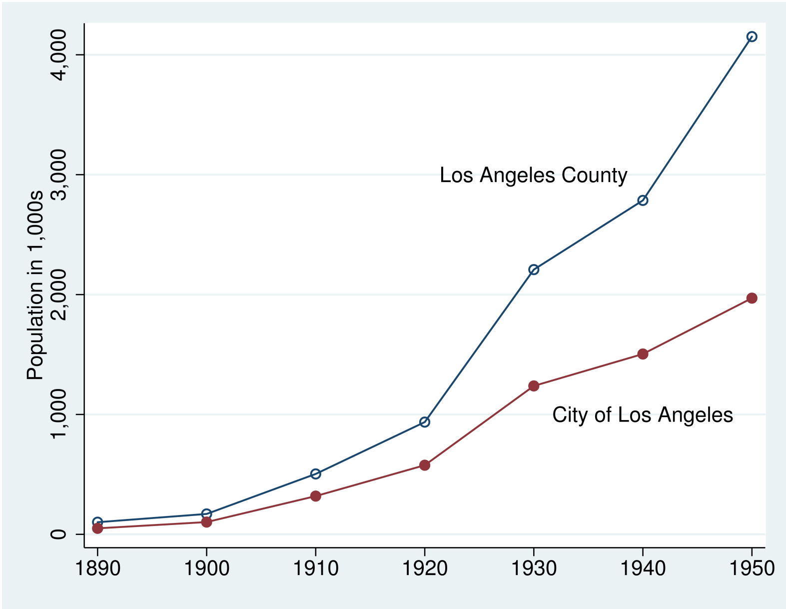
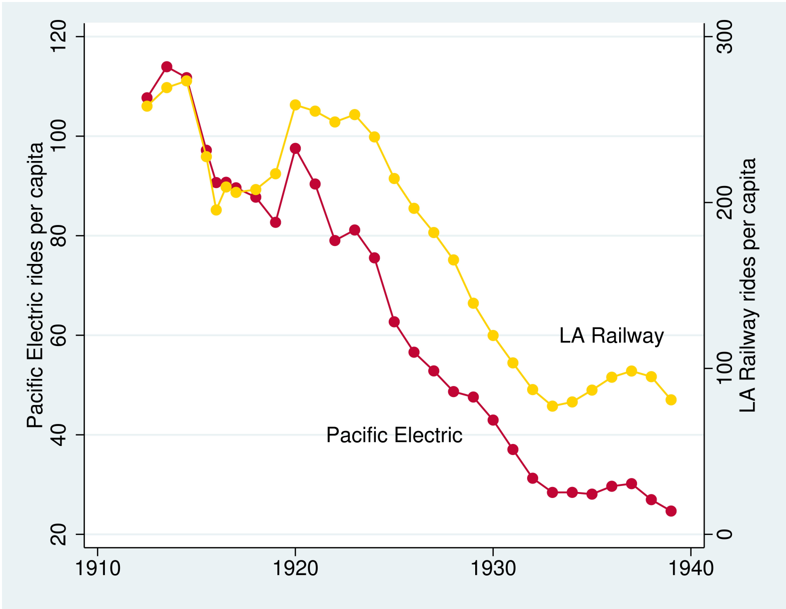
8 Online Only Appendix: Appendix Figures and Tables

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

(a) Los Angeles Population, 1880 to 1950

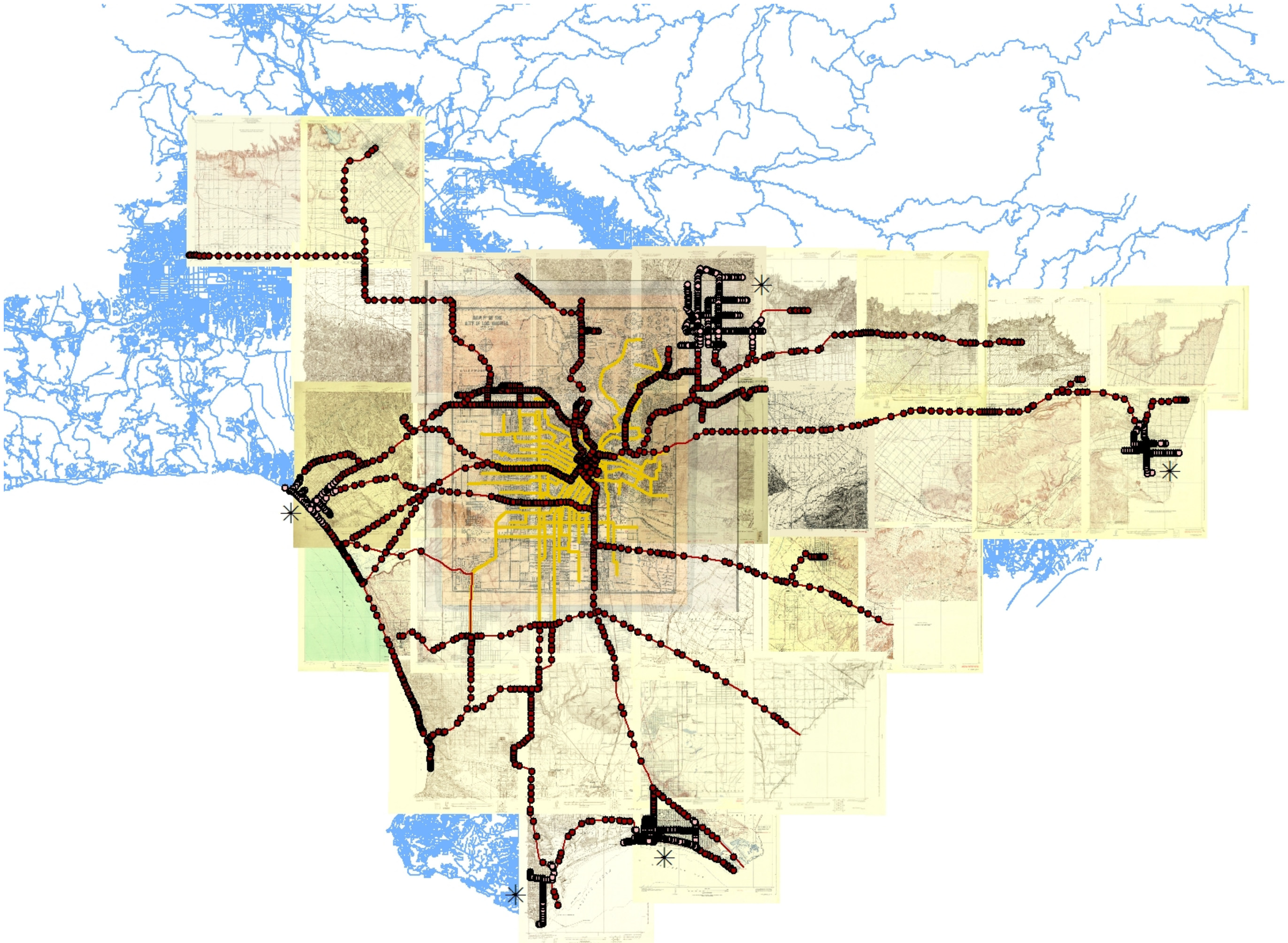


(b) Streetcar Ridership Per Capita



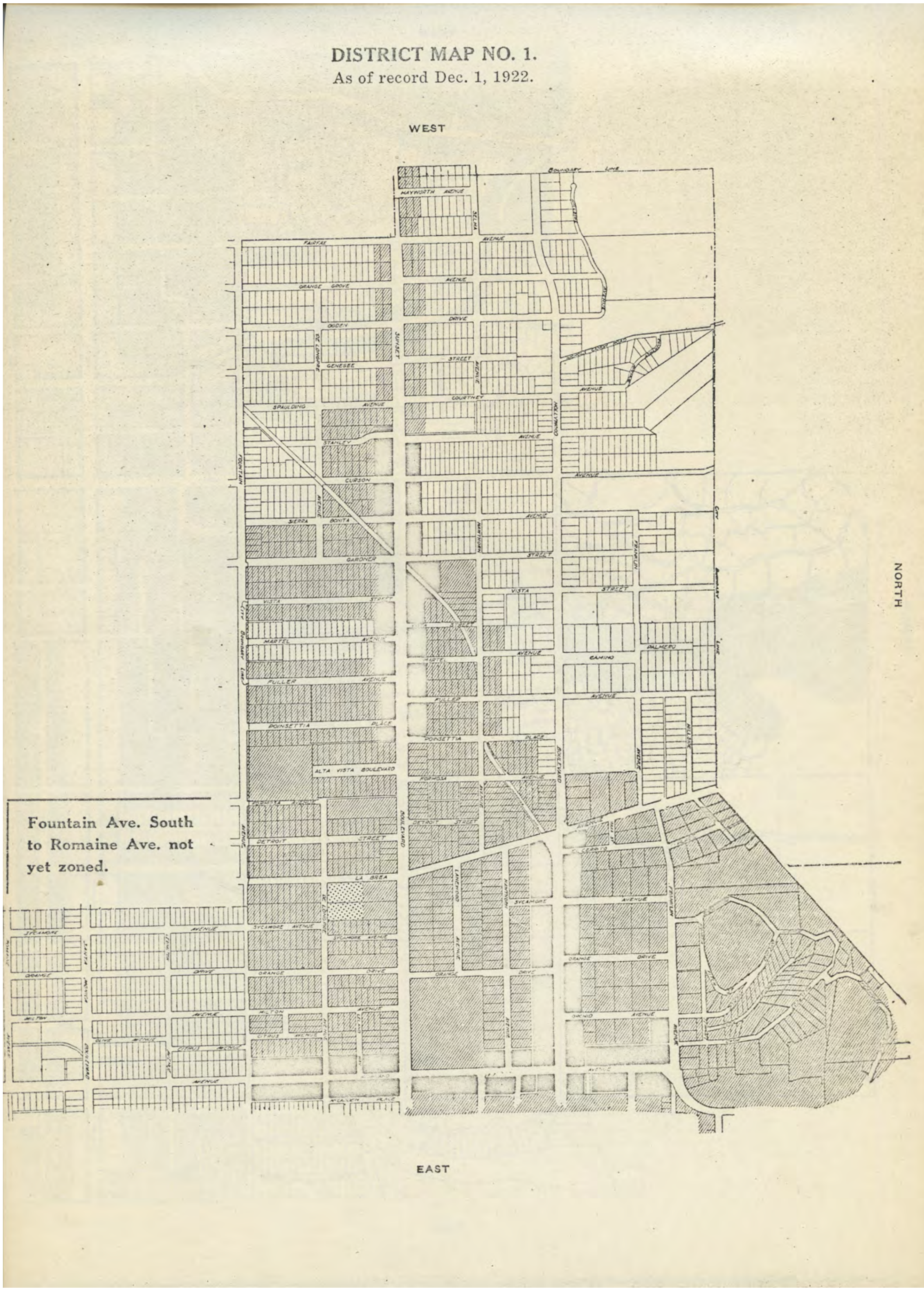
Notes: Figure 1 (a) shows the meteoric rise in the population of the city and county between 1890 and 1950. Figure 1 (b) shows per capita ridership (based on the Los Angeles County population) for the Pacific Electric and Los Angeles Railway. We use two sources for Pacific Electric ridership; the source 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.

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

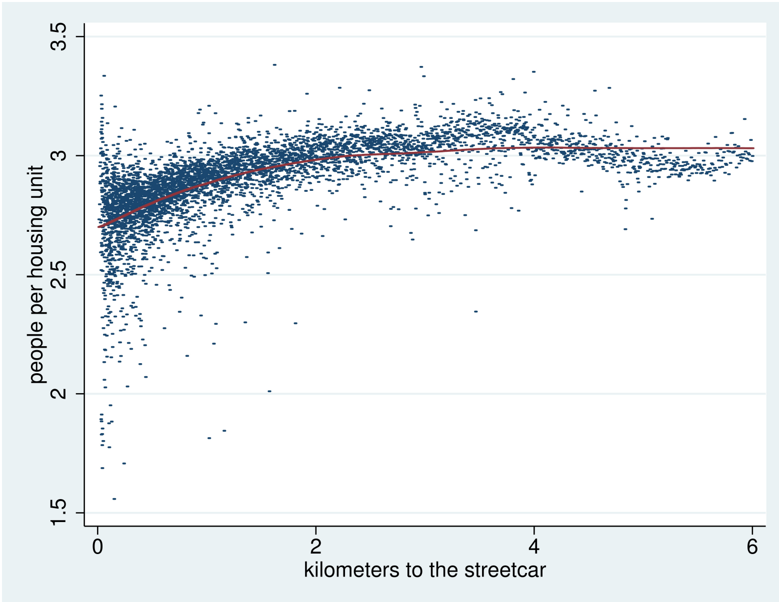
Appendix Figure 3: 1922 Zoning Map



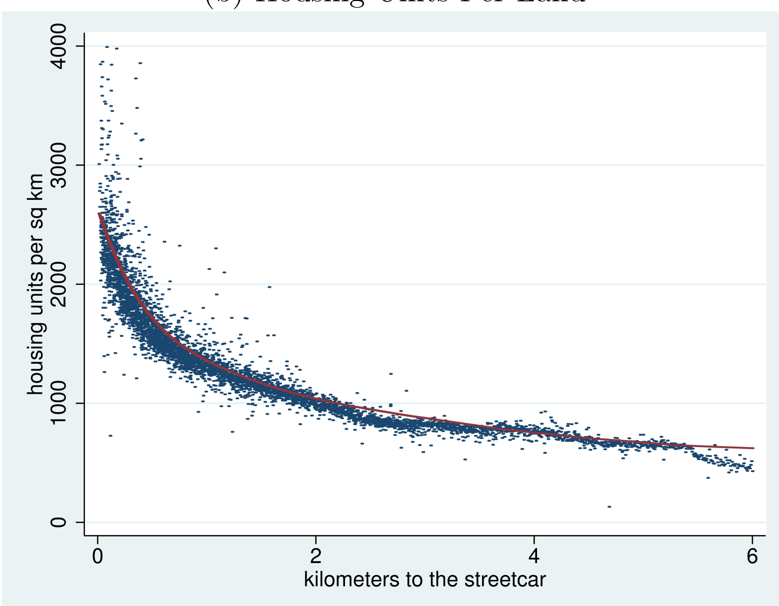
Notes: The figure shows one page from the 1922 City of Los Angeles zoning map. See Appendix Section 9.5 for source details.

Appendix Figure 4: Structures or People?

(a) People Per Housing Unit



(b) Housing Units Per Land



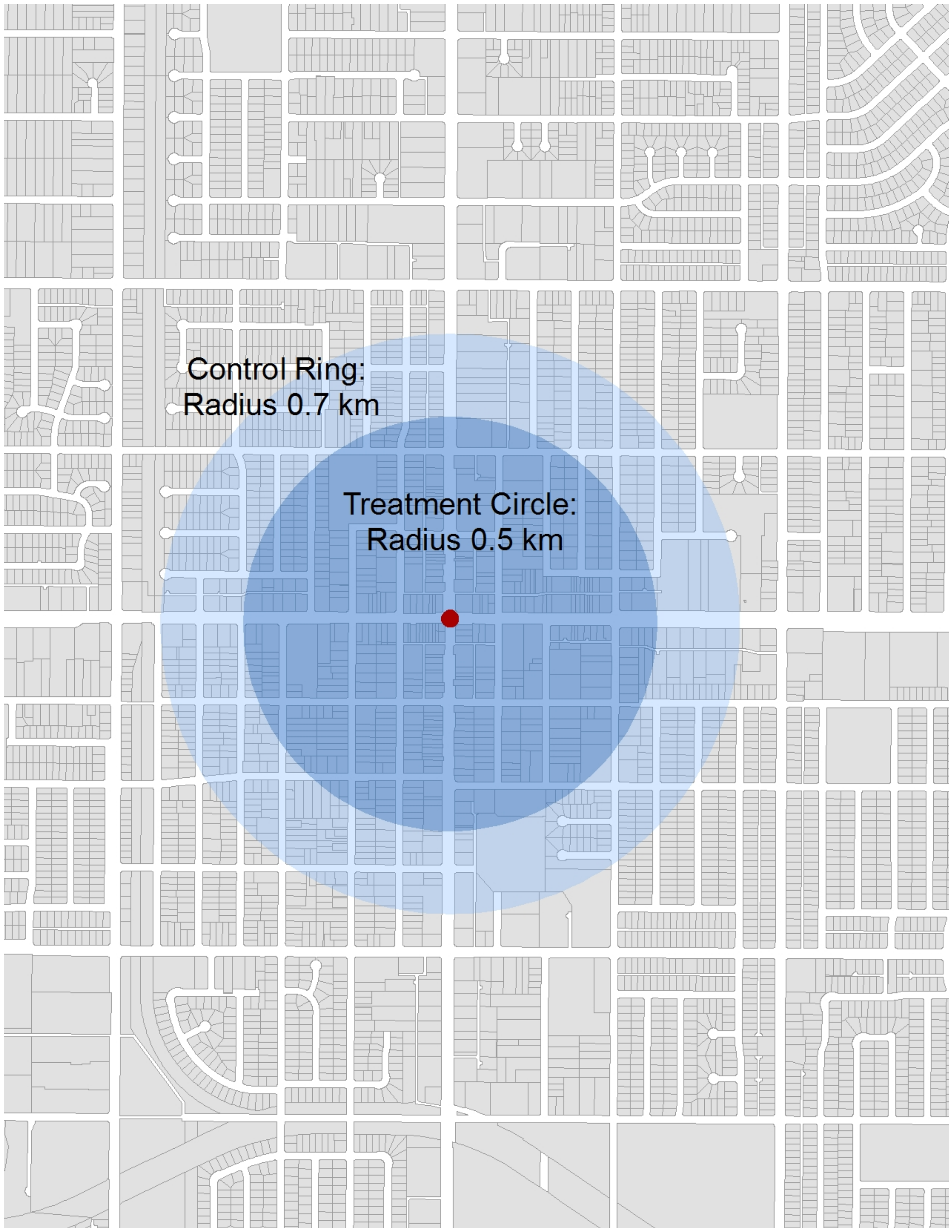
Notes: People near old streetcar locations are not housed in greater density per unit; however, locations near old streetcars do have more housing units per land area. Each point represents the average of approximately 400 parcels.

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

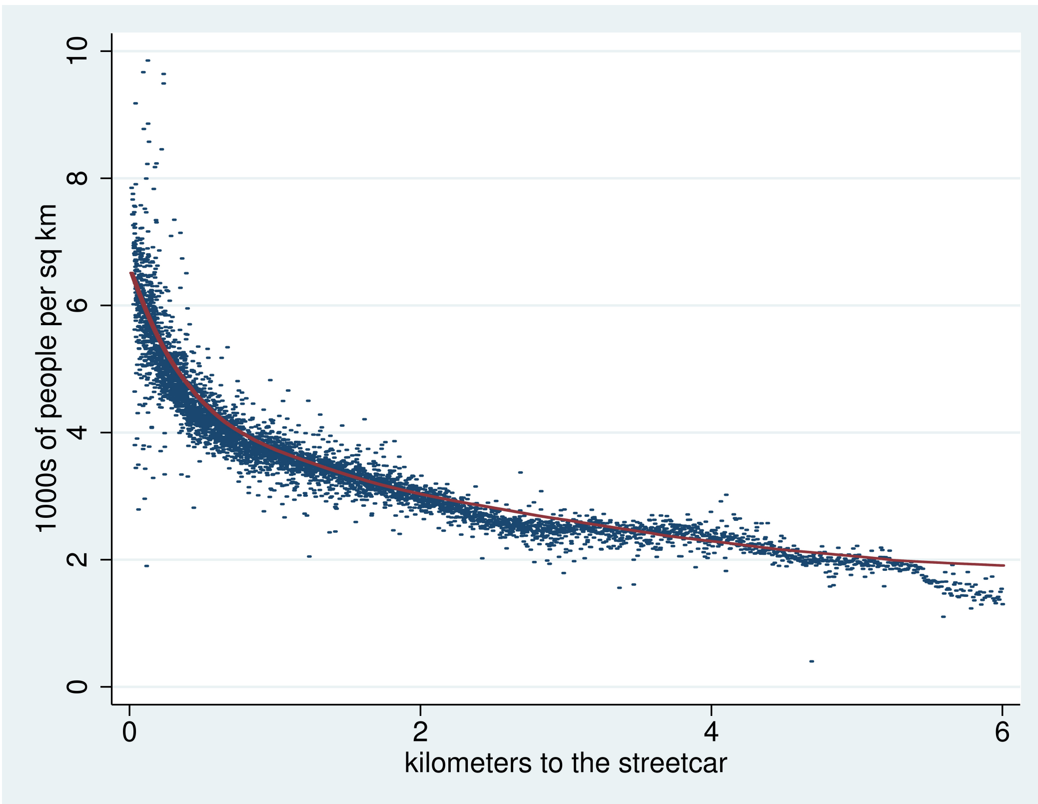
Notes: This figure uses the same method as Figure 1. The figure is coarser because there were many fewer tracts, and therefore much less variation in density, in 1930 relative to 2010. Sources: Density information comes come from the 1930 Decennial Census via National Historic Information System. We 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.

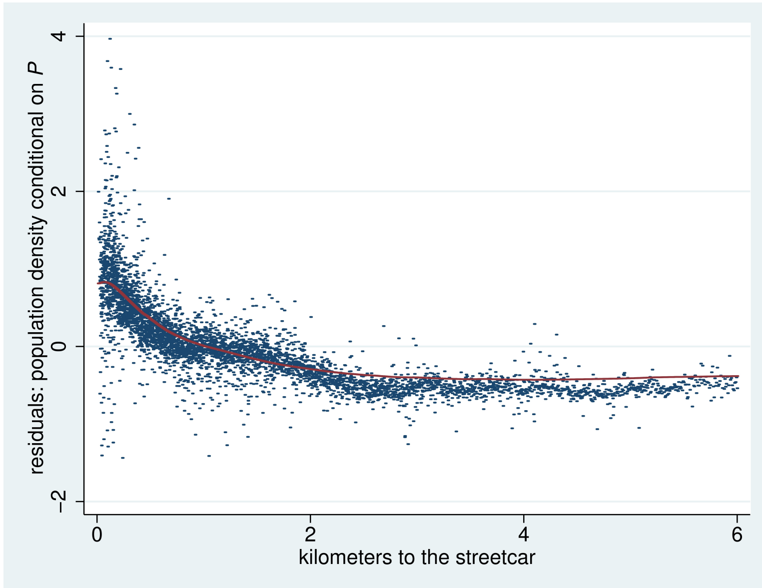
Appendix Figure 7: Figure 1 Omitting Yellow Cars



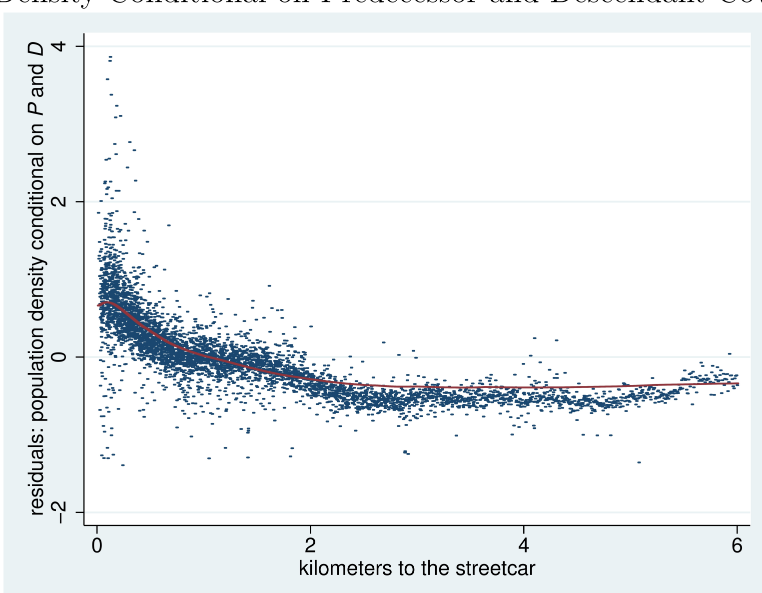
Notes: This figure reproduces Figure 1, but omits all parcels within 0.1 km of Los Angeles Railway lines.

Appendix Figure 8: Population Density Decreases with Distance to the Streetcar, Conditional on Covariates

(a) Population Density Conditional on Predecessor Covariates P



(b) Population Density Conditional on Predecessor and Descendant Covariates P and D

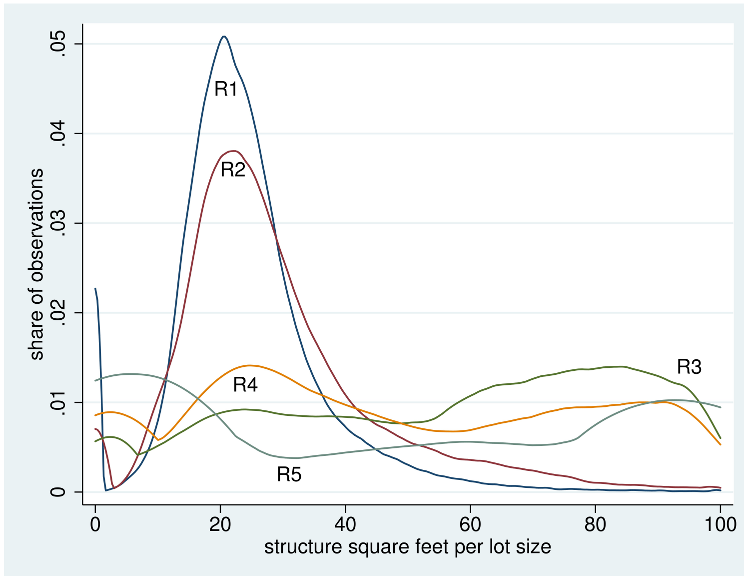


Notes: See note for Figure 1, except that this figure relies on density conditional on predecessor characteristics of the city (panel a); and both predecessor characteristics and characteristics that may have been influenced by the streetcar (panel b). For a complete list of these P and D covariates, see Section 5.1. This figure omits for clarity the one-half a percent of observations with residuals greater than 4 or less than -2.

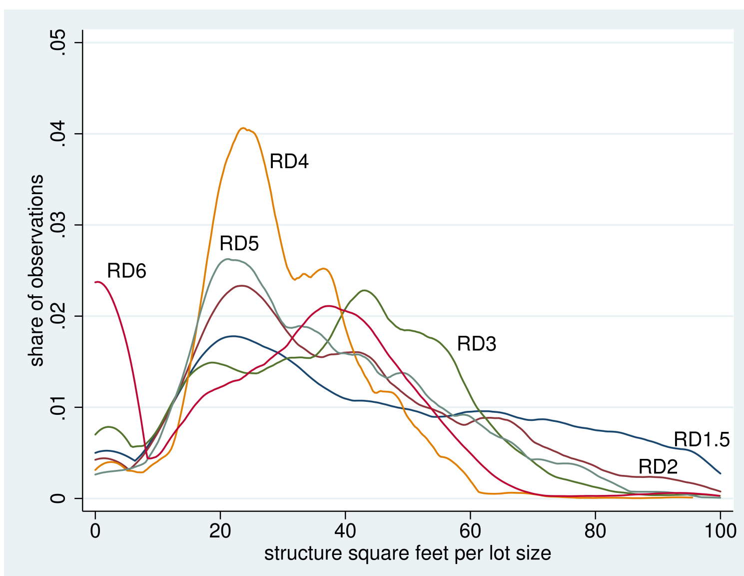
Sources: Los Angeles parcel data; streetcar maps.

Appendix Figure 9: Variation in Structure Density by Zone Code

A. R Zones

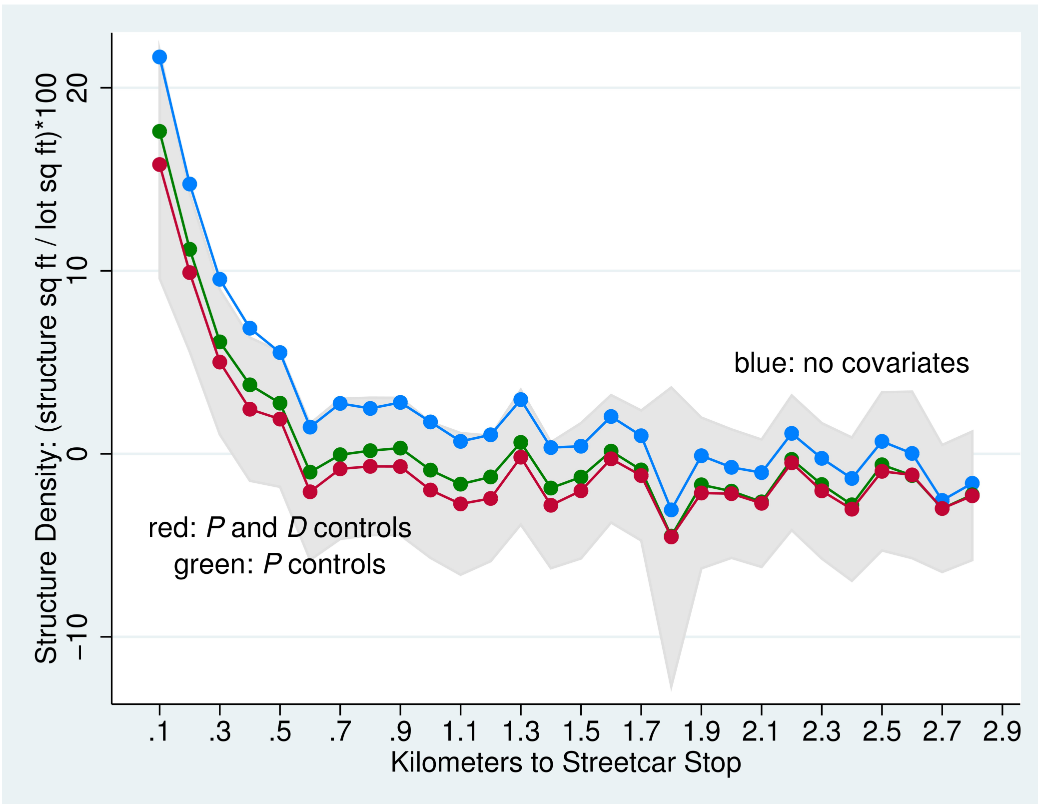


B. RD Zones



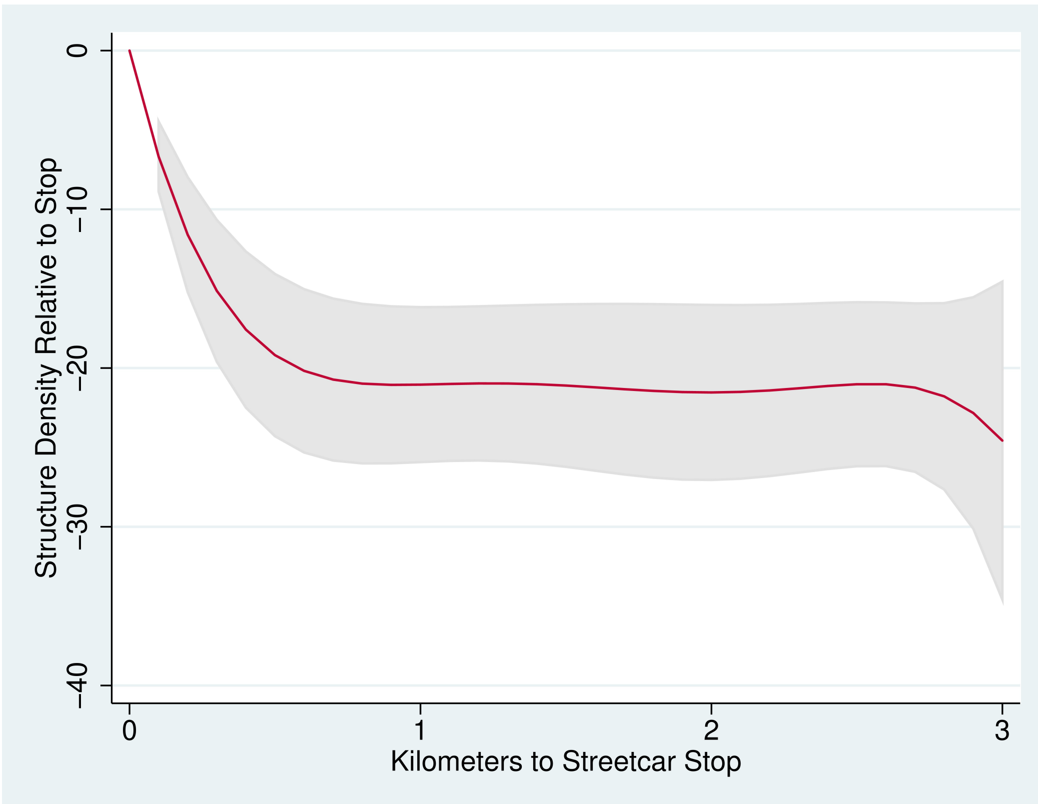
Note: City of Los Angeles parcels only. For legibility, we limit to measures of structure square feet per lot size of 100 and below; this cutoff leaves approximately 90 percent of parcels in these zone codes. Both R zones and RD zones are City of Los Angeles residential zones. We display structure per lot size distributions for the zoning designations in most frequent use. R1 is a single-family residential zone, R2 is for two family dwellings, R3 for "restricted density multiple dwellings," and both R4 and R5 are for "multiple dwelling." All RD zones are for "restricted density multiple dwellings," but allow increasing density as

Appendix Figure 10: Distance to Streetcar Effect Implemented Continuously with Bands



Note: The figure displays coefficients on a series of indicator variables for 0.1 km width bins a given distance from the streetcar stop. The final bin—2.9 km to 3 km from the stop—is the omitted category. The first treatment bin is a circle around the stop of radius 0.1 km; the remaining bins are rings of width 0.1 km. See Appendix equation 1. Note that the vertical axes of this figure and Figure 3 have very different scales and that, more generally, these estimates cannot be directly compared; please see Appendix Section 10.

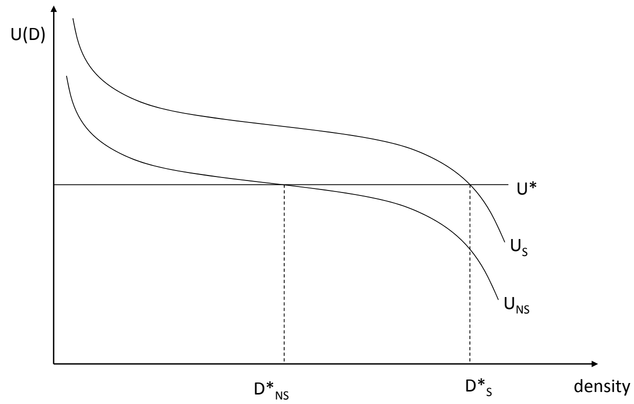
Appendix Figure 11: Distance to Streetcar Effect Implemented Continuously as a Fifth Order Polynomial



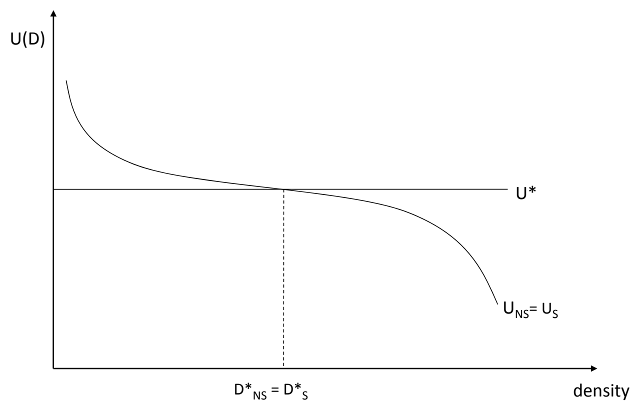
Note: The figure uses the same sample and specification as Appendix Figure 10, but instead of specifying proximity to the streetcar as a series of indicator variables, we use a fifth-order polynomial in distance to the streetcar and evaluate the coefficients to produce the figure. See Appendix equation 1.

Appendix Figure 12: Density at Two Locations

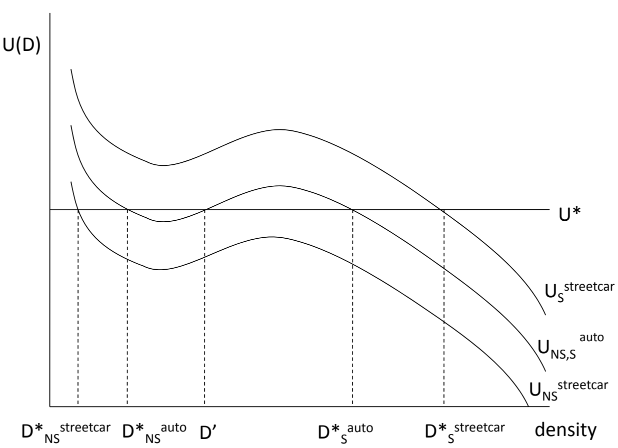
A. Equilibrium Density in Streetcar Era Under Decreasing Returns to Density



B. Equilibrium Density in Auto Era Under Decreasing Returns to Density



C. Equilibrium Density in Streetcar and Auto Eras Under Increasing Returns to Density



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

Note: Thie table reports distance to the red and yellow car lines for all 2,318,481 parcels of land in Los Angeles County.

Appendix Table 2: 2011 Parcel Characteristics

				Circle Estimation Strategy					
	All Parcels			≤ 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	38.68	47.96	275,504	32.91	37.60	129,745
Struc. Val. / Lot Size	25.37	38.56	2,297,823	31.57	90.62	275,504	26.34	75.59	129,745
B. Current Use									
Non-residential	0.11	0.31	2,321,904	0.31	0.46	275,504	0.21	0.41	129,745
Multifamily	0.25	0.43	2,070,937	0.41	0.49	249,309	0.32	0.47	121,619
C. Zoning Regulation									
Non-residential	0.15	0.36	1,521,345	0.17	0.37	189,523	0.11	0.31	94,220
Max. Units*	11.32	58.19	1,332,380	7.85	34.19	177,901	5.03	14.61	90,449
Max. Height in Ft.	35.66	8.44	1,452,802	37.21	12.66	182,599	35.27	9.91	92,489
Min. Covd. Parking	1.65	0.77	1,465,275	1.49	0.93	181,876	1.62	0.84	91,662

Note. * Max # units is only defined for residential properties. We multiply structure square feet per lot size by 100 here and

Appendix Table 3: Logged Dependent Variable Yields Similar Results

	Dependent Variable is log(Structure Density)	
	(1)	(2)
A. No Covariates		
Treatment $\text{Circle}_{i,s}$	0.098	0.109
	(0.017)	(0.018)
Parcels	442,738	397,206
Streetcar Stops	1,38	890
B. Controlling for Predecessors		
Treatment $\text{Circle}_{i,s}$	0.069	0.075
	(0.018)	(0.02)
Parcels	442,738	397,206
Streetcar Stops	1,38	890
C. Controlling for Predecessors and Descendants		
Treatment $\text{Circle}_{i,s}$	0.052	0.06
	(0.017)	(0.019)
Parcels	442,738	397,206
Streetcar Stops	1,38	890
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

Appendix Table 4: Density Finding Robust to Alternative Specifications

	No	Covariates	
	Covariates	P	P and D
	(1)	(2)	(3)
Only Post-1963 Construction			
Treatment $\text{Circle}_{i,s}$	5.87	5.73	4.89
	(1.48)	(1.56)	(1.54)
Parcels	107,612	107,612	107,612
Streetcar Stops	571	571	571
Mean, Control Dep. Variable	72.63	72.63	72.63
Cities with No Fire Map Before 1898			
Treatment $\text{Circle}_{i,s}$	3.47	3.19	3.29
	(0.91)	(0.83)	(0.81)
Parcels	162,685	162,685	162,685
Streetcar Stops	376	376	376
Mean, Control Dep. Variable	33.57	33.57	33.57
Omit Five Stop Clusters			
Treatment $\text{Ring}_{i,s}$	6.53	5.64	5.02
	(0.73)	(0.77)	(0.76)
Parcels	370,838	370,838	370,838
Streetcar Stops	743	743	743
Mean, Control Dep. Variable	38.73	38.73	38.73
Treatment Ring, Not Treatment Circle			
Treatment $\text{Circle}_{i,s}$	3.86	4.25	3.94
	(0.67)	(0.7)	(0.68)
Parcels	272,75	272,75	272,75
Streetcar Stops	908	908	908

Appendix Table 5: 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$_{i,s}$	0.032	2.277	1.065	-0.11
	(0.009)	(0.429)	(0.263)	(0.019)
Parcels	283,743	268,350	275,088	273,538
Streetcar Stops	644	593	624	608
Mean, Control Dependent Variable	0.107	5.03	35.27	1.623

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 that have a Yellow Car route in either the treatment or control area, and use a treatment circle radius of 0.5 km. Further, all estimates control for P and D, as defined in Table 1. 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.

Appendix 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 $\text{Circle}_{i,s}$	0.022	0.033	0.004
	(0.007)	(0.025)	(0.002)
Parcels	33,810	33,810	33,810
Streetcar Stops	128	128	128
Dep. Variable Mean, Control	0.029	0.281	0

Note. All estimates use a treatment radius of 0.5 km, and control for P and D, as defined in Table 1. The dependent variable mean in the last column is truly zero: no property in this sample changes from a non-commercial use to a commercial use from 1922 to 2013.

Appendix Table 7: 1922 City of Los Angeles Zoning and Modern Zoning

	2013 Zoning, by 1922 Definition				Total	
1922 Zoning District	A	B	C	D	Parcels	Shares
	(1)	(2)	(3)	(4)	(5)	(6)
Parcels						
A = Single Family Residential	4,747	3,343	254	136	8,480	0.095
B = Multifamily Residential, Churches, Schools	11,079	42,906	2,787	632	57,404	0.642
C = Stores or Shops, Wholesale or Retail	180	1,906	5,993	424	8,503	0.095
D = Light Manufacturing	872	795	6,638	4,462	12,767	0.143
E = Any Structure Not Prohibited by Law	368	106	666	1,085	2,225	0.025
Share						
A	0.56	0.394	0.03	0.016		1
B	0.193	0.747	0.049	0.011		1
C	0.021	0.224	0.705	0.05		1
D	0.068	0.062	0.52	0.349		1
E	0.165	0.048	0.299	0.488		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

Appendix Table 8: Bus Stop Robustness Check

		Covariates	
	No Covariates	P and D	P, D, & cubic in distance to bus stop
	(1)	(2)	(3)
Treatment Circle$_{I,s}$	6.58	5.34	4.79
	(0.75)	(0.81)	(0.81)
Parcels	332,198	332,198	332,198
Streetcar Stops	711	711	711

Note. See notes from Table 1. The dependent variable is structure density. All estimates use a treatment circle radius of 0.5 km, control for streetcar stop fixed effects and omit stops with parcels omits any streetcar stops that have a Yellow Car route in either the treatment or control area. The sample is further restricted to streetcar treatment/control regions with at least one parcel within $\frac{1}{2}$ kilometer of an Metropolitan Transit Authority (MTA) bus stop in order to avoid areas where we lack data on bus stop locations. Column (3) controls for a cubic in distance to the nearest MTA bus stop.

9 Online Only 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.

<u>Dorothy Peyton Grey Transportation Library</u>

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

<u>University of California at Santa Barbara Alexandria Digital Library</u>

- 1920s USGS topographic maps (1:24000)

<u>California Railroad Museum</u>

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

<u>Electric Railroad History Association</u>

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

<u>Huntington Library</u>

- 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.[34] 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/`.

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

10 Online Only Appendix: Continuous Spatial Treatment Effect

As discussed in Section 5.2, our primary circle estimation strategy requires an arbitrary choice of treatment circle radius and does not report a continuous spatial treatment effect. To address these concerns, we estimate

$$outcome_{is} = \gamma_0 + \tilde{m}(dist_{i,s}) + \delta_s + \gamma_2 P_{is} + \gamma_3 D_{is} + \epsilon_i \tag{1}$$

where $dist_{i,s}$ is distance to the streetcar stop. We parameterize this in two ways. First, we specify $\tilde{m}(dist_{i,s})$ as a vector of 29 indicators for rings of 0.1 km width (so that rings are from 0 to 0.1 km, 0.1 to 0.2 km, etc). Results are in Appendix Figure 10. Second, we specify $\tilde{m}(dist_{i,s})$ as a fifth order polynomial in $dist_{i,s}$; results are in Appendix Figure 11. Regardless of approach, the effect of proximity to the streetcar stop dissipates quickly and is negligible past one-half a kilometer.

Finally, it is important to note that Appendix Figure 10 and Figure 3 are not directly comparable. Although the scale of the horizonal axes are the same, estimates at each distance are conceptually very different. Figure 3 provides the mean difference in density between the treatment circle (as defined by its radius from the streetcar stop, displayed on the horizontal axis) and the control ring. Each point is the result of a separate regression. In contrast, Appendix Figure 10 presents results from one regression. Here, each point represents the difference in density at that distance from the streetcar, relative to the omitted category, which is the ring from 2.9 to 3 km from the stop. Finally, note the very different scale of the vertical axis across Figure 3 and Appendix Figure 10 .

11 Online Only Appendix: Robustness Check

This Appendix section addresses challenges to the circle estimation strategy presented in section 5.2. We start with the concern that, despite the small radius for our analysis, properties in the circle may have been more likely than the control ring to host population centers predating 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 to identify populated areas as of 1898.[35] 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 stringent 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

[35] 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.

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.[36]

Although the sample decreases by more than one-third, the second panel of Appendix Table 4 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 ten 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 Appendix 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 Appendix Table 4 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 Appendix Table 4 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 Appendix Figure 6, the treatment circle will mechanically have parcels with a lower average distance to the intersection and road, relative to the control ring.[37] 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 define an alternative treatment area: the treatment ring. We construct the ring by removing

[36] 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.

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

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 1, these point estimates 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 1.

The fifth panel of Appendix Table 4 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 $5 per square foot—an increase of 14 percent relative to the control area mean.[38] 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.

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 sample as the bus stop sample.

[38] 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.

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 8 presents streetcar stop density estimates analogous to those in column (2) of Table 1, 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.

Finally, 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 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.) 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. Results available upon request.

12 Online Only Appendix: Agglomerative Externalities in the Post-Streetcar Era

This Appendix Section discusses the possibility that agglomerative forces are responsible for the persistent density around the streetcars in greater detail than in section 2 of the main text. In order to set the stage, first consider the streetcar era and, as in section 2.1, assume decreasing returns to density. In Panel A of Appendix Figure 12, the decreasing returns are expressed as a downward sloping utility as a function of density. The streetcar utility curve U_S lies above the non-streetcar curve U_{NS} at any density, reflecting the lower cost of commuting from S. Density at both S and NS is pinned down by the outside option U^*. Panel B of Appendix 12 displays the auto era under decreasing returns to density. With commuting costs equal at locations S and NS, $U_{NS} = U_S$ at any density level. Density is again pinned down by the outside option U^*.

Now assume that utility increases over a certain range of density $0 < D_L < \infty$. Panel C of Appendix Figure 12 depicts this case. When returns to density are increasing, the positive amenity value of density increases more quickly than congestion costs 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 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, under this configuration, agglomerative externalities are responsible for the persistent density around the obsolete streetcar stops.[39][40]

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. Evidence suggests such spillovers can operate over very short distances (Arzaghi and Henderson, 2008; Rosenthal and Strange,

[39] Note that location NS has two possible equilibrium in the post-streetcar era, although the second possible equilibrium, D', is not stable.

[40] See Bleakley and Lin (2011b) and Helpman (1998) for a more complete treatment.

2001), although these studies focus on specific industrial categories, which we do not.