestion costs and agglomerative benefits of the greater density found there. To the extent that this density is *caused* by zoning, the streetcar stop effect on land values can be thought of as capturing the external zoning effect of Turner et al. (2014). Regardless, in the absence of an offsetting factor such as agglomerative forces, the congestion costs near the stops should suppress the value of land (conditional on the *own* lot zoning effect).

presents the results. Column (1) shows that properties near the streetcar sell for around 5 percent more than do those in the control region. This result is rather unsurprising. Land near the streetcar has more capital on it and is zoned for more capital-intensive use. Both of these factors should boost the value of these parcels. To isolate the value of land, column (2) controls for capital in a relatively non-parametric manner by including a full set of interaction terms between decile indicators for structure vintage and decile indicators for structure square feet, all interacted with the type of capital (single family, multi-family, etc.) The price premium to being in the treatment region falls to near zero and has a tight confidence interval—we can rule out a difference in price of any economically meaningful magnitude. Columns (3) and (4) additionally control for the zoning designation of each parcel of land. This estimate is again close to zero with tight confidence intervals. Columns (5) to (10) demonstrate that the lack of a streetcar stop price effect is robust to estimating the specification separately by use type. The equality of land values in and out of the treatment circle is consistent with positive agglomerative forces offsetting congestion costs near the streetcar stops.[36]

6.3 Interpreting the Focal Point Evidence

We believe the evidence we have marshaled on mechanisms strongly points toward the streetcar as a focal point for post-streetcar era change. Strictly parsing out the relative contributions of the two focal point channels—zoning and agglomeration—is extraordinarily difficult and our evidence is insufficient to do so. Theoretically, it is possible that just one of these explanations is the sole cause of the persistent density near the streetcar. For instance, the persistent density may be caused by agglomeration, with zoning merely following the market

[36] In terms of the theoretical framework, the results are consistent with the land market being in equilibrium at points $D_S^{*,auto}$ and $D_{NS}^{*,auto}$ on Appendix Figure 8. Given the level of land use regulation in Los Angeles, the market may very well not be in a true market equilibrium. The price results, though, are also consistent with outcomes that would be unstable in the absence of regulation, such as the pair of points $D^{'}$ (for the non-stop location) and $D_S^{*,auto}$.

(Wallace, 1988; Munneke, 2005). That said, there is substantial evidence that land use regulation binds in Los Angeles and significantly alters market outcomes (Glaeser et al., 2005; Brooks and Lutz, 2016) and evidence from Chicago suggests that historical zoning choices can have long-run effects on land use patterns (Shertzer et al., 2016). Overall, we view the weight of the evidence as most consistent with both land use regulation and agglomeration as causal mechanisms for persistence.

We also view it as probable that zoning and agglomeration are mutually reinforcing. For instance, zoning may reinforce agglomeration by influencing expectations over the likely future density near the stops: McAdams writes that "When individuals have a common interest in coordinating, as frequently occurs, a legal rule may guide behavior merely by influencing expectations about how others will behave" (McAdams, 2000, p. 1651). In turn, agglomeration may reinforce zoning by creating a set of land owners with a vested interest in maintaining the current regulatory regime.

7 Conclusion

Since its invention in 1888 through the early 1910s, the fast, cheap streetcar dominated urban transit. Despite its short heyday and later extinction, we document that the streetcar continues to exert a powerful influence on modern land use in Los Angeles. Notably, building activity since the removal of the last streetcar has reinforced, rather than muted, density near streetcars. Our evidence suggests that only a limited portion of the persistent influence of the streetcar is explained by durable capital, either in the form of private structures or public infrastructure.

Instead, we find evidence consistent with the streetcar serving as a focal point to coordinate both private and public action. Specifically, we find that land use regulation modified over the course of the century to coordinate more intensive uses near the defunct streetcar. In addition, we find evidence consistent with agglomerative forces at work near former streetcar locations.

Our work highlights the powerful role of the past, even at a very small spatial scale. Our findings hint that a richer explanation of the modern distribution of economic activity should consider the past as well as the present. In addition, our work documenting long-run modification of the institution of land use regulation suggest that initial conditions may profoundly direct later institutional changes.

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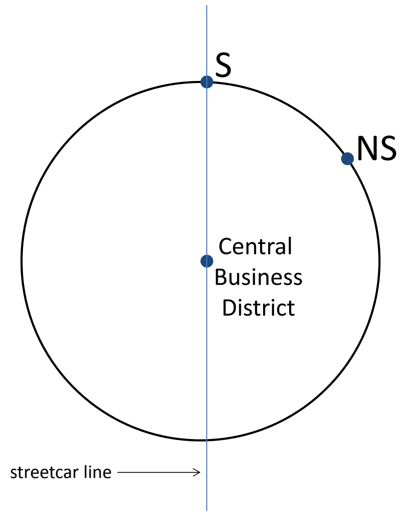
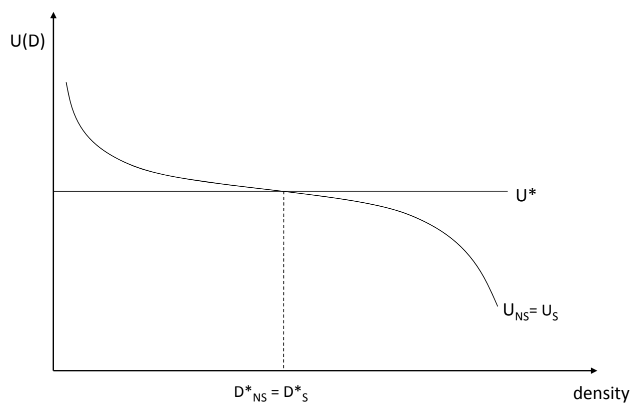
Figure 1: Density at Two Locations

(a) Two Locations Equidistant from the Central Business District



(b) Equilibrium Density in Pre-Streetcar Era



(c) Equilibrium Density in Streetcar Era

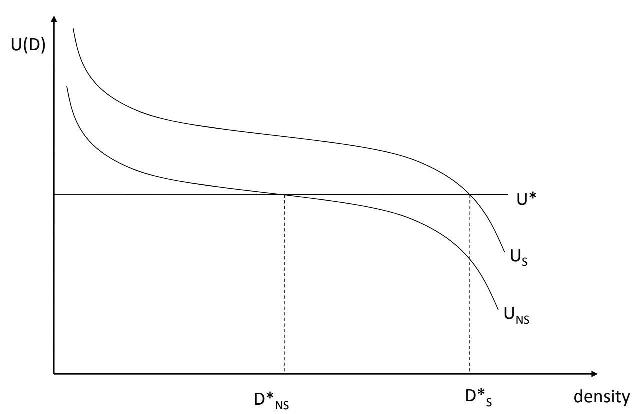
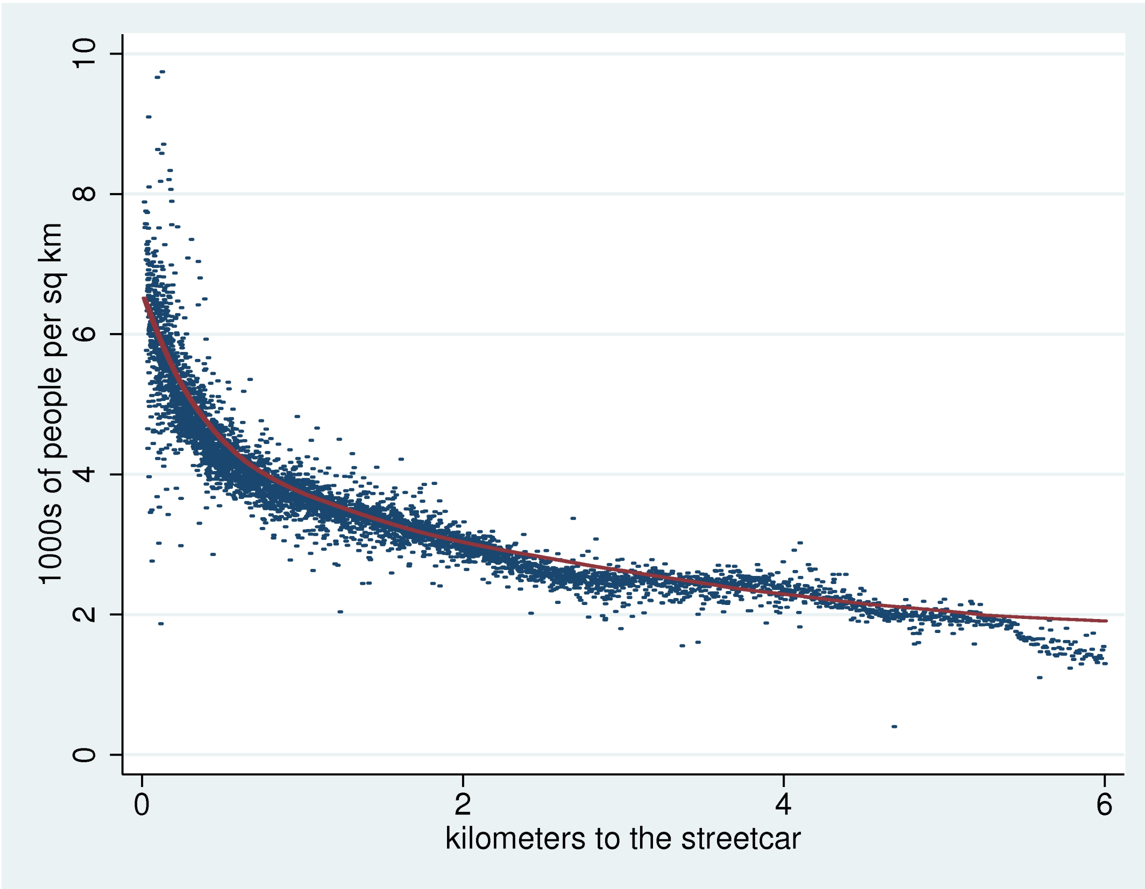


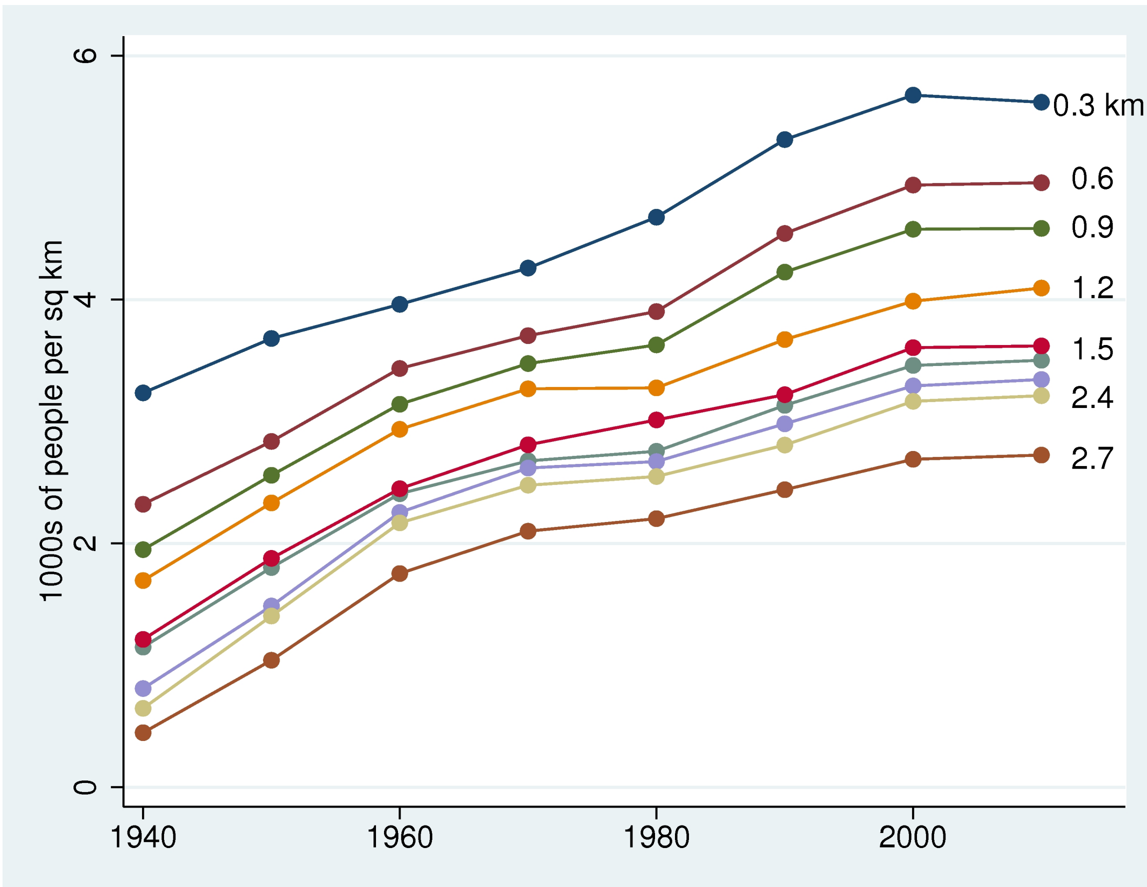
Figure 2: Modern Population Density Strongly Related to Streetcar Location



Notes: The figure shows a pattern of declining 2010 population density with distance to 1920s-era streetcar. Each point is the average tract density of approximately 400 parcels. The red line is a local linear regression.

Sources: Density information comes come from the 2007-2011 American Community Survey census tract level data, expressed in terms of 1940 census tract boundaries. We calculate distance to the streetcar for each parcel in the County based on our digitization of streetcar maps.

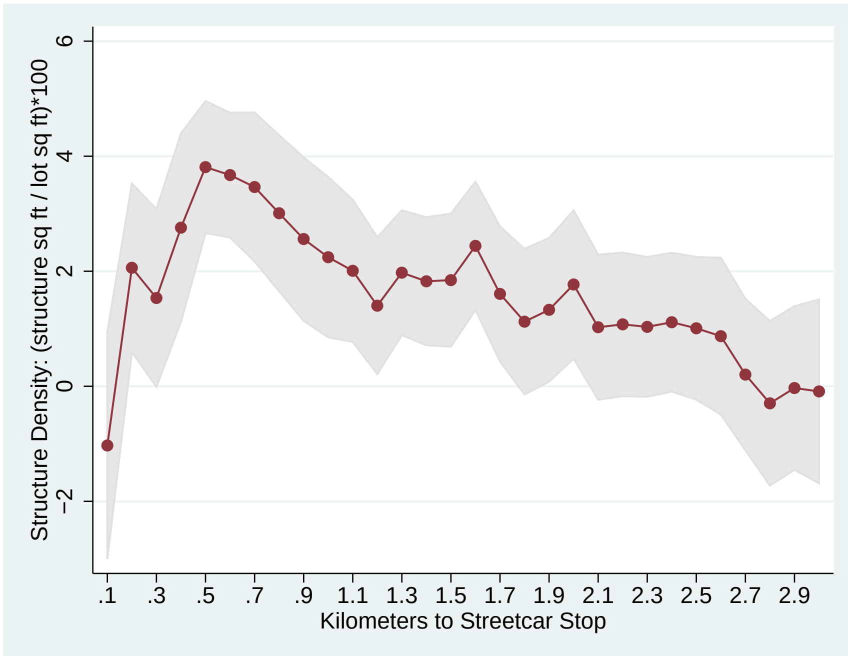
Figure 3: Density Shifts Upward Everywhere



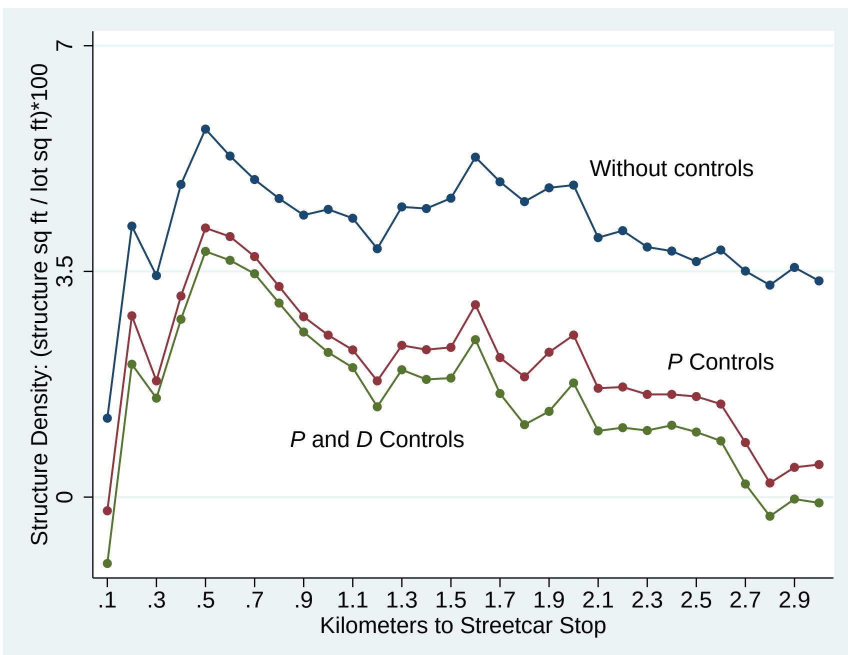
Notes: The figure shows a pattern of declining 2010 population density with distance to 1920s-era streetcar. Each point is the average tract density of approximately 400 parcels in the horizontal axis year at the marked distance from the streetcar.
Sources: Density information comes come from the 2007-2011 American Community Survey census tract level data, expressed in terms of 1940 census tract boundaries. We calculate distance to the streetcar for each parcel in the County based on our digitization of streetcar maps.

Figure 4: Density Effects Near Streetcar Stops

(a) Density at Multiple Radii from Streetcar



(b) Estimates With and Without Controls



Notes: Gray bands in top figure are 95% confidence intervals. Regression are as described in Table 2, using the sample in column (2). Vectors P and D are described in the note to Table 2.
Sources: Los Angeles parcel data; streetcar maps.

Table 1: 2011 Parcel Characteristics

	All Parcels			Circle Estimation Sample					
				≤ 0.5 km from Streetcar Stop			≥ 0.5 km Streetcar Stop & ≤ 0.7 km Streetcar Stop		
	Mean	S.D.	Obs.	Mean	S.D.	Obs.	Mean	S.D.	Obs.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Capital Intensity									
Sq. Ft. / Lot Size	32.34	32.80	2,297,543	38.28	47.97	289,550	32.52	38.22	134,911
Struc. Val. / Lot Size	25.37	38.56	2,297,823	30.51	89.23	289,550	25.72	74.96	134,911
B. Current Use									
Non-residential	0.12	0.32	2,340,150	0.32	0.47	289,550	0.22	0.41	134,911
Multifamily	0.25	0.43	2,070,937	0.40	0.49	255,710	0.32	0.47	124,397
C. Zoning Regulation									
Non-residential	0.15	0.36	1,521,345	0.17	0.38	195,774	0.11	0.31	96,906
Max. Units*	11.32	58.19	1,332,380	7.82	34.09	178,650	4.96	14.40	90,785
Max. Height in Ft.	35.66	8.44	1,452,802	37.44	13.20	188,063	35.47	10.23	94,922
Min. Covd. Parking	1.65	0.77	1,465,275	1.48	0.93	186,820	1.63	0.83	93,927

Note. * Max # units is only defined for residential properties. We multiply structure square feet per lot size by 100 here and elsewhere for legibility. Structure value is the assessed value. Columns (4) - (6) display statistics for parcels within 0.5 km of a streetcar stop—the "treatment" areas. Columns (7) - (9) display statistics for parcels greater than 0.5 km from a streetcar stop and less than 0.7 km from a streetcar stop—the "control" areas. The sample in columns (4) - (9) is streetcar stops where no parcel is within 0.1 km of a yellow car line, and stops where treatment and control areas both have a minimum of 10 parcels (the same sample as Column (2) in the following table). Means are weighted as noted in the following table. Columns (1) to (3) of Panel A report statistics omitting the 99th percentile to avoid inflation by the very high values in the tail of the distribution.

Table 2: Streetcar Stop Density Effect in 2011

	Dependent Variable is Structure Density	
	(1)	(2)
A. No Covariates		
Treatment $\text{Circle}_{i,s}$	5.33	5.71
	(0.7)	(0.61)
Parcels	475,407	424,461
Streetcar Stops	1,163	993
B. Controlling for Predecessors		
Treatment $\text{Circle}_{i,s}$	3.78	4.17
	(0.7)	(0.61)
Parcels	475,407	424,461
Streetcar Stops	1,163	993
C. Controlling for Predecessors and Descendants		
Treatment $\text{Circle}_{i,s}$	3.36	3.81
	(0.69)	(0.59)
Parcels	475,407	424,461
Streetcar Stops	1,163	993
Streetcar Stop Fixed Effects	X	X
Stops Near LA Railway Excluded		X

Note. Standard errors clustered by streetcar stop in parentheses. Structure density is (structure square feet / lot square footage) * 100. The unit of observation is the 2011 parcel. All estimates are weighted by lot size, normalized such that each streetcar treatment and control area has a total weight of 1. Each column contains the largest possible consistent sample. Column (2) omits any streetcar stops that have a Yellow Car route in either the treatment or control area. The sample is parcels within 0.7 km of the nearest streetcar stop (the distance at which the treatment area, with radius 0.5 km, is the same size as the control area). We further restrict the sample to streetcar stops where treatment and control areas both have a minimum of 10 parcels. "Predecessor" controls are measure of ruggedness of terrain and cubics of elevation, distance to downtown (proxied by Los Angeles City Hall), distance to the coast, distance to a 1925 major road, and distance to a 1934 major intersection. "Descendant" controls are cubics in distance to a modern major road, distance to a Metro rail line, distance to a Metrolink line, and distance to a highway entrance. We set missing values for elevation and ruggedness equal to 0 and include an indicator variable equal one when they are missing.

Table 3: Density Finding Robust to Alternative Specifications

	No Covariates	Covariates	
		P	P and D
	(1)	(2)	(3)
Only Post-1963 Construction			
Treatment Circle$_{i,s}$	5.66	4.09	3.45
	(1.48)	(1.52)	(1.5)
Parcels	110,192	110,192	110,192
Streetcar Stops	590	590	590
Mean, Control Dep. Variable	72.83	72.83	72.83
Cities with No Fire Map Before 1898			
Treatment Circle$_{i,s}$	3.23	2.29	2.28
	(0.79)	(0.78)	(0.76)
Parcels	169,480	169,480	169,480
Streetcar Stops	404	404	404
Mean, Control Dep. Variable	33.02	33.02	33.02
Omit Five Stop Clusters			
Treatment Ring$_{i,s}$	6.51	4.96	4.29
	(0.69)	(0.69)	(0.67)
Parcels	388,220	388,220	388,220
Streetcar Stops	793	793	793
Mean, Control Dep. Variable	37.98	37.98	37.98
Treatment Ring, Not Treatment Circle			
Treatment Circle$_{i,s}$	3.74	3.17	3.04
	(0.64)	(0.63)	(0.61)
Parcels	283,491	283,491	283,491
Streetcar Stops	955	955	955
Mean, Control Dep. Variable	38.02	38.02	38.02
Dependent Variable is Structure Value / Lot Size			
Treatment Circle$_{i,s}$	4.65	3.26	3.16
	(1.01)	(1.13)	(1.12)
Parcels	424,461	424,461	424,461
Streetcar Stops	963	963	963
Mean, Control Dep. Variable	33.63	33.63	33.63
Streetcar Stop Fixed Effects	X	X	X
Stops Near LA Railway Excluded	X	X	X

Note. See notes from Table 2. All specifications save the final panel use structure density as the dependent variable. All estimates exclude streetcar stops with any parcels within 0.1 km of a Los Angeles Railway line, and use a treatment circle radius of 0.5 km. For details on the second panel see appendix section 9.7. Structure value/lot size is the assessed improvement value / lot size. "Omit Five Stop Clusters" drops streetcar stops in the areas marked with a star in Figure 2. The table's fourth panel replaces the treatment circle with a treatment ring, which omits parcels between the stop and $\sqrt{2} *$ circle radius.

Table 4: Modern Zoning More Permissive Near Streetcar

	Dependent Variable is			
	1{Non-Residential}	Maximum Units	Maximum Height, Feet	Minimum Covered Parking Spaces
	(1)	(2)	(3)	(4)
Treatment Circle$_{i,s}$	0.028	2.239	0.926	-0.119
	(0.008)	(0.426)	(0.275)	(0.019)
Parcels	292,680	269,435	282,985	280,747
Streetcar Stops	656	578	621	611
Mean, Control Dependent Variable	0.11	4.96	35.47	1.631

Note. Standard errors clustered by streetcar stop in parentheses. The unit of observation is the 2011 parcel. All columns are weighted by lot size, normalized such that each streetcar treatment and control area has a total weight of 1. All estimates exclude streetcar stops with any parcels within 0.1 km of a Los Angeles Railway line, and use a treatment circle radius of 0.5 km. Further, all estimates control for P and D, as defined in Table 2. The sample shrinks relative to the previous tables because we do not observe zoning information for all cities in the County. Across the columns of the table the sample size differs because not all parcels have, for example, a maximum height in feet.

Table 5: Zoning Statistically Explains the Density Effect

	Dependent Variable is Structure Density			
	(1)	(2)	(3)	(4)
A. Sample With Modern Zoning Information				
1. Controlling for Modern Zoning				
Treatment Circle$_{i,s}$	4.33	2.04	1.02	0.37
	(0.67)	(0.53)	(0.46)	(0.43)
Parcels	289,751	253,014	289,751	289,751
Streetcar Stops	643	537	643	643
2. Using Post-1963 Construction Only				
Treatment Circle$_{i,s}$	4.63	2.77	1.05	1.37
	(1.55)	(1.52)	(1.38)	(1.36)
Parcels	73,286	57,212	73,286	73,286
Streetcar Stops	395	313	395	395
B. 1922 Zoning Sample				
1. Controlling for Modern Zoning				
Treatment Circle$_{i,s}$	4.08	0.62	1.68	0.77
	(1.91)	(1.15)	(1.45)	(1.09)
Parcels	35,111	29,990	35,111	35,111
Streetcar Stops	122	91	122	122
2. Controlling for 1922 Zoning				
Treatment Circle$_{i,s}$	4.08	5.02	2.56	3.21
	(1.91)	(1.74)	(1.78)	(1.64)
Parcels	35,111	33,044	35,104	35,111
Streetcar Stops	129	117	129	129
3. Controlling for 2013 Zoning in 1922 Terms				
Treatment Circle$_{i,s}$	4.08	2.77	3.25	2.08
	(1.91)	(1.57)	(1.65)	(1.40)
Parcels	35,111	33,082	35,104	35,111
Streetcar Stops	139	120	139	139
Streetcar Stops Fixed Effects	X	X	X	X
Only Parcels with Zones in Circle and Ring		X		
Zone Code Fixed Effects			X	
Streetcar Stop * Zone Code FE				X

Note. All estimates exclude parcels within 0.1 km of a Los Angeles Railway line, use a treatment radius of 0.5 km, and control for P and D, as defined in Table 2.

Table 6: 1922 Zoning and Zoning Changes from 1922 - 2013

	Zoned Non-Residential in 1922	Any Zone Code Δ, 1922 to 2013	Zone Code Δ to Commercial, 1922 to 2013
	(1)	(2)	(3)
Treatment Circle$_{i,s}$	0.021	0.038	0.005
	(0.008)	(0.026)	(0.002)
Parcels	34,918	34,918	34,918
Streetcar Stops	134	134	134
Dep. Variable Mean, Control	0.031	0.292	0.000

Note. All estimates use a treatment radius of 0.5 km, and control for P and D, as defined in Table 2.

Table 7: There Are More Non-Residential Parcels Near Streetcars, and They are More Concentrated

Panel A: Land Use Near Streetcar

	Dependent Variable is Land Use	
	1{Non-Residential}	1{Multifamily, if Residential}
	(1)	(2)
Treatment Circle$_{i,s}$	0.047	0.066
	(0.008)	(0.007)
Parcels	424,461	380,107
Streetcar Stops	963	822
Mean, Control Dependent Variable	0.216	0.317

Panel B: Concentration of Land Use Near Streetcar

	Dependent Variable is Number of Non-Residential Parcels within x meters, where x is		
	50	100	200
	(1)	(2)	(3)
Treatment Circle$_{i,s}$	0.030	0.080	0.316
	(0.013)	(0.036)	0.098
Parcels	45,104	45,104	45,104
Streetcar Stops	155	146	139
Mean, Control Dep. Variable	1.295	2.298	5.466
Streetcar Stop Fixed Effects	X	X	X

Notes: All other regressions require, for each streetcar stop, a minimum of 10 parcels in the treatment circle and control ring. Given the substantially smaller number of non-residential parcels, we relax that requirement to 5 parcels for these estimations. Standard errors clustered by streetcar stop in parentheses. The unit of observation is the 2011 parcel. All columns are weighted by lot size, normalized such that each streetcar treatment and control area has a total weight of 1. All estimates exclude streetcar stops with any parcels within 0.1 km of a Los Angeles Railway line, and use a treatment circle radius of 0.5 km. Further, all estimates control for P and D, as defined in Table 2.

Table 8: Streetcar Stop Sales Price Effect 1999-2011

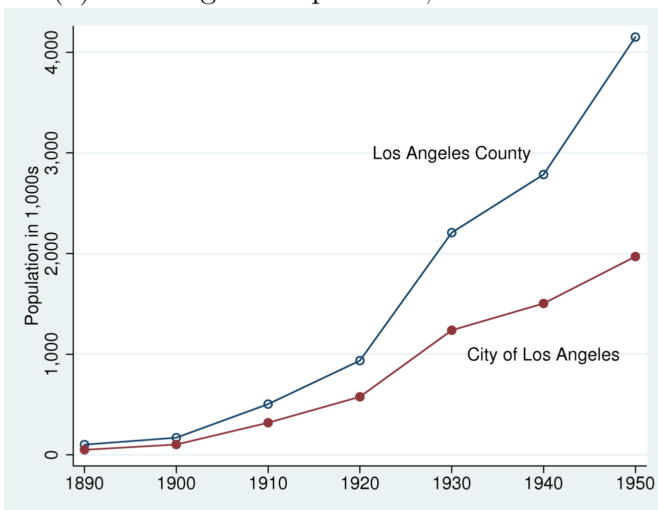
	Log(Sales Price / Lot Square Feet)									
	All Uses				Single-Family		Condos		Non-Residential	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment Circle$_{is}$	.048	.003	-.009	-.009	.003	-.004	-.027	-.007	.015	-.001
	(.021)	(.007)	(.007)	(.006)	(.009)	(.004)	(.069)	(.021)	(.032)	(.036)
No. Parcels	246,684	246,684	208,517	208,517	124,098	103,130	63,271	63,271	14,162	11,812
No. Streetcar Stops	993	993	858	858	971	831	622	502	856	729
Capital Controls		X	X	X		X		X		X
Zone Code F.E.			X	X		X		X		X
Streetcar Stop F.E.	X	X	X		X	X	X	X	X	X
City-Year F.E.	X	X	X		X	X	X	X	X	X
Streetcar Stop-Year F.E.				X						

Note. Standard errors clustered by streetcar stop in parentheses. Dependent variable is the log of the per square foot of land sales price. The unit of observation is the parcel and the sample runs from 1999 - 2011. The sample has been restricted to parcels within 0.7 km of the nearest streetcar stop (the distance at which the treatment area, with radius 0.5 km, is the same size as the control area). All columns control for P and D, as defined in Table 2. “Capital Controls” include interactions of indicators for decile of structure age with deciles of structure square feet divided by lot square feet (for both deciles an 11th indicator variable is added to denote missing values).

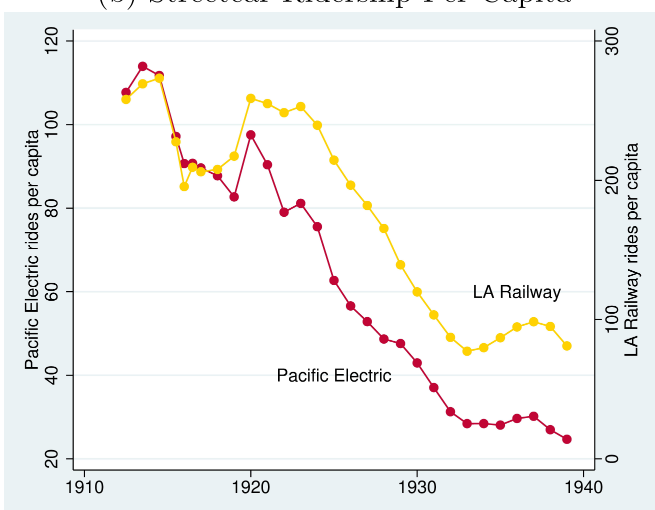
8 Appendix Figures and Tables

Appendix Figure 1: Los Angeles Population Grows and Streetcar Ridership Declines

(a) Los Angeles Population, 1880 to 1950

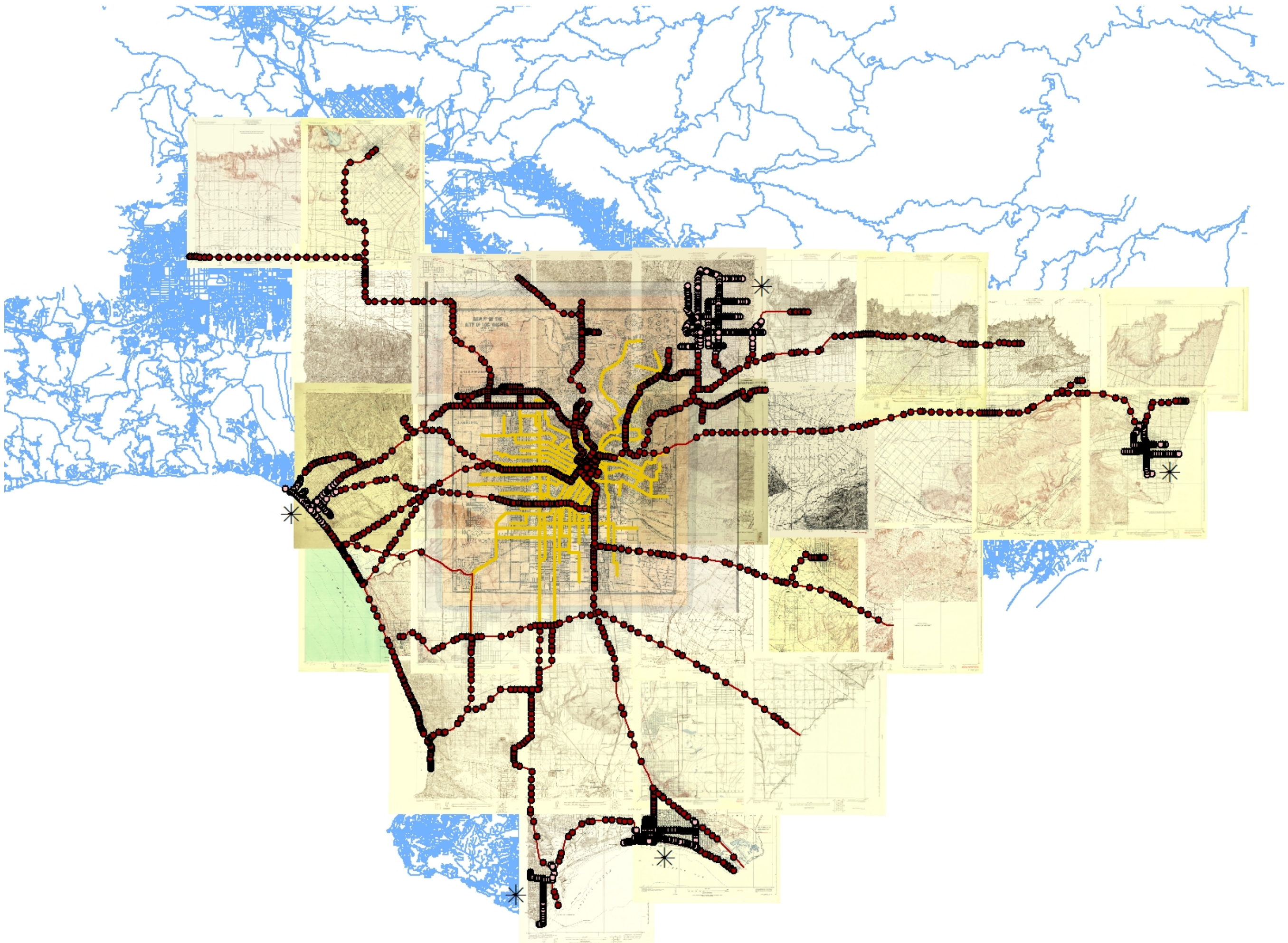


(b) Streetcar Ridership Per Capita



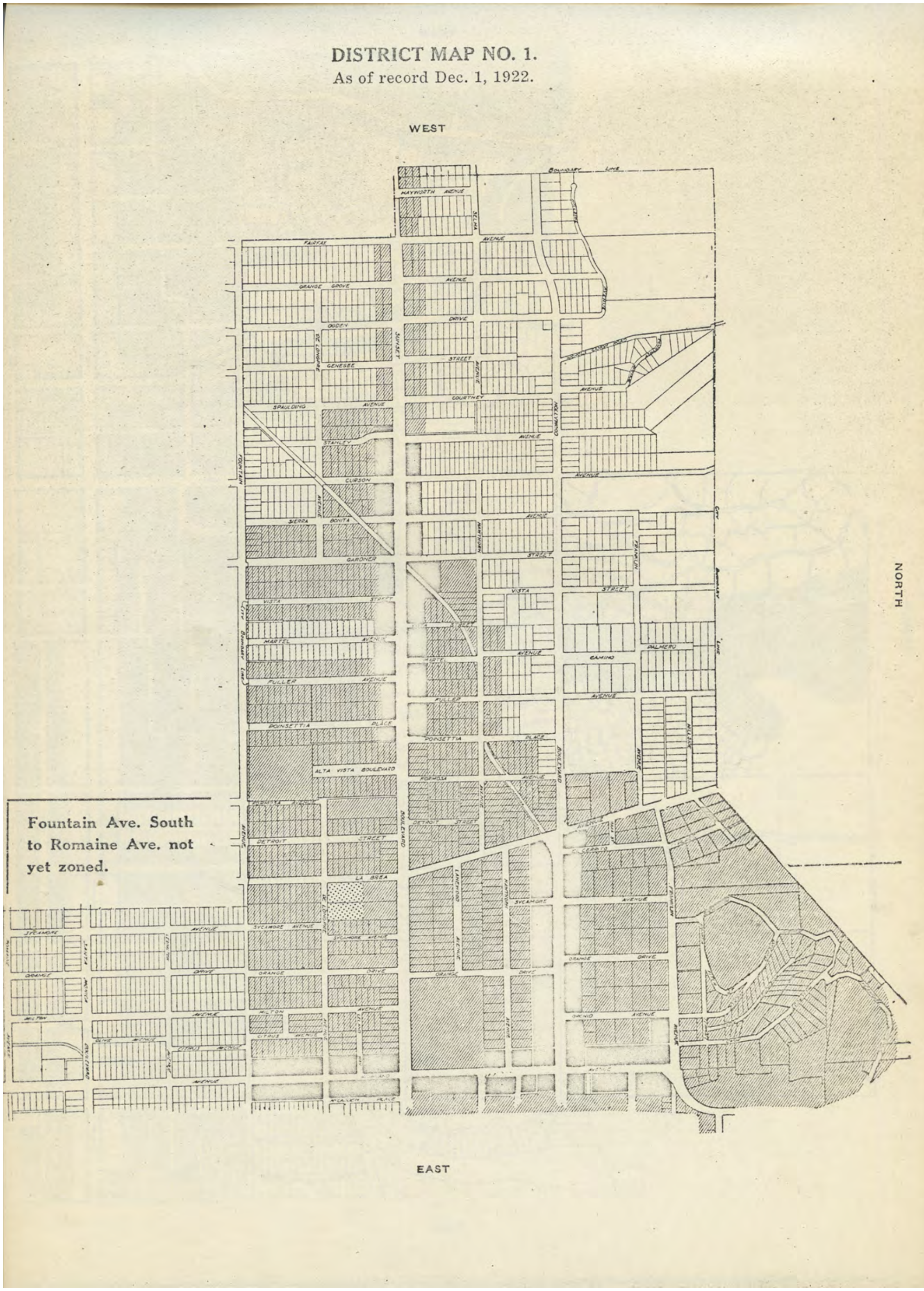
Notes: Figure 1 (a) shows the meteoric rise in the population of the city and county between 1890 and 1950. Figure 1 (b) shows per capita ridership (based on the Los Angeles County population) for the Pacific Electric and Los Angeles Railway. We use two sources for Pacific Electric ridership; the source available for later years includes only "local lines," and reports smaller ridership. As the sources overlap for three years, we calculate the average of the ratio between the sources and use that ratio to inflate the later data to make a consistent series over time.
Sources: County population data come from Forstall (1996). City population data come from Gibson (1998). Ridership data are from Jenkins (1940) and Kelker, De Leuw and Co. (1925).

Appendix Figure 2: Process of Digitizing Historical Maps



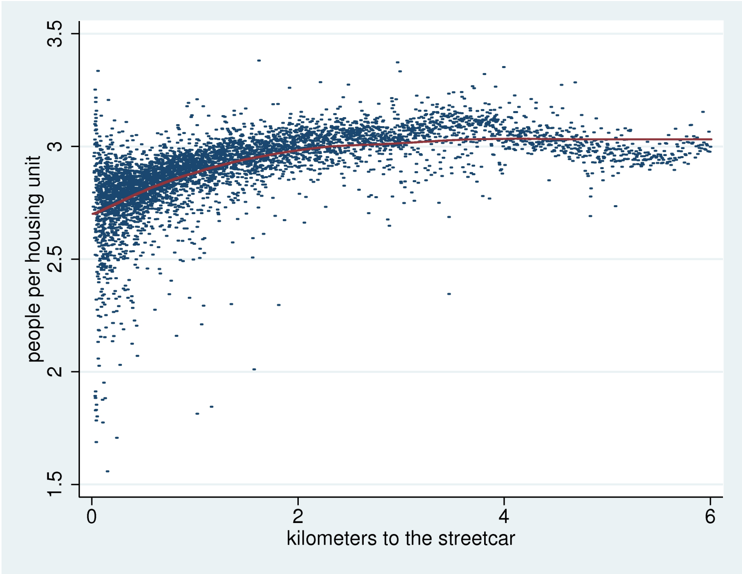
Notes: This picture shows modern streets in light blue and georeferenced historical topographic maps in sepia tones. Georeferencing means finding points on historic maps that allows them to be geographically aligned with modern digital maps. On top of the topographic maps, there is a historical map of the Los Angeles Railway at center, and our digitized maps assigning lines for the Los Angeles Railway (in yellow) and Pacific Electric lines and stops (in red). Note that the clusters at the end of the Pacific Electric lines are pink; we omit these clustered stops as robustness check in Table 3.

Appendix Figure 3: 1922 Zoning Map

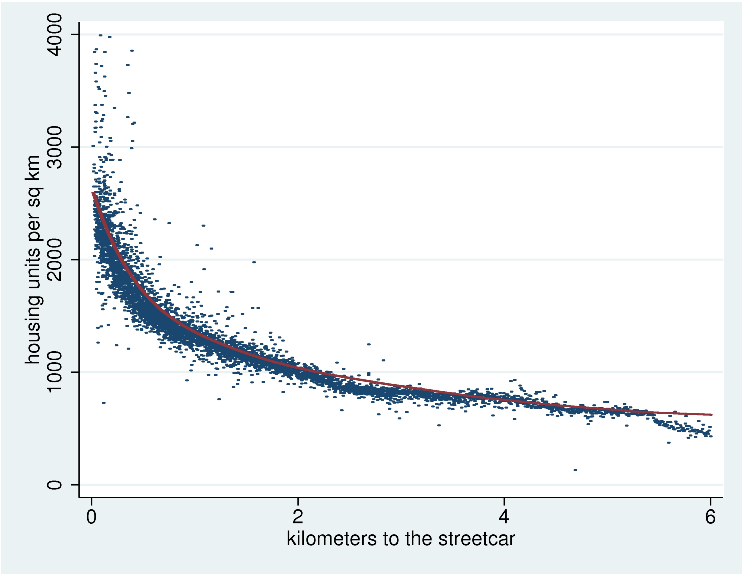


Appendix Figure 4: Structures or People?

(a) People Per Housing Unit



(b) Housing Units Per Land



Notes: People near old streetcar locations are not housed in greater density per unit; however, locations near old streetcars do have more housing units per land area. Each point represents the average of approximately 400 parcels.

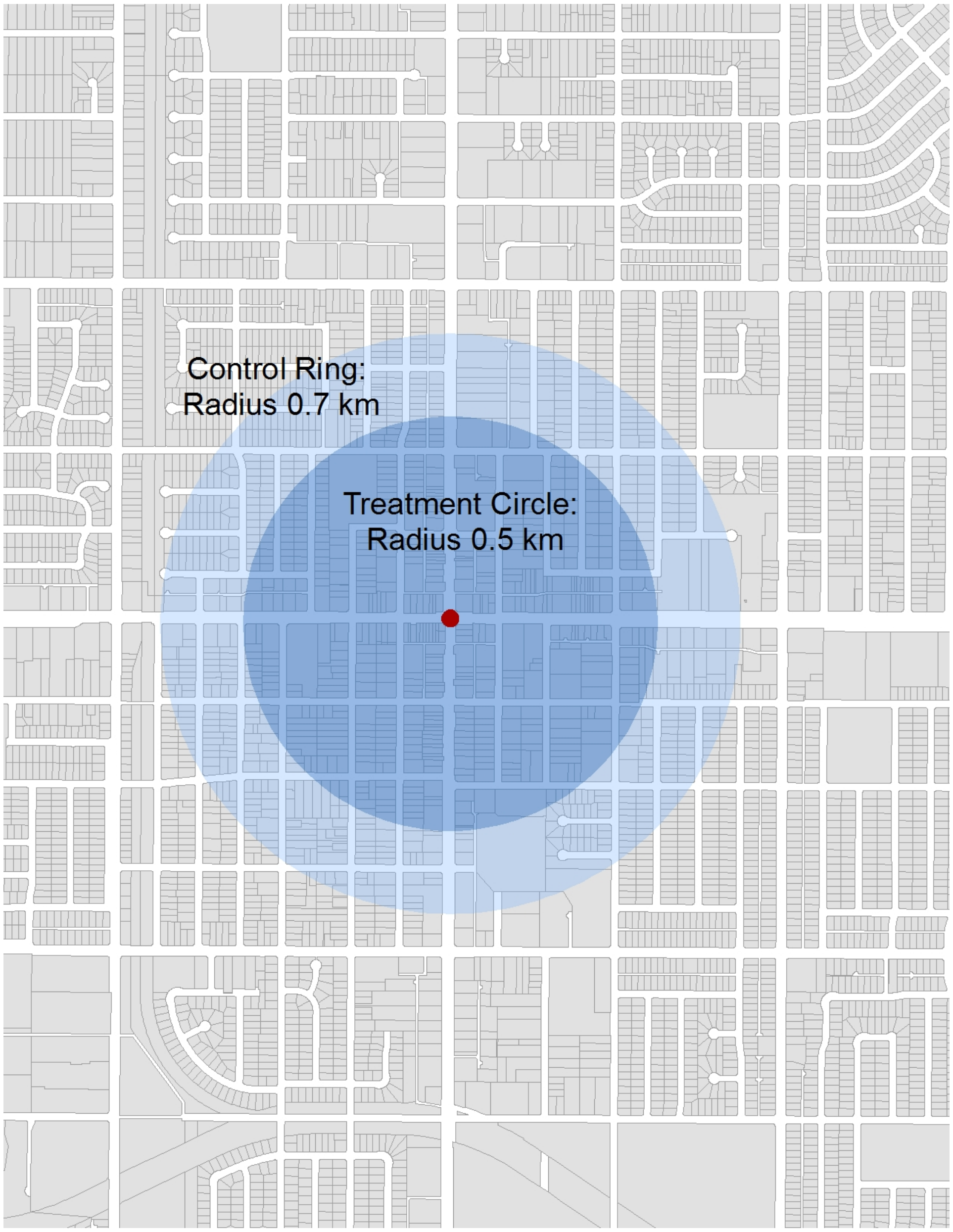
Sources: We calculate people per housing unit and housing units per land area from the 2007-2011 American Community Survey census tract level data, expressed in terms of 1940 census tract boundaries. We calculate distance to the streetcar for each parcel in the County based on our digitization of streetcar maps.

Appendix Figure 5: 1930 Population Density and Streetcar Location

Notes: This figure uses the same method as Figure 2. The figure is coarser because there were many fewer tracts, and therefore much less variation in density, in 1930 relative to 2010.

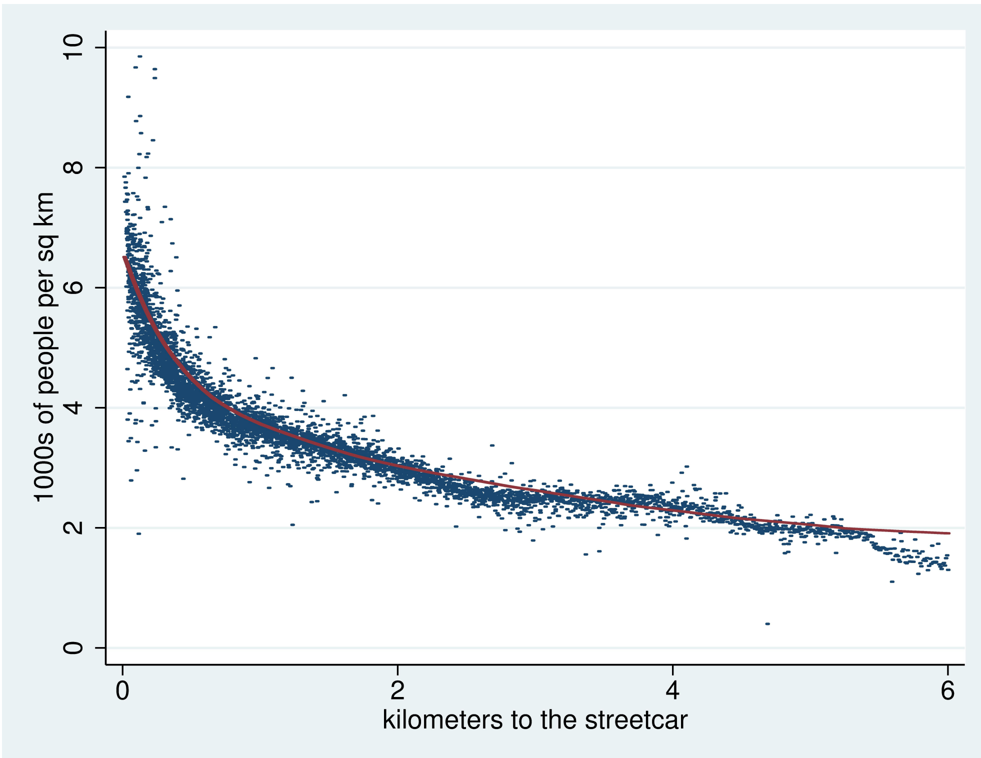
Sources: Density information comes come from the 1930 Decennial Census via National Historic Information System. We calculate distance to the streetcar for each parcel in the County based on our digitization of streetcar maps.

Appendix Figure 6: Comparison of Treatment and Control Areas



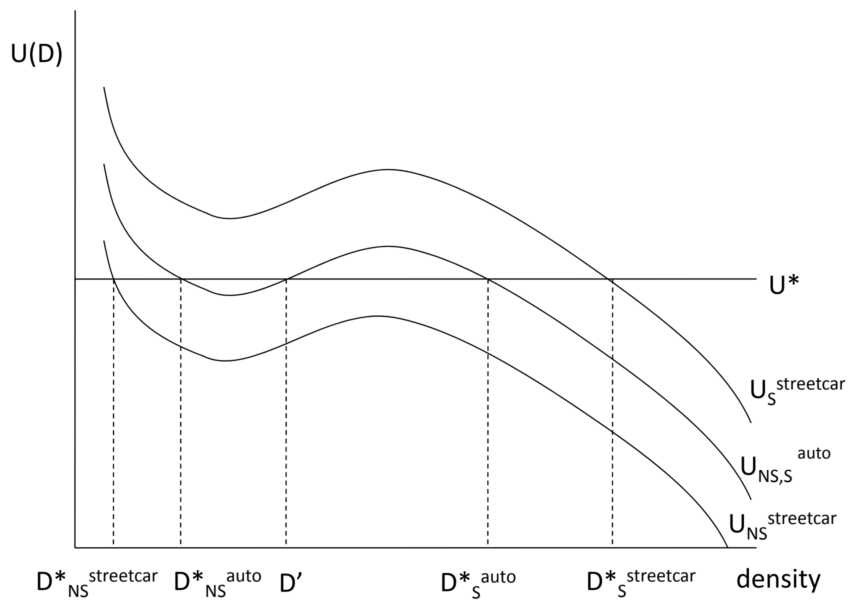
Notes: The red dot notes the location of the Pacific Electric streetcar stop. The darker blue circle, with a radius of 0.5 km, is our treatment circle. The lighter blue circle – without the area of the darker circle – is our control region, with a radius of 0.7, so that the total areas of the treatment circle and control region are the same. Behind the circles, in light grey, are our unit of observation: individual parcels of land. White areas are roads.

Appendix Figure 7: Figure 2 Omitting Yellow Cars



Notes: This figure reproduces Figure 2, but omits all parcels within 0.1 km of Los Angeles Railway lines.

Appendix Figure 8: Density at Two Locations



Appendix Table 1: Streetcars Were Abundant

	Distance Measures				Share of Parcels		
	Mean	Std. Dev.	Min.	Max.	≤ 0.5 km	> 0.5 and ≤ 0.7 km	> 0.7 and ≤ 3 km
By Parcel, Shortest Distance (km) to	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pacific Electric Stop	6.7	13.4	0	100.6	0.178	0.067	0.409
Los Angeles Railway Line	17.9	16.7	0	123.9	0.072	0.014	0.091
Min(Distance to PE stop, LA Ry line)	6.5	13.5	0	100.6	0.232	0.07	0.376

Appendix Table 2: 1922 City of Los Angeles Zoning and Modern Zoning

1922 Zoning District	2013 Zoning, by 1922 Definition				Total	
	A	B	C	D	Parcels	Share
	(1)	(2)	(3)	(4)	(5)	(6)
Parcels						
A = Single Family Residential	4,536	2,561	186	75	7,358	0.16
B = Multifamily Residential, Churches, Schools	9,232	21,214	1,298	171	31,915	0.71
C = Stores or Shops, Wholesale or Retail	178	742	2,509	63	3,492	0.08
D = Light Manufacturing	818	284	478	223	1,803	0.04
E = Any Structure Not Prohibited by Law	365	22	21	22	430	0.01
Share						
A	0.62	0.35	0.03	0.01		1
B	0.29	0.66	0.04	0.01		1
C	0.05	0.21	0.72	0.02		1
D	0.45	0.16	0.27	0.12		1
E	0.85	0.05	0.05	0.05		1

Notes: The sample is restricted to parcels within 0.7 km of the nearest streetcar stop (the treatment and control area for the treatment circle identification strategy) located within the City of Los Angeles, excluding the San Fernando Valley. There are five zoning classes in 1922. Certain parcels, such as parks and cemeteries, were not classified in 1922 are omitted from the sample. These omitted parcels account for roughly two percent of all 1922 zoned parcels. We also omit a small number of parcels with modern zoning (e.g., "OS" for open space) that did not correspond well to the 1922 categories.

Appendix Table 3: Bus Stop Robustness Check

	No Covariates	Covariates	
		P and D	P and D *plus* Dist. to Bus Stop
	(1)	(2)	(3)
MTA Bus Stop Sample			
Treatment Circle$_{i,s}$	6.62	4.41	3.87
	(0.72)	(0.70)	(0.71)
Parcels	348,562	348,562	348,562
Streetcar Stops	788	788	788
Streetcar Stop Fixed Effects	X	X	X
Stops Near LA Railway Excluded	X	X	X

Note. See notes from Table 2. The dependent variable is structure density. All estimates use a treatment circle radius of 0.5 km. The sample is restricted to streetcar treatment/control regions with at least one parcel within $\frac{1}{2}$ kilometer of an MTA bus stop. This restriction is made to avoid areas where we lack any data on bus stop locations. Column (3) controls for a cubic in distance to the nearest MTA bus stop.

9 Data Appendix: Everything But Modern Zoning

The zoning data are sufficiently complicated that we explain them in a stand-alone appendix. We describe all other data sources here.

9.1 Streetcar Maps

We relied upon a variety of maps and textual sources to construct the greatest extent of the electrified rail network in Los Angeles County. We list map sources by library.

Dorothy Peyton Grey Transportation Library

- 1928 "Pacific Electric Railway Guide. Names and Locations of Stops, Cross Streets and Important Points of Interest."
- With thanks to Matthew Barrett.

University of California at Santa Barbara Alexandria Digital Library

- 1920s USGS topographic maps (1:24000)

California Railroad Museum

- 1916 Board of Public Utilities, City of Los Angeles. "Railroad and Spur Track Map II. Part of Industrial Districts 3 and 4."

Electric Railroad History Association

- Undated. Electric Railroad History Association's "Lines of the Pacific Electric Railway in Southern California." For visual reference (no georeferencing) only.

Huntington Library

- Wheeler, Frank. Undated. "Pacific Electric Railway – as planned in 1904 and as built in 1914."
- 1915 Gillespie's Guide to the City of Los Angeles. Section on Los Angeles Railway routes.
- With thanks to Jennifer Goldman.

City of Los Angeles Public Library

- 1935 (Date using citation in Walker book). "Official Route Map of the Los Angeles Railway."
- With thanks to Glen Creason

University of Toronto Libraries

- 1914. "Map of the City of Los Angeles."

9.2 Major Road Maps

UCLA Map Library

- 1934, "Average Daily Load Highway Traffic Survey County of Los Angeles," The Regional Planning Commission. (UCLA call number G4363 Los Angeles Co. P21 63 RPC 1934)

- With thanks to Jon Hargis and Peter Lacson

Archives of Automobile Club of Southern California

- 1925, "Automobile Road Map of Metropolitan Los Angeles," Compiled and copyright by the Automobile Club of Southern California.

- With thanks to Matthew Roth and Morgan Yates

9.3 Geographically Consistent Census Tract Data

We used tract shapefiles from NHGIS (Minnesota Population Center. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011) for years 1940, 1950, 1960, 1970, and 1980. For 1990 through 2010 we used block group shapefiles provided by the US Census Bureau on their website.

We used tract data from NHGIS for 1940, 1950, and 1960 (datasets 76, 82, and 92). From 1970, 1980, 1990 and 2000 we used data from the Interuniversity Consortium Political and Social Research (1970: Summary Tape File 4a #6712, 1980: Summary Tape File 3a #8071, 1990: Summary Tape File 3a #9782). We used tract data for 1970 and 1980 and block group data for 1990 and 2000. For 2010 (officially the 5-year estimates for 2007 to 2011 from the American Community Survey), we downloaded block group data directly from the Census website.

Making the geographically consistent census tracts required a few assumptions which we detail here. First, for each decade after 1940, we intersected that decade's shapefile with the 1940 shapefile. This intersection divides each later year tract into pieces by its overlap with a 1940 tract (we use the term "tract" generically here, since in later years we used the smaller block groups for a better match). If any of these resulting pieces is less than five percent of the later year tract and does not match to a unique 1940 tract, we drop that piece. While this may drop actual matches, it also surely drops many "slivers" of tracts that are created when two shapefiles do not exactly agree at the borders. We believe that the benefit of dropping the slivers exceeds the cost of dropping true matches. Except when slivers abound, we drop a very small share of intersected pieces.

9.4 Elevation

We received elevation data by parcel circa 2010 from Mark Greninger, Geographic Information Officer, Los Angeles County.

9.5 Historical Zoning Data

We are very grateful to the City of Los Angeles Planning Department, specifically Fae Tsukamoto, Carl Nelson, and John Butcher, for helping us find old Los Angeles zoning maps. We used *Official Atlas: District Zoning Maps*, 1922.

9.6 Intersections, c. 1925 and c. 1934

We used the map of 1934 major roads and ArcGIS to make an initial dataset of intersections. We then manually cleaned this file to arrive at a full set of intersections. We require an intersection to include the intersection of at least two unique roads, so that a "T" intersection is in included, but a "L" is not. When a road is divided, with two separated lanes of traffic, we locate the intersection point between the two roads.

9.7 Sanborn Fire Insurance Maps

Ideally, we would have a map of the Los Angeles region that shows, in substantial detail, which areas were developed before the streetcar. In practice, we were not able to find such a map. This is because detailed road maps – which we need to sufficiently accurately pinpoint population centers – were not available before the rise of the automobile, which post-dates the streetcar era.

Instead, we relied on the Sanborn Fire Insurance map collection at the Library of Congress. Sanborn produced maps for insurance purposes, and maps from California date as early as 1887. We use data from the Library of Congress's California page (`http://www.loc.gov/rr/geogmap/sanborn/states.php?stateID=5&Submit=SEARCH`), and from the 1902 Sanborn catalog, which lists the date of the most recent map (Sanborn Map Company, 1902).

9.8 Bus Stop Data

Los Angeles County is covered by many regional bus services, and, to the best of our knowledge, no organization maintains a comprehensive GIS file of all bus stops.[37] Los Angeles County Metropolitan Transportation Authority runs the plurality of bus lines, and they provide a map of bus stops as of December 2013. We downloaded the data from `http://developer.metro.net/introduction/gis-data/download-gis-data/`.

10 Appendix: Bus Stop Analysis

For our examination of the extent to which the streetcar density effect operates through follow-on investment in bus stops, we restrict the sample to streetcar stops where at least one parcel in either the treatment or control region is within a half of a kilometer of an MTA bus stop. This drops geographic areas in which the MTA does not operate. We refer to this

[37] The Southern California Association of Governments has a GIS file for bus lines, but not stops.

sample as the bus stop sample. Other bus services run buses into the area serviced by the MTA and we do not observe these stops (except when they overlap with the location of an MTA stop).

It is also important to realize that bus stops are thick on the ground: in our bus stop estimation sample there are 3,980 unique bus stops while there were only 788 streetcar stops. Moreover, bus stops can be relocated at low cost. These facts make reverse causality a possible concern. For instance, suppose bus stops have no independent effect on density, but that any location which becomes denser than a given threshold receives a bus stop. Controlling for distance to the bus stop will attenuate the streetcar density effect in this case, even though the bus stops exert no independent influence on density. The other forms of modern transit – e.g. rail and highway entrances – involve large fixed costs and are therefore moved extremely infrequently. This reduces (but does not completely eliminate) the scope for such reverse causality.

With the above caveats in mind, Appendix Table 3 presents streetcar stop density estimates analogous to those in column (2) of Table 2, but estimated on the bus stop sample. Column (1) displays the results of estimating with no covariates and column (2) adds in the P and D vector of controls. The results are similar to those produced using the full sample. Column (3) additionally controls for a cubic in distance to the nearest MTA bus stop. The results are little changed by controlling for the proximity to a bus stop. We find this result unsurprising as bus stops can be relocated quickly and at low cost. Capital investment decisions are irreversible in the short run and this likely reduces the tendency to build dense capital around these transit nodes.

11 Appendix: Agglomerative Externalities in the Post-Streetcar Era

Assume that the return to density increases over a certain range of density. Appendix Figure 8 depicts this case. When returns to density are increasing, the amenity value of density increases more quickly than congestion costs, $\delta'(D) > \mu'(D)$, and the utility curve slopes upward. With regions of both increasing and decreasing returns to density in the utility curve—that is, both upward and downward sloping regions—density may persist at the streetcar location even after the introduction of the automobile.

First consider the equilibrium densities at S and NS during the streetcar era. Utility curves for S and NS are denoted $U_S^{streetcar}$, and $U_{NS}^{streetcar}$. $U_S^{streetcar} > U_{NS}^{streetcar}$ for any density. In the streetcar era, there are two stable equilibria: $D_{NS}^{*,streetcar}$ and $D_S^{*,streetcar}$.

With the rise of the auto, the utility curves converge—as in the walking era—to $U_{NS,S}^{auto}$. However, even after the introduction of the automobile, in this example location S remains denser than location NS, $D_S^{*,auto} > D_{NS}^{*,auto}$. This persistent differential is due to the region of increasing returns to density. Thus, the obsolete streetcar stop is a coordinating mechanism for agglomeration externalities and determines which location is denser.[38]

[38]Note that location NS has two possible equilibrium in the post-streetcar era, although the second

We remain deliberately agnostic over the precise micro-foundations that could produce a region of increasing return to density. However, given the extremely small geographic area we consider, it seems likely to us that the consumption amenities made feasible by density play an important role (Glaeser et al., 2001). Starting with consumers, of the three theoretical sources of agglomeration identified by Duranton and Puga (2004)—sharing, matching, and learning—sharing appears the most relevant. In particular, the sharing of indivisible facilities (e.g., dense areas support theaters, while less dense areas cannot) and the sharing of the gains from variety (e.g., increased variety of local businesses such as restaurants, bars and shops) appear plausible at the small scale of a streetcar stop neighborhood (Couture, 2014). Matching may also play a role if, for example, density provides increased opportunities for finding amenable social interactions.

Although our model has no commercial sector, businesses may also generate or benefit from agglomerative forces near streetcars. Just as consumers may desire density because of the retail access it provides, retail firms may desire to locate near these customers to increase revenues. Alternatively, businesses may wish to co-locate to reduce consumer transport or search costs. In this case, commercial, rather than residential, density drives agglomerative externalities. Businesses may also co-locate to access or communally provide indivisible public goods, such as marketing, cleaning, or safety (firms sometimes provide such goods via Business Improvement Districts (Brooks, 2008; Brooks and Strange, 2011)). Finally, firms may benefit from concentration due to matching and learning. Recent evidence suggests such spillovers can operate over very short distances (Arzaghi and Henderson, 2008; Rosenthal and Strange, 2001), although these studies focus on specific industrial categories, which we do not.

If increasing returns to scale causes persistent density near defunct streetcars, this density may manifest itself in a number of ways. In the residential context, we could observe more capital per land area, more housing units per land area, or greater multifamily use near streetcars. In the commercial area, measurable outcomes are more commercial capital per land area, and greater prevalence of commercial uses.

possible equilibrium, $D^{'}$, is not stable.