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Vestiges of Transit: Path Dependence and the Modern City

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Vestiges of Transit: Path Dependence and the Modern City

By the 1910s, Los Angeles had one of the largest urban rail networks in the world. Streetcars dominated urban transit and motivated building and investment. New streetcar construction ceased by 1922 and the system entered a long, slow decline, culminating with elimination in 1963. Does the modern metropolitan area still reflect vestiges of this fifty-year-extinct transport system? In other words, are metropolitan areas sufficiently malleable to allocate capital to current demands? We use data on the location of extinct streetcar routes in Los Angeles and data on modern-day land use at the level of the individual property to show that properties near streetcars are statistically significantly different from other similar properties as of 1999. Relative to properties in a small neighborhood farther from the extinct streetcar, properties closer to the extinct streetcar are more likely to be zoned less restrictively, to have more capital per unit of land, and to have higher land values.

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Recent work in urban economics suggests that cities are exceedingly persistent structures. Bleakley and Lin (2011) show that cities that gained an locational advantage as a good place to portage canoes in the 1700s are more likely to be cities today, long after the natural advantage of the portage has worn off. Davis and Weinstein (2002) find that the long run path of city growth is unchanged even by nuclear bombardment. Redfearn (2009) shows that twenty-year old employment density does a substantially better job of explaining current employment density than distance from the CBD or distance to the highway network, two fundamental predictors of employment in most urban models.

What are the micro roots of this type of persistence? In this paper, we examine persistence at the level of the individual property by asking whether proximity to now-extinct streetcars is correlated with patterns in modern day land use and land value. In particular, we use data from Los Angeles County and ask whether distance to the now-extinct streetcar is associated with modern capital intensity, intensity of land use regulation, and land value. Streetcars' effect on land value is of particular interest. Land value provides a summary measure of the net effect of all external effects on the property. In particular, our estimates shed light on infrastructure investment's long-run effects on land value.

We are interested in streetcars for two key reasons. First, streetcars rose to prominence in the late 1890s, and were almost entirely gone in Los Angeles by the 1950s, though their ridership began to dwindle even in the 1920s (Post, 1989). Therefore, streetcars pinpoint discrete investment locations, and we are sure that those investments are now completely obsolete. Second, in their heyday, streetcars dominated urban transit and thereby molded cities. Their rise pre-dates the widespread availability of cars, and they presented a substantial advance over the urban transport options that preceded them.

Were cities per-by-period optimizing entities – or, perhaps even decade-by-decade optimizing entities – we would expect that the influence of streetcar locations should have now waned. Instead, we find exactly the opposite. Using data on individual properties as of 1999, we find that distance to the streetcar – even when comparing two properties within a very small neighborhood – is associated with higher capital intensity, smaller lots, less restrictive zoning, and higher land values.

1 Historical Background

To put our theoretical framework in context, we begin with a brief historical background on transit and zoning in Los Angeles. We chart the rise, growth, decline, and rebirth of electrified transit, and detail the advent of modern zoning. Our period of interest is roughly 1880 to 1920, a period during which Los Angeles grew from a village of 11,183 people to a city of 576,673 residents (Department of the Interior, Census Office, 1895, p. 370; Gibson, 1998, Table 15).

1.1 Streetcars

Streetcars rose to prominence at the end of the 1800s, replacing horsecars and cable cars. The first form of motorized public transit in Los Angeles County was the 1885 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). The cable car predecessor, 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.

In contrast, when a successful design was finally found, streetcars were faster and cheaper. Electric streetcars were first successfully employed in Richmond, Virginia in 1888. When introduced in Southern California a few years later, electric streetcars quickly became the standard. Already in 1893, Los Angeles had an impressive network of over 38 miles of electric trolley, 20.5 cable car route miles, and 9.09 miles of horse railway (Post, 1989, p. 123). In 1894, the first of what would be a large interurban streetcar network began running between the two largest cities in the County: Los Angeles and Pasadena. This heralded an intense period of electrification (Post, 1989, p. 124, 127). The interurban streetcar network would become known as the Pacific Electric, and colloquially as "red cars." By 1896, all public transit lines were electrified (Walker, 2007, p. 7). As of 1900, Los Angeles, with a population of 100,000, had over 100 miles of track, and over 20 streetcar routes (Post, 1989, p. 145). Intraurban routes ran on a narrower gauge. These lines were operated by the Los Angeles Railway, and known as "yellow cars." Figure 1 shows images of yellow and red cars.

Henry Huntington, nephew of Southern Pacific founder Collis P. Huntington, moved to Southern California and was the largest investor in the group that bought the Los Angeles Railway in 1898 (Walker, 2007, p. 21; Post, 1989, p. 139). Huntington led the company through its period of greatest growth. By the time Huntington was about to leave the Pacific Electric, the PE was billing itself as the "world's greatest interurban," with over 1,000 miles of track, or roughly five percent of the total track in the entire country (Post, 1989, p. 141; Fischel, 2004). In 1911, Huntington sold his holdings to the Southern Pacific, and the red and yellow cars ran under consolidated ownership.

During the peak of the streetcar era, residential and some commercial development followed the streetcar lines. This was true with Los Angeles's earliest motorized cable car lines in 1885, and continued as transit improved (Post, 1989, p.52). One seller advertised that "all lots were within 600 feet of the new car line" (Post, 1989, p. 22; Fogleson, 1967, p. 87). Huntington, in particular, made the bulk of his fortune by selling land adjacent to his streetcar routes.

Streetcar construction peaked nationally in 1906 (Fischel, 2004, p. 321). After this, in Los Angeles and elsewhere, the system began a long, slow decline. As early as 1922, Los Angeles Railway was using "motor coaches" (buses) for new routes (Walker, 2007, p. 30).

The 1923 map of the Los Angeles Railway in Figure 2 shows the San Pedro line in the south being operated by bus. 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).[1] In 1927, "patronage was no longer keeping pace with population growth" (Post, 1989, p. 152).

Decline built on decline. At least as early as 1939, Los Angeles Railway began replacing streetcar routes with buses (Walker, 2007, p. 59). Thus, except for a brief return to prominence during the shortages of World War II, the streetcar began a long, slow decline starting in the 1920s. A 1954 map of the Los Angeles Railway, shown in Figure 3, clearly shows that most of the old yellow car routes operated by bus. In 1958 there were only five streetcar lines remaining Walker (2007, p. 115).

The original system finally disappeared completely in the early 1960s. The Pacific Electric ran its last train in 1961, and the Los Angeles Railway its last train in 1963 (Walker, 2007, p. 104, 115, 119).

It was another three decades before rail returned to Los Angeles. In 1985, voters approved funding for light rail. The Metropolitan Transit Agency's Blue Line opened in 1990 serving a very similar route to the Pacific Electrics downtown Los Angeles to Long Beach line (Walker, 2007, p. 123-124).

1.2 Zoning

Because we are interested in the intersection of land development and land use planning, we now turn to a brief history of land use regulation, with special attention to its development in Los Angeles.

Historians date zoning to the late 1800s in Germany, and the passage of a zoning law in

[1] 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).

Frankfurt in 1891 (Burgess, 1994, p. 63-4). 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. In the United States, historians date the advent of modern zoning with two key occurrences. The first is the passage of New York City's Zoning Resolution of 1916 which mandated height and bulk restrictions for commercial buildings Longtin (1999, p. 2). The second is the Supreme Court's decision in Euclid v. Ambler (272 U.S. 365) that zoning is within the bounds of municipal authority because it derives from the city's police powers (Burgess, 1994, p. 2).

There are some notable predecessors to this modern zoning. Early developers used covenants on residential properties to limit access to neighborhoods (Burgess, 1994, p. 2-3), Boston restricted height (Burgess, 1994, p. 65), and in 1904 Los Angeles restricted the location of commercial laundries, which served the dual purpose of segregating uses and segregating Chinese immigrants (Burgess, 1994, p. 65; Whittemore, 2010, p. 32). By 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). However, New York was the first city to specificy structure requirements, and to begin the entire-city type of restrictions we currently associate with zoning.

Zoning arrived in the city of Los Angeles in 1921, when the city delineated five zoning districts: single family, multi-family, commercial, limited industrial, and unlimited (Whittemore, 2010, p. 14, 58).[2] In 1929, the city put its entire urbanized area into one of these five districts (Whittemore, 2010, p. 73). 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). Los Angeles was the first city in the country to specifically protect the single family home (Whittemore, 2010, p. 80). Contemporary commentators felt that the city was "over-zoned," meaning that the zoning allowed for more construction than

[2]Zoning was found constitutional by the California Supreme Court in 1924 (Longtin, 1999, p. 3).

was likely to take place (at least in the near term) on the land (Whittemore, 2010, p. 78). Also, this early zoning grandfathered in inconsistent uses, but did not allow them to expand Whittemore (2010, p 58-9).

Why did zoning grow when it did? Fischel (2004, p. 320) argues that zoning was not a response to the streetcar, which yielded homogeneous suburbs without the necessity of zoning. Zoning was unnecessary because the streetcar kept out noxious commercial uses, which would have been hard put to transport inputs and finished goods via the streetcar in and out of outlying neighborhoods. Apartments were built very close to the streetcar, and single-family homes were segregated a few blocks farther away. Fischel blames the truck, which "liberated heavy industry from close proximity of downtown railroad stations and docks. It allowed manufacturers to take advantage of lower cost land in residential districts"(Fischel, 2004, p. 321). Buses – which, unlike streetcars could be easily re-routed and which were cheaper and therefore were available to lower-income families – further threatened higher income neighborhoods with lower-income interlopers.

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).

Regulations further increased in the 1970s. In the early 1970s, California mandates that cities have a general plan, and that zoning is consistent with the land use in the general plan. The California Environmental Quality Act (CEQA) requires projects to identify and mitigate significant environmental impacts. The law was passed in 1970, and in 1972 was interpreted by the courts as apply to all private projects, thereby increasing its scope and the regulatory burden on private land owners (Longtin, 1999, p. 4-5). Outright limits on permits for new construction were found constitutional in 1976 (Longtin, 1999, p. 13).

In sum, modern zoning clearly post-dates the arrival of the electric streetcar. While there is some temporal overlap, the type of density and use restrictions we consider empirically are adopted at the earliest in 1929, well after all streetcar investment decisions were made.

2 Framework

With this historical background in mind, we now describe a framework for city and land value evolution. The standard model for describing urban form is the monocentric model (Alonso, 1964; Mills, 1967; Muth, 1969), which posits that residents trade off between commuting costs and rent. This model assumes that all business takes place at the center of the city, that all residents are identical, and that they commute to the center of the city. A spatial equilibrium occurs when everyone is equally happy everywhere. Given the assumptions, such an equilibrium occurs only when locations farther from the city center charge lower rents to compensate for the longer commute.

The monocentric model in a city without any forms of electrified transit predicts a very sharp decrease in rent with distance from the center, or a steep bid-rent curve, commensurate with the high cost of commuting by foot. This curve is depicted in black in Figure 4. This bid rent curve is the maximum rent that an individual is willing to pay at a given distance from the city center. Where the curve hits the x-axis (or where residents fails to outbid farmers who pay the agricultural rent represented by the dashed green line) the city ends.

The arrival of the streetcar fundamentally changes the distance-rent trade-off by changing commuting costs. Prior to the streetcar, transit options were walking and various horse-drawn modes. These were either directly costly, unreliable, or time consuming. With the arrival of the streetcar, a far speedier form of transit than its predecessors, locations near the streetcar saw dramatic declines in the cost of travelling to the center. In addition, because transit was more rapid, locations farther from the city center became economically viable. Further, a location slightly farther from the center yet closer to the streetcar could reach the city center faster and therefore be more valuable than a more geographically central location. In short, we believe that the streetcar created the zig-zag bid rent curve as shown in blue in Figure 4. Streetcar stops are marked with "S"s on the x axis, and predict the local maxima of the streetcar bid rent curve.

The historical record suggests that developers were keenly aware of the advantage to land value created by the streetcar. Streetcars were frequently built as loss leaders to draw people to new neighborhoods. Jackson describes these "streetcar suburbs" as upper-middle class enclaves (Jackson, 1985). While the streetcar did lower transit costs, transit costs remained not insignificant, and life along the streetcar was limited to those that could afford a daily ride.

The arrival of the affordable automobile yet again changed this equation. Unlike the streetcar, with its discrete stops and lines, autos are flexible and allow users quick transit times to any paved location. This feature of the auto smooths and lengthens the bid-rent curve as shown in the orange line in Figure 4.

The monocentric model predicts greater capital density as distance to the center decreases. Where land is expensive, developers should add capital to create more structure and accommodate more population. The type of transit cost changes we describe here predict a clear hierarchy of average density, keeping in mind that the edge of the city expands with each transportation innovation. The walking city is the most dense, the streetcar suburbs the second most dense (though only near streetcar stops), and the driving city the least dense. Empirical evidence on average densities within cities across time accords with this ranking (Jackson, 1985).

Were cities entirely adaptable, and capital investments easily modified, the physical structure of cities and the regulatory environment of cities would reflect modern transit costs. However, if cities change only very slowly, decisions determined by 60 year-extinct transit should continue to influence modern land use decisions.

Why might cities change slowly? We anticipate at least three key reasons that cities are not constantly malleable. First, land development has option value (Cunningham, 2007), and it is therefore not optimal to re-invest every period. Second, as we show in related work, fundamental change in urban areas requires assembly of land – particularly in older neighborhoods with smaller properties – and it is very difficult to assemble land (Brooks and Lutz, 2011). Third, public infrastructure, including roads and zoning, are key limits on the path of development. Changing the direction or existence of roads is difficult and costly; changing the broad direction of restrictions embodied in zoning can also be politically very challenging.

However, zoning, which generally grandfathers in old uses and structures, was perceived by one of its chief promulgators to be adaptive to current needs. Edward Bassett, who worked on New York City's landmark zoning ordinance, and who introduced zoning model statutes across the United States, wrote that zoning's purpose was, "to safeguard the future, in the expectation that time will take care of the mistakes of the past"(Burgess, 1994, Bassett cited on p. 67).

In the following sections, we test whether cities are malleable. Are characteristics of individual properties – lot size and capital intensity – still associated with being near a streetcar? Are zoning regulations still influenced by distance to the streetcar? And does land value differ systematically with distance to the streetcar? In the malleable city, the answers to these questions should be no.

3 Data and Descriptive Statistics

Our data consist of three major components: cross-sectional property data, historical streetcar routes, and zoning information. These data cover Los Angeles County, which contains 88 incorporated cities and a large unincorporated area. The cross-sectional property data contain information on each legally defined piece of land, called parcels. We observe information on all the roughly 2.2 million parcels existing in Los Angeles County in 1999; we purchased these data from Dataquick.[3] To document the 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.[4] Figure 5 gives a graphical representation of the extent of this work. The specific maps and documents we use are listed in the data appendix.

Finally, we collected information on municipal zoning restrictions. Each parcel in each city is associated with a zone code, for example, R-1 or C-2. 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. 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.

We use GIS to determine the census block group for each parcel. We also calculate the shortest distance from the center of each parcel to a variety of other things: the extinct streetcar, major road, modern light rail, coast, and highway entrance or exit. Table 1 reports the average distance in kilometers to the streetcar (the term which we use as shorthand for the distance to the closest extinct streetcar) for a variety of measures of streetcars. The first and fourth rows of the table show the distance to, separately, the Los Angeles Railway and the Pacific Electric. The average distance to the LA Railway is much farther, as it operated only in the central area. In contrast, the average distance to the Pacific Electric is only

[3] We actually have a panel of properties and hope to expand our work to look at urban changes over time.

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

about 6 1/2 kilometers.

There are two possible ways to implement "distance to the streetcar." The Pacific Electric had discrete stops, and for some lines there was substantial distance between stops. It is currently unclear to us whether the Los Angeles Railway had discrete stops. We have found no map with stops, and if the lines had stops, it seems that they must have been very close together. Therefore, for the Los Angeles Railway, we divide the streetcar lines into points no more than 200 feet apart. For the Pacific Electric, we measure distance both to PE stops and to PE lines, similarly divided into points. Empirically, the difference between distance to stops and lines is quite negligible, as seen by comparing the second and third rows of Table 1. The second row – distance to Pacific Electric stops and LA Railway lines – is our preferred measure, as it seems most consistent with how residents used these forms of transit.

Location near streetcars is not a historical anomaly that affects only small parts of the city. Using our preferred measure for distance to the streetcar, Column 5 of Table 1 shows that slightly over one-third of all parcels in current-day Los Angeles are located less than one kilometer of a streetcar, and almost 70 percent are located within three kilometers of a streetcar.

Table 2 presents summary statistics for our key variables, with means presented for properties close (< 1 kilometer) and far (> 3 kilometers) from the streetcar. The first panel of the table presents our measures of capital intensity: assessed improvements / assessed land value, assessed improvements per unit of lot size, units per square foot, and lot size. Parcels near extinct streetcars have lower ratios of capital to land value, but higher levels of capital per square foot, more units per square foot, and smaller lots. The second panel of the table compares the zoning restrictions applied to parcels near and far from the streetcar. In the sample means, parcels near streetcars frequently differ from parcels far from streetcars. Parcels near streetcars have more units per lot square footage, and smaller lots. On average, they allow smaller structures, and require smaller lots. The final panel of the table uses the sample of properties that sold in the previous year and finds that parcels near streetcars have appreciably higher land values and sale prices measured in per square foot terms.

4 Empirical Methods

To test whether distance to the streetcar affects modern land use patterns, regulatory patterns, and land value we need to separate the effect of the streetcar from the effect of other, temporally or spatially correlated factors. For instance, parcels near old streetcars are more likely to have been initially developed in the 1910s and 1920s, and we want to separate this "vintage" effect from the streetcar effect. Broadly, we do this in this version in two key ways: we look within very small neighborhoods to control for geographically correlated factors, and we use observables to control for property features that may be correlated in time with streetcar vintage.

Using the 1999 cross-section of parcels, we estimate

$$\text{outcome}_i = \beta_0 + \beta_1 \text{distance to streetcar}_i + \beta_2 X_i + \beta_3 \text{block group}_i + \epsilon_i, \tag{1}$$

where outcome_i is one of the variables described in Table 2. We control for being in a given small neighborhood of roughly 300 parcels (block group_i). This means that our estimates should be interpreted as asking, for parcels within a small neighborhood, does the one nearer to the streetcar differ systematically in its relationship to the outcome relative to the parcel further from the streetcar.

We are concerned about three possible confounders: structure vintage, the effect of major roads, and the effect of modern transit. In this preliminary draft, we address these concerns by controlling for observables X_i. To separate vintage effects from streetcar effects, we control for the age of the structure. To separate the effect of being near a major road from the effect of the streetcar, we control for distance to a modern major road. To separate modern streetcar effects from extinct streetcar effects we control for distance to the current metrorail network. The current network is broader than the lines that existed as of 1999 (our year of analysis), so our measure controls for anticipatory effects of lines that open shortly after 1999. We also control for distance to the nearest freeway entrance or exit and distance to the coast.

In future work, we hope to improve on this strategy. We have three possibilities in mind. First, there are some possible discontinuities from the historical record. Huntington may have attempted to develop certain streetcar lines without success; these areas would be a good control group. Alternatively (and perhaps easier to document) Huntington developed streetcars where he owned land, so if he owned land that, for idiosyncratic reasons was not developed, that land may also may present a natural control group. Finally, by the mid-1920s, new transit lines were (to the best of our knowledge) bus lines. These routes may also be a good control for the streetcar lines of interest, as the development should be roughly the same time, and roughly the same era of construction.

5 Results

We begin by examining the relationship between extinct streetcars and modern zoning in Table 3. Each regression's dependent variable is the log of the variables listed at the top of the column. Column 1 shows that the linear distance to the streetcar is unrelated to the log of the parcel's floor area ratio, controlling for block group fixed effects and the vintage and distance variables discussed above. However, in Column 2, the logged distance to the streetcar is strongly negatively related to the logged floor area ratio. This pattern makes economic sense: being 5 miles from the streetcar in an era without motorized transit is as useless as being 50 miles from the streetcar, so we expect only the very short distances to the streetcar to be important. Taking the log allows to more closely compare all "far" distances to "near" distances. The negative coefficient tells us that the farther a parcel is from the streetcar, the lower the allowed floor area ratio, or the more restrictive the zoning. In these specifications, we give parcels with no floor area restriction a value of zero, but include a dummy for having no restriction. We omit downtown parcels in Column 3, and see that the result is virtually unchanged. This tells us that this is an effect of streetcars, not an effect of downtown land use.

More precisely, we can interpret the coefficient in Column 3 as an elasticity: for a ten percent increase in the distance to the streetcar, we observe a 0.23 percent decline in the floor area ratio. Evaluated at the mean floor area ratio near the streetcar (2.39), this means a ten percent increase in distance to the streetcar yields a decrease in the floor area ratio of roughly 0.005. Translated, this means that an owner could build half a percent "more building" relative to his or her lot when ten percent closer to the streetcar.

Columns 4 through 7 repeat this same estimation for other zoning variables. The farther from the streetcar, the shorter the allowed building height, and the fewer the allowed units. Again, these findings both show that the restrictiveness of modern zoning is negatively correlated with distance from the now-extinct streetcar. The coefficient on height, like the coefficient on floor area ratio, yields a relatively small 0.16 percent decline in height with a ten percent increase in distance from the streetcar. However, the coefficient on units is larger: a ten percent increase in distance to the streetcar yields a 1.5 percent decrease in the number of units allowed on the property.

Columns 6 and 7 consider minimum requirements. As distance from the streetcar increases, regulations require larger lots and more covered parking spots. Here, as with units, coefficients are substantial. A ten percent increase in distance to the streetcar yields a 1.7 percent increase in the minimum lot size required. A ten percent increase in distance to the streetcar is associated with a 4.3 percent increase in the number of covered parking spots required on a property. Thus, all of the findings from the land use regulation data show that greater distance to the streetcar is associated with more stringent regulation.

The historical record suggests that these findings are not driven by reverse causation: zoning did not drive streetcar location, as streetcar decisions pre-date zoning regulations of the type we observe here. Also, these findings have implications beyond structures that may have been grandfathered in to zoning regulation. New structures replacing older structures face a looser regulatory environment close to extinct streetcars.

In Table 4, we investigate the role of the streetcar in creating capital intensity. In Column 1, we do not find that parcels near old streetcars have more capital value per unit of land value, as measured by assessed capital and land values. In fact, we find the opposite. We have some concerns with the measure of land value due to Proposition 13. California's Proposition 13 caps on assessment increases to 2 percent per year, and returns assessments to market value upon sale. However, our estimates are unbiased if the relative value of capital and land is unchanged since last sale (this may be a heroic assumption). Even when we exclude downtown, which has the largest structures per lot size, we find that there is more capital for unit of land farther from extinct streetcars (column 2). However, in Column 3 we show that there are fewer units per lot square foot as we move farther from old streetcars (column 3), and that the observed lot size increases with distance to the streetcar (column 4). Note that while observed lot size increases with distance to the streetcar, the coefficient is a tenth the size of the coefficient on the regulation of lot size from Table 3 Column 6.

Finally, we examine whether current land value, as a summary evaluation of the land use patterns generated by the streetcar, is correlated with distance to the streetcar. For these estimations, we use only sales that occurred in 1999, to align with the year of data we have used for the above estimations. The sample size shrinks to about 120,000 observations. We run these regressions in log-log form so as to able to interpret the coefficients as elasticities. In Table 5 Column 1 we show that a ten percent increase in distance from the streetcar is associated with a 0.38 percent decline in land value – or that properties near old streetcars have relatively higher land value. The second column shows that this coefficient is roughly unchanged when we drop parcels downtown. The final column of the table examines the relationship between the distance to the streetcar and price per square foot. Here we find that property price – the land and structure – decrease less than land does (and the coefficient is measured less precisely) with distance from the streetcar. Thus, land near old streetcars is more valuable, and it has relatively less valuable capital on it.

6 Conclusion

In sum, we find that distance to now-extinct streetcars is correlated with many patterns of modern-day land use. Parcels near old streetcars are zoned less restrictively, allowing larger buildings and smaller lots. Beyond the regulations, in practice these parcels have smaller lots, more units per lot square footage, yet fewer structural improvements per lot size. These parcels also have more valuable land, but relatively less valuable structures.

This evidence suggests that land use decisions have long-term outcomes. This could be either because initial decision-markers correctly foresee future needs (which seems doubtful to us), or because frictions in land markets make changing extant decisions very very costly (as we suggest in related work (Brooks and Lutz, 2011)). Because zoning, which did not exist at the time of streetcar development, is related to the streetcar, this suggests that zoning decisions respond to market forces, but that they may also persist even when market forces no longer propel them.

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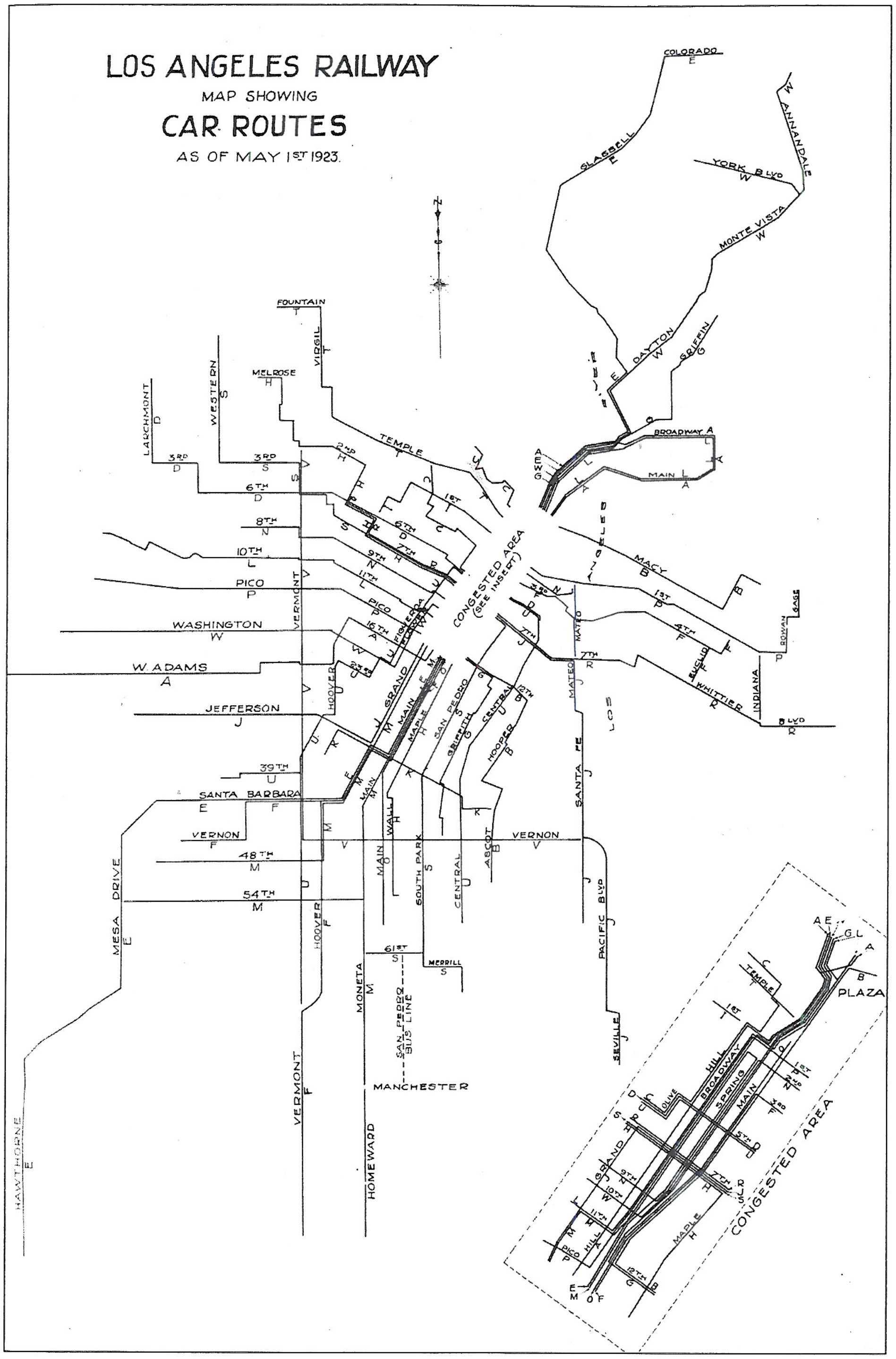
Figure 1: Streetcars in Action

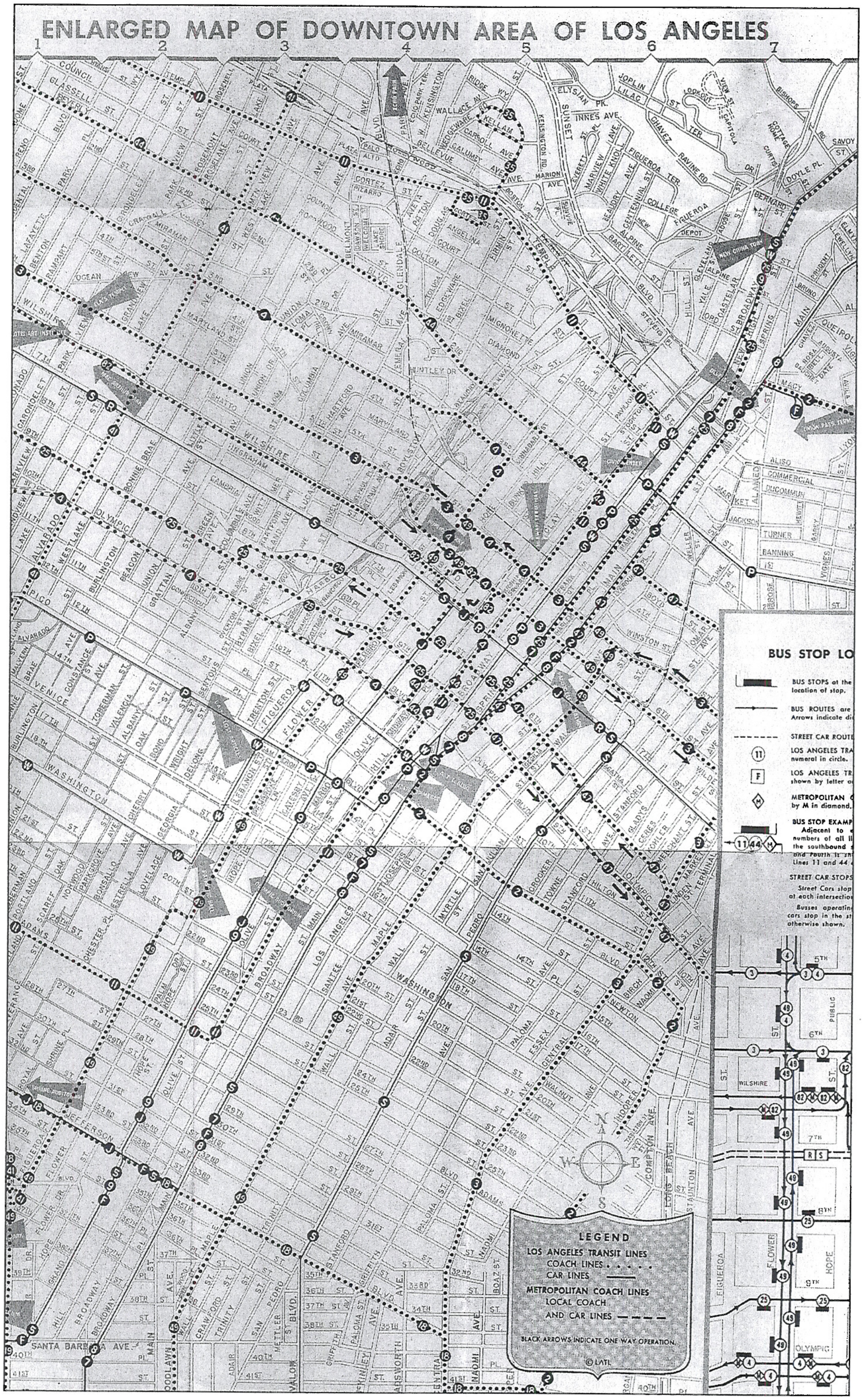
Note: On top, a 1909 "yellow car"; on bottom, a 1949 "red car." Photos are from the collection of the Los Angeles Public Library, numbers 6813 and 71923 respectively.

Figure 2: 1923 Los Angeles Railway Map



Note: This 1923 map of the Los Angeles Railway shows one bus route – the dotted line in the southern part of the figure, labeled "San Pedro Line" (Walker, 2007, p. 39).

Figure 3: 1954 Los Angeles Railway Map



Note: This 1954 map shows Yellow Car routes. Most are represented by dotted lines, showing that almost all routes have been converted to buses (Walker, 2007, p. 112).

Figure 4: Monocentric Model With Changes in Transit Costs

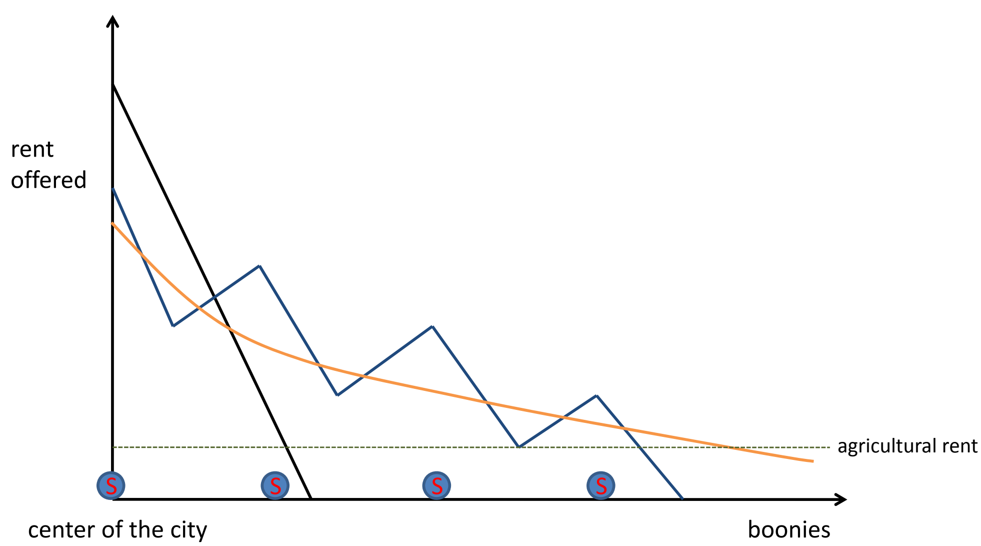
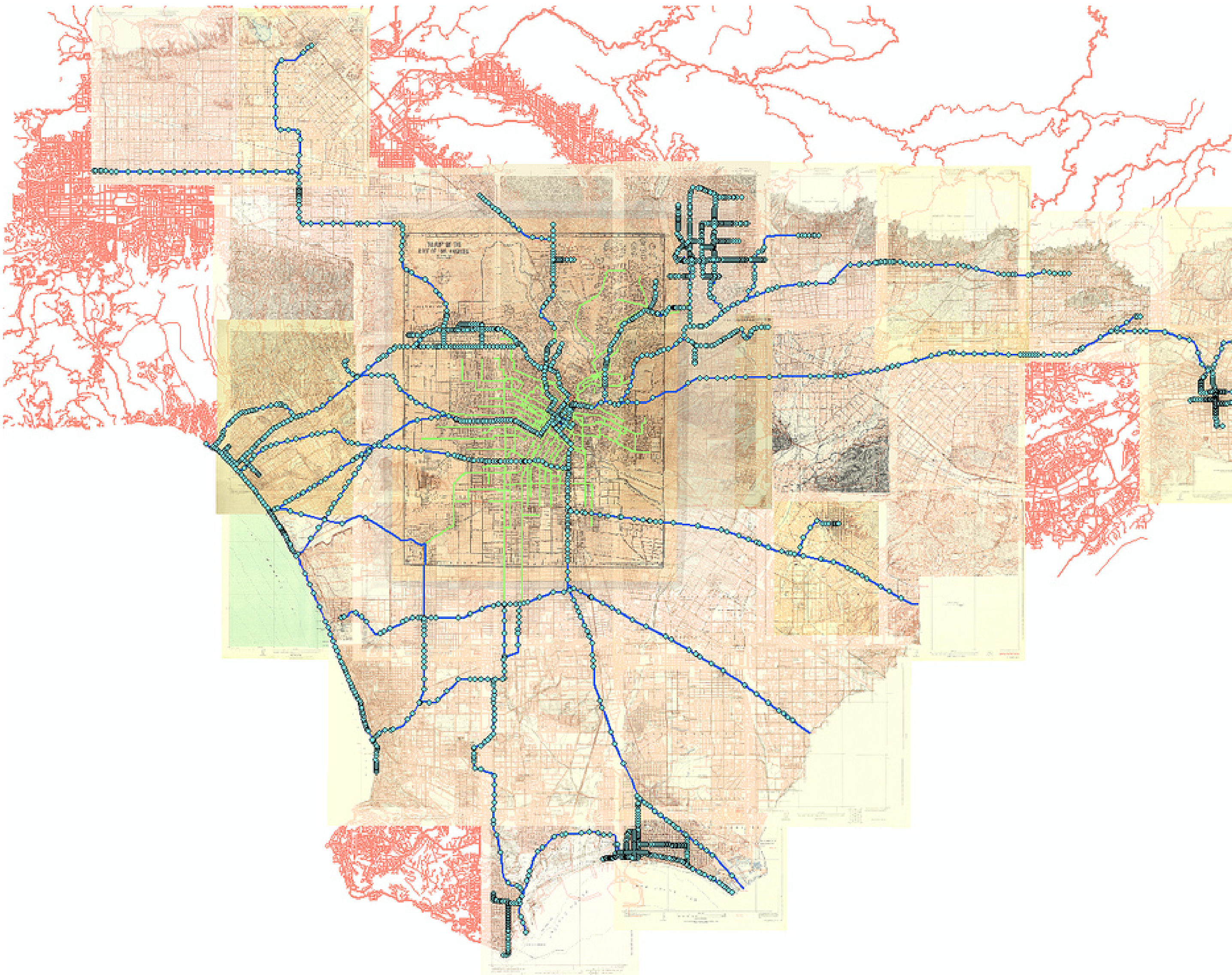


Figure 5: Process of Digitizing Historical Maps



Notes: This picture shows modern streets in pink, 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 these, there is a historical map of the Los Angeles Railway at center, and our work assigning lines and stops for the Los Angeles Railway (in green) and the Pacific Electric (in blue).

Table 1: Distance to Streetcar

	Statistics for Distance Measures				Share of Parcels		
Distance to Streetcar in Kilometers Defined as	Mean	Std. Dev.	Min.	Max.	≤ 1 km	> 1 km & ≤ 3 km	> 3 km
Distance to closest Los Angeles Railway Line	17.51	16.48	0.00	204.86	0.101	0.078	0.821
Min(distance to PE stops, distance to LR lines)	6.25	13.19	0.00	199.61	0.385	0.300	0.315
Min(distance to PE lines, distance to LR lines)	6.22	13.21	0.00	199.31	0.399	0.289	0.313
Distance to closest Pacific Electric Line	6.41	13.13	0.00	199.61	0.329	0.331	0.340

Notes: PE = Pacific Electric, which are the interurban lines; LR = Los Angeles Railway, which are the intraurban lines. These calculations are based on 2,197,723 parcels.

Table 2: Parcel Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
				Mean		
	Mean	Median	Standard Deviation	≤ 1 km of streetcar	> 3 km from streetcar	Observations
Capital Intensity						
Assessed Improvements/Assessed Land Value	4.31	1.05	892.54	3.99	8.27	2,184,131
Assessed Improvements/Lot Size	16.50	8.49	41.20	22.30	13.33	2,196,879
Units/Lot Size	271.01	161.89	437.90	372.69	157.08	1,478,964
Lot Size	45,195	6,749	697,428	10,531	117,427	2,197,717
Zoning Restrictiveness						
Maximum Allowed						
Floor Area Ratio	2.06	1.3	2.61	2.39	3.84	1,546,954
Height in Feet	33.40	33	10.86	35.73	35.07	1,546,954
Units	9.85	1	58.09	8.77	8.73	1,487,388
Minimum Required						
Lot Size	8,573	5000	25,300	6,198	14,824	1,546,954
Covered Parking	1.69	2	0.76	1.99	1.96	1,486,869
Uncovered Parking	0.25	0	0.60	1.33	1.10	1,486,852
Value						
Assessed Land Value per Square Foot	19.41	11.43735	51.51	26.47	10.72	123,943
Price per Square Foot	64.51	31.32211	252.69	85.79	43.77	123,944

Table 3: Streetcars and Zoning

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Restriction has Maximum Allowed					Minimum Required	
	Floor Area Ratio			Height in Feet	Units	Lot Size	Covered Parking Spots
Distance to Streetcar	0.003						
	(0.014)						
Ln(Distance to Streetcar)		-0.024***	-0.023***	-0.016***	-0.148***	0.172**	0.436***
		(0.006)	(0.006)	(0.002)	(0.021)	(0.056)	(0.060)
Block Group Fixed Effects	x	x	x	x	x	x	x
Distance Controls	x	x	x	x	x	x	x
Without Downtown			x	x	x	x	x
Dummy for No Restriction	x	x	x	x	x		
R-squared	0.995	0.995	0.995	0.998	0.874	0.435	0.652
Obs	1,410,773	1,410,773	1,409,821	1,409,821	1,352,086	1,409,821	1,351,859

Notes: All dependent variables are in log form.

Table 4: Streetcars and Capital Intensity

	(1)	(2)	(3)	(4)
	Dependent Variable			
	Ln(Assessed Improvements / Assessed Land Value)	Ln(Assessed Improvements / Assessed Land Value)	Ln(Units / Lot Size)	Ln(Lot Size)
Ln(Distance to Streetcar)	0.051***	0.049***	-0.094***	0.017*
	(0.007)	(0.007)	(0.009)	(0.008)
Block Group Fixed Effects	x	x	x	x
Distance Controls	x	x	x	x
Without Downtown		x	x	x
R-squared	0.152	0.151	0.483	0.376
Observations	1,976,160	1,972,758	1,460,104	1,973,122

Table 5: Streetcars and Land Value

	(1)	(2)	(3)
	Ln(Assessed Land Value / Lot Size)	Ln(Assessed Land Value / Lot Size)	Ln(Sales Price / Lot Size)
Ln(Distance to Streetcar)	-0.038**	-0.036*	-0.025+
	(0.014)	(0.014)	(0.014)
Block Group Fixed Effects	x	x	x
Distance Controls	x	x	x
Without Downtown		x	x
R-squared	0.431	0.431	0.498
Obs	118,199	118,055	118,055

7 Data Appendix: 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 Associations's "Lines of the Pacific Electric Railway in Southern California." For visual reference (no geoferencing) 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."