The Opportunity Cost of Parking Requirements: Would Silicon Valley Be Richer if its Parking Requirements were Lower?

December 2018

A Report from the Pacific Southwest Region University Transportation Center

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UCLA ITS

INSTITUTE OF TRANSPORTATION STUDIES

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UCLA-18-32, CA-20-3411	N/A	N/A

4. Title and Subtitle
The Opportunity Cost of Parking Requirements: Would Silicon Valley Be Richer if its Parking Requirements were Lower?

5. Report Date
January 2020

6. Performing Organization Code
N/A

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8. Performing Organization Report No.
PSR-UCLA-18-32

9. Performing Organization Name and Address
METRANS Transportation Center
University of Southern California, RGL 216
Los Angeles, CA 90089-0626

10. Work Unit No.
N/A

11. Contract or Grant No.
USDOT Grant 69A3551747109
Caltrans Grant 65A0674, Task Order 3411

12. Sponsoring Agency Name and Address
Caltrans DRISI
1727 30th Street, MS 82
Sacramento, CA 95816

13. Type of Report and Period Covered
Final report (Jan. 2018 – Dec. 2018)

14. Sponsoring Agency Code
USDOT OST-R

15. Supplementary Notes
Report URL: https://www.metrans.org/research/the-opportunity-cost-of-parking-requirements-would-silicon-valley-be-richer-if-its-parking-requirements-were-lower-

16. Abstract
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17. Key Words
Parking demand; Parking facilities; Parking garages; Parking industry; Parking lots

18. Distribution Statement
No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	42	N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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Table of Contents

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Disclosure

Principal Investigator, Co-Principal Investigators, others, conducted this research titled, "The Opportunity Cost of Parking Requirements" at UCLA's Institute of Transportation Studies. The research took place from February 2019 to January 2020 and was funded by a grant from the PSR and the state California in the amount of $82,257. The research was conducted as part of the Pacific Southwest Region University Transportation Center research program.

Acknowledgements

We thank Cassie Halls for excellent research assistance, and the Santa Clara Assessor's Office for data.

Abstract

We estimated the off-street parking supply of the seven most economically productive cities in Santa Clara County, California, better known as Silicon Valley. Using assessor data, municipal zoning data, and visual inspection with aerial imagery, we estimate that about 14 percent of the land area in these cities is devoted to parking, and that over half the average commercial parcel are parking spaces. This latter fact suggests that minimum parking requirements, if binding, could depress Silicon Valley's commercial and industrial densities, and thus its productivity. In an exploratory empirical exercise, we simulated a reduction in parking requirements from the year 2000 forward, and showed that under conservative assumptions the region could have added space for an additional 12,886 jobs, which is 37 percent of the actual job growth that occurred during that time. These additional jobs would be disproportionately located in the region's highest-wage zip codes, further implying a large productivity gain.

The Opportunity Cost of Parking Requirements: Would Silicon Valley Be Richer if its Parking Requirements were Lower?

Executive Summary

A canonical finding in urban economics is that productivity moves in sync with density. This fact suggests that an anomaly sits atop America's productivity heap: Silicon Valley. Ranking large U.S. urban areas by their productivity (measured as regional gross domestic product (GDP per capita) yields a list that reads, for the most part, like a catalog of central city density: San Francisco, Seattle, Boston, New York. All these places, however, are less productive than Silicon Valley. And while Silicon Valley is dense compared to the average US metropolitan area, it is much less dense than its productive peers. Silicon Valley is part of a triumvirate of regions, along with New York and San Francisco, that Hsieh and Moretti (2019) identify as disproportionate engines of American growth. Yet the Valley, which we — following convention — defined as Santa Clara County, stands out *within* that club of growth for being less centralized, less dense, and *more* productive.

Silicon Valley's low density owes to two facts. The first, which is not the focus of this paper, is the region's sheer prevalence of detached single-family homes, and its relative absence of taller multifamily structures. The second, which is the focus of this paper, is the inordinate share of the Valley's commercial and industrial land that is devoted to parking.

We contend that the cities of Silicon Valley have high minimum off-street parking requirements. These parking requirements essentially impose low-value uses on high-value land. This, in turn, implies a large opportunity cost. A Silicon Valley with lower parking requirements might have less parking, and less parking could enable more clustering of firms and workers. More clustering, in turn, could make the region more productive. If this so, local parking requirements are restraining one of the world's most dynamic urban economies. That is the idea we examine here.

Our contribution in this paper is twofold. First, we estimate the parking inventory of Silicon Valley's most productive cities. Second, we use that estimate to generate a counterfactual scenario: what if these cities had reduced their parking requirements in the year 2000?

Method

We first secured data from the Santa Clara County Assessor's Office. For each parcel, we estimated the building footprint (by dividing total building area by number of stories) and then subtracted that estimated footprint from the parcel area. This leaves us with the parcel's non-building area.

We assume that 70 percent of the non-building area is parking spaces or areas otherwise devoted to parking (e.g. driveways, ramps.) We then made an estimated count of parking spaces. We assume, following convention, that an off-street parking space requires 300 square feet, once accounting for driveways and lanes between rows of spaces

We then turn to the question of whether the zoning created the parking. We measure bindingness by first inventorying the parking requirements themselves. For each of the seven cities in our sample, we tracked the evolution of parking requirements, as best we could, for as many land uses as possible. We then matched these requirements to each developed parcel, and generate an estimate of each parcel's required parking.

As a final step, we aggregate our parcel-level data to the zip-code level, which is the smallest level of geographic detail that lets us see wage, firm, and employment data, as well as data on venture capital (VC) activity, which is a measure of innovation.

With the assembled data, we create a counterfactual scenario that assumes that the seven cities had reduced their parking requirements by 50 percent in 2000. From there we estimated the additional jobs that would result from built space added as a result of foregone parking.

Results

The median share of a parcel devoted to parking was about 52 percent, and the median number of parking spaces on a parcel was 26. If we convert the share of land in parking into an estimated number of spaces, the result suggests that these 7 cities have 311,308 multifamily parking spaces attached to housing of five or more units, and just over 1.45 million non-residential off-street spaces.

We find that parking is supplied most heavily on parcels developed in the postwar 20th century era. Of all the parcels, roughly 62 percent of residential developments and 46 percent of non-residential developments (but 61 percent of office developments) fall into our definition of binding.

We use these data to build our counterfactual scenario, shown below. Reducing the parking requirements by 50 percent in these seven cities in the year 2000 would result in 36,726 fewer parking spaces, totaling some 11 million square feet. The average parcel built under lower requirements would devote only 38 percent of its land area to parking, as opposed to the

current mean of 44 percent. By our estimate, this new space could be repurposed as over 6,700 additional multifamily housing units, and in nonresidential space that could hold 12,886 additional jobs. Of these jobs, almost 10,400 would be office jobs, since office jobs tend to have much higher densities than other categories. Since these seven cities actually added 34,636 jobs between 2000 and 2017, office jobs accounted for 92 percent of the net jobs created, this projected increase amounts to a 37 percent greater rate of job growth.

Table ES-1: Comparison between Actual and Counterfactual

Use category	Parking spaces - Actual	Parking spaces - Counterfactual	Parking change in counterfactual (spaces)	Parking change in counterfactual (sq. ft.)	Additional housing units*	Additional employment**
Industrial and manufacturing	672,137	671,382	(755)	(226,551)	n/a	164
Multifamily	308,372	299,396	(8,976)	(2,692,680)	6,732	n/a
Office	283,640	266,050	(17,590)	(5,276,919)	n/a	10,388
Other urban	28,089	27,576	(513)	(153,804)	n/a	111
Public/quasi-public	120,949	120,949	-	-	n/a	-
Retail	344,556	335,664	(8,892)	(2,667,741)	n/a	2,223
Total	**1,757,743**	**1,721,017**	**(36,726)**	**(11,017,695)**	**6,732**	**12,886**

We estimated a simple model of the wage elasticity of density, similar to those employed by Glaeser and Kahn (2004) and Anderson and Larsson (2016). For each zip code in the Bay Area, we regressed the log of wages on the log of job density (the number of jobs in a zip code divided by the zip code's land area) and the log of population. We employed a fixed effect for the city within which a given zip code is located. We find that, as zip code employment density increases by 10 percent, the wages paid by employers in a zip code increases by 1.3 percent.

Summing our parcel-level estimates to the zip code level shows that in our counterfactual scenario, parcels in the counterfactual would have less of their area covered by parking and more covered by buildings. Parcel parking coverage in the median zip code would drop from 46.3 percent to 44.5 percent. Parking coverage in the bottom quartile of zip codes would decrease from 42.9 percent to 39.9 percent and in the top quartile would decrease from 47.5 percent to 46.6 percent.

The reduction in parking would leave room for additional office space and associated employment. The reduced parking requirements in the counterfactual would increase the number of office jobs in the median zip code by about 16 jobs. While 15 of the zip codes would see no change, the top quartile of zip codes would have between 126 and 1,746 additional jobs. About 67 percent (6,997 jobs) of the overall job growth would be in the five zip codes with the newest jobs, and 88 percent (9,173 jobs) of the overall job growth would be in the top ten zip codes. Eighty percent of the new jobs would be office employment.

The counterfactual scenario suggests that total employment in these 49 zip codes would rise from 943,592 to 956,478 employees, and that employment density would rise by 1.4 percent.

Based on our computed elasticities for the entire Bay Area, this 1.4 percent increase in employment density would be associated with a 0.18 percent or $236 increase in annual average wages in Silicon Valley. Across the county, this would lead to about $220 million in higher wages annually.

Introduction

A canonical finding in urban economics is that productivity moves in sync with density. This finding holds almost regardless of how productivity is measured. Wages, rents, patents, and regional product per capita are all higher in places where people and firms are more tightly clustered (Glaeser and Kahn, 2001; Ahlfedlt and Pietrostefani, 2019; Carolino et al., 2007; Graham, 2007; Harris and Ioannides, 2001).

This relationship, moreover, also appears to hold *within* regions. The densest areas of productive regions are themselves disproportionately productive (Rosenthal and Strange, 2003 and 2010; Arzaghi and Henderson, 2008; Melo et al., 2009). New York is more productive than Orlando, and Manhattan is more productive than New York. Clustering can powerfully boost economic output even at the neighborhood scale (Rosenthal and Strange, 2003; Arzaghi and Henderson, 2008; Andersson et al., 2016).

These stylized facts, well-accepted as they are, also suggest that an anomaly sits atop America's productivity heap: Silicon Valley. Ranking large U.S. urban areas by their productivity (measured as regional Gross Domestic Product (GDP) per capita) yields a list that reads, for the most part, like a catalog of central city density: San Francisco, Seattle, Boston, New York. All these places, however, are less productive than Silicon Valley. And while Silicon Valley is dense compared to the average United States (U.S.) metropolitan area, it is much less dense than its productive peers. Silicon Valley is part of a triumvirate of regions, along with New York and San Francisco, that Hsieh and Moretti (2019) identify as disproportionate engines of American growth. Yet the Valley, which we — following convention — define as Santa Clara County, stands out *within* that club of growth for being less centralized, less dense, and *more* productive.

Silicon Valley's low density owes to two facts. The first, which is not the focus of this paper, is the region's sheer prevalence of detached single-family homes, and its relative absence of taller multifamily structures. The second, which is the focus of this paper, is the inordinate share of the Valley's commercial and industrial land that is devoted to parking.

Parking is not a productive land use. Parking can *complement* productive land uses (if, for instance, a building full of jobs can only be accessed by car), but land used for parking tends not by itself to generate substantial income or employment. For this reason, parking tends to be most prevalent in places where land values are lower. Parking is abundant in suburbs, and in central cities struggling with decline. It is scarce in New York, London, and Tokyo, more common in these cities' outlying areas, and plentiful in the economically troubled urban centers of the American Midwest. In Buffalo, (NY), Cleveland, (OH) and Rochester, (NY), large swathes of land have few economically viable uses, so their owners convert them to vehicle storage. The land earns little money, but costs little to operate. The result is a phenomenon urbanists that call "parking craters" –voids in the urban fabric created by parking lots (e.g. Schmitt, 2014).

Silicon Valley is, assuredly (>), not in decline. To the contrary, its land ranks among the most valuable on earth. In its parking provision, however, it looks more like a suburb, or a declining city, than it does its productive peers. We contend that this is so because the cities of Silicon Valley have high minimum off-street parking requirements. These parking requirements essentially impose low-value uses on high-value land. This in turn implies a large opportunity cost. A Silicon Valley with lower parking requirements might have less parking, and less parking could enable more clustering of firms and workers. More clustering, in turn, could make the region more productive. If this is so, local parking requirements are restraining one of the world's most dynamic urban economies. That is the idea we examine here.

Our contribution in this paper is twofold. First, we estimate the parking inventory of Silicon Valley's most productive cities. Second, we use that estimate to generate a counterfactual scenario: what if these cities had reduced their parking requirements in the year 2000? While we examine all parcels in these cities, we paid particular attention to office parcels. We did so for both conceptual and practical reasons. The conceptual reason springs from the important role of office work in Silicon Valley's economy; what happens on office parcels arguably drives the region's output. The practical reason is that office parcels, for reasons we will discuss, may offer the most reliable window into the region's parking provision.

Applying some baseline assumptions about increased density, as well as reasonable elasticities of employment and wages to density, we find that a Silicon Valley with lower parking requirements may have had job growth 25 percent higher than what actually occurred.

The paper's next section illustrates Silicon Valley's unusual position in the hierarchy of American productivity. Section III then discusses some relevant literature from urban economics and land use, and in Section IV we lay out our methodological approach. Section V presents our results, and Section VI concludes.

Note—as we discuss below, for the purposes of this study, Silicon Valley means the seven largest cities in Santa Clara County, which hold the clear majority of jobs and economic activity. These cities include Cupertino. Milpitas, Mountain View, Palo Alto, San Jose, Santa Clara, and Sunnyvale.

Silicon Valley: Urban Economy, Suburban Zoning

Table 1 illustrates Silicon Valley's exceptionalism, and begins our examination of what explains it. The table compares the Santa Clara metropolitan statistical area (MSA) to New York, San Francisco and Boston. All four are economically dynamic. As context, in 2017, across 389 U.S. MSAs, the average per capita regional product was $42,530. The first row in Table 1, therefore, shows that New York's regional product ($70,000) is 66 percent higher than the U.S. average, Boston's ($77,000) is 88 percent higher, and San Francisco's ($87,500) is over 100 percent larger. Even among this group, however, Santa Clara sits in a class by itself. Its regional product,

at just under $120,000 per capita, is well above San Francisco’s and almost triple the national average.

Table 1

Density and Productivity, Four Metropolitan Areas, 2017

	Santa Clara	San Francisco	New York	Boston
GDP per Capita	$119,736	$87,536	$70,314	$76,831
Center City Population Share	52%	19%	63%	14%
Employment Density				
Region	372	837	1195	673
Center City	2015	13435	7317	9556
Establishments per Square Mile				
Region	37	65	250	37
Center City	114	732	790	385
Population Density				
Region	728	1,867	2429	1375
Center City	5,800	19,000	28,000	13,937
Share Housing Detached Single Family				
Region	53%	50%	37%	48%
Center City	53%	20%	9%	11%
Share Housing w/Garage or Carport				
Region	89%	79%	45%	43%
Center City	91%	70%	22%	30%

Sources: US BEA, US BLS, American Community Survey, American Housing Survey (2017). Quarterly Census of Employment and Wages.
Parking includes all MSA center cities, does not include off-street spaces that are not garage or carport

The puzzle begins in the table's subsequent rows. Santa Clara has—both regionally but especially in its center city—far less clustering of people and firms. The population density of the Santa Clara MSA is less than half that of San Francisco and one-third that of the New York MSA. Its business establishment density is less than half of San Francisco's density and one-seventh of New York's density. Boston's employment density is almost double Santa Clara's, and the employment density in the San Francisco and New York MSAs is more than double Santa Clara's.

In the center cities, even larger differences emerge. San Jose, Santa Clara's largest city, has a population density of less than half of Boston's, less than a third of San Francisco's, and less than a quarter of New York's population density.[1] Where San Jose has just over 100

[1] Some might argue that San Jose is not Silicon Valley's "true" center, even though it is far and away the region's largest and densest city. The most likely alternate would be Palo Alto. But Palo Alto is only half as dense as San Jose. In any event, the fact that anyone can have this argument is telling. No one wonders which city is the New York region's true center.

establishments per square mile, New York and San Francisco each have over 700, with New York being closer to 800. Nor is this difference a result of the Valley having bigger firms (across all three places, only about 3 percent of firms have 100 employees or more). Perhaps most striking is that employment density in the city of San Francisco is over six times that in San Jose. Boston's employment density is almost five times San Jose's.

On their face, these statistics could suggest a tremendous inefficiency. Silicon Valley is far more productive than Boston, New York or San Francisco, but uses its land much less intensively. Land is the defining factor of any urban economy: it is the fixed and immobile resource on which labor and capital are mixed. We know a product or firm is from "Silicon Valley" not because of who financed it or made it, because those people and capital were combined on land that is commonly understood to be Silicon Valley. Failing to use that land intensively, then, implies productivity lost.

Table 1's bottom portion suggests two reasons for the Valley's low land-use intensity, both of which we mentioned in the introduction. The first is the region's preponderance of detached single-family homes. Over half the housing units in Santa Clara are detached and single family. This proportion is higher than in other MSAs, but not dramatically so. In the Boston and San Francisco MSAs about half of all housing is detached single family, while in New York the figure is 37 percent. Notably, however, in Silicon Valley this tendency toward single family living does not diminish in the center city. San Jose's proportion of housing units in detached single family homes is almost identical to the proportion in Silicon Valley overall. By way of comparison, in San Francisco city only 20 percent of housing units are detached single family homes, in Boston 11 percent, and in New York 9 percent.

Second is the inordinate share of land the Valley devotes to parking. We have no direct way to quantify the Valley's parking, because parking inventories, and especially nonresidential parking inventories, are not directly measured in any national statistics. For the moment, then, we will use some proxies. Table 1's last rows are drawn from the American Housing Survey (AHS), which tracks the share of housing units that include a garage or carport in their rent or purchase price. To the extent such bundled parking is an indicator of parking abundance overall, these figures suggest parking is much more common in Silicon Valley. Almost 90 percent of housing units in San Jose come with parking, compared to 70 percent in San Francisco and less than 30 percent in Boston and New York. These figures, moreover, may well understate the difference. The AHS only tracks housing units, and only records whether a unit has any parking included. It does not say how many spaces per unit. The prevalence of detached single-family homes in Silicon Valley, which often feature driveways and garages,

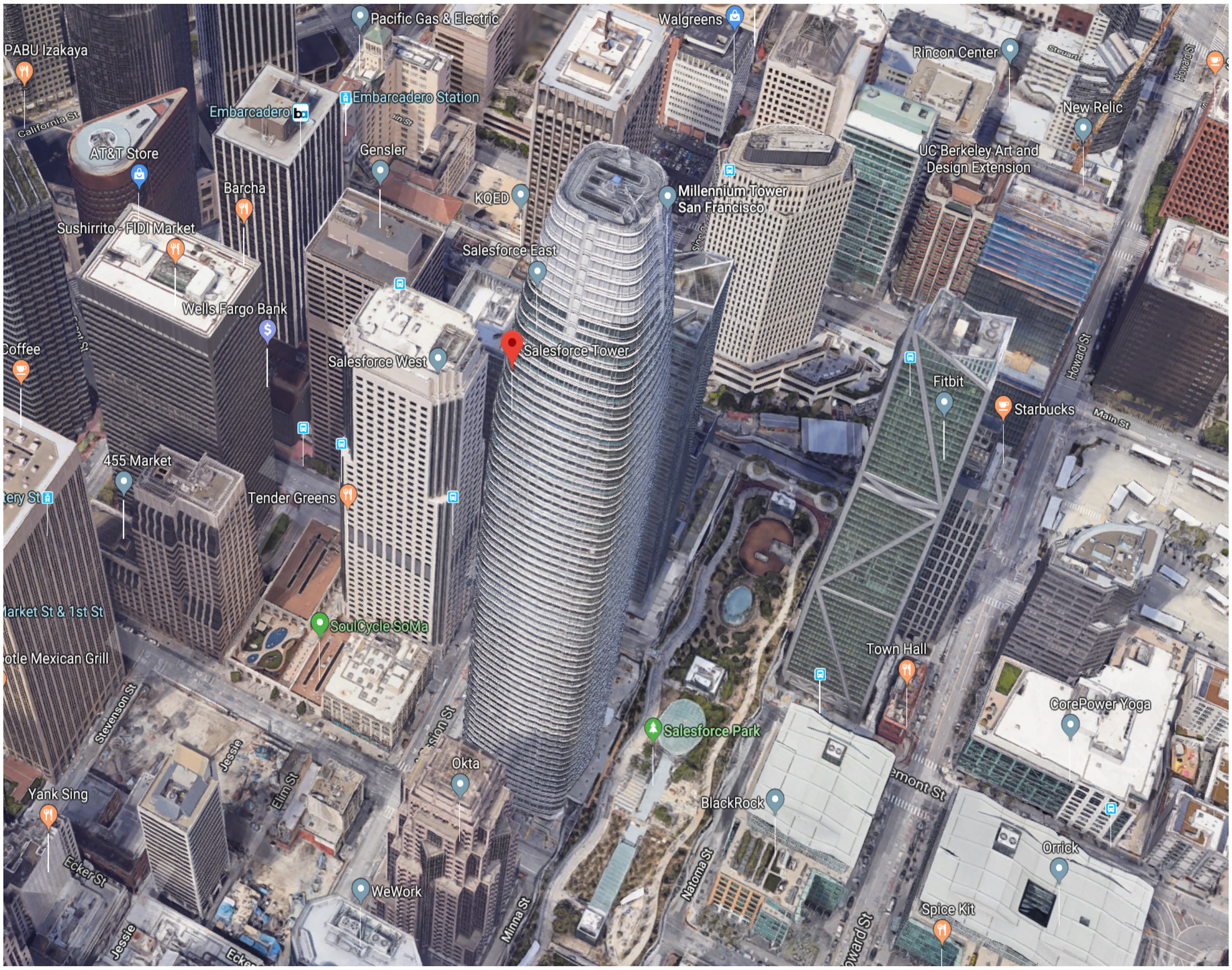
suggests that compared to San Francisco, New York, and Boston, the typical Silicon Valley housing unit may not be just more likely to have parking, but more likely to have *more* parking.

Residential parking, of course, can help explain low *residential* density, but cannot directly explain a low density of jobs or firms. And no data set we are aware of systematically tracks commercial or industrial parking. Nevertheless, we have reason to think that compared to other productive regions, Santa Clara devotes far more nonresidential land to parking. Figure 1 shows aerial imagery, from Google Maps, of the tallest commercial buildings in San Francisco (the 61-story, 1000-foot Salesforce Tower), San Jose (the 19-story, 285- foot Sobrato Office Tower) and Detroit (the 73-story, 727 foot Marriott hotel at the General Motors' Renaissance Center complex).

The disparity in land use intensity between San Francisco and San Jose, and the role parking plays in that disparity, is obvious.[2] Salesforce Tower is San Francisco's tallest building, but it is like the highest peak in a mountain range. Other towers surround it, many almost as tall, and no parking is visible anywhere near it. The Sobrato Office Tower is more like a volcano in San Jose—a relatively lonely peak, sitting atop a parking podium and surrounded on all sides by surface parking. Perhaps most startling is that in an aerial view the Sobrato Office Tower and its landscape more closely resembles Detroit, a city far away in both geographic distance and economic fortune, than San Francisco, which is 50 miles north and has an overlapping industrial base. Detroit is an exemplar of urban decline. Its per capita regional product, at just under $51,600, is 60 percent lower than Santa Clara's. Its central city has borne the brunt of the region's reversals, it is renowned for its vacant housing, and its surplus land has led its downtown to become pockmarked with surface parking.

[2] Some parts of San Jose's downtown sit in a flight path to Mineta San Jose International Airport, which leads to lower building height regulations (City of San Jose 2013; San Jose Mercury News 2019).

Figure 1



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Source: Google Maps

Silicon Valley is not Detroit, but it has a housing crisis caused by *low* levels of vacancy, not high, and so decline cannot explain its parking landscape. Zoning, however, does offer a plausible explanation. Compared to Boston, New York and San Francisco, the cities of Silicon Valley have minimum parking requirements that are not just higher but also apply to a greater share of buildings, especially in the central city. The densest parts of New York, San Francisco and Boston have large areas where the government imposes parking maximums—limiting rather than mandating the supply of parking. Boston's commercial parking freeze (enforced in its downtown and Seaport districts) began in 1976, and neighboring Cambridge began restricting parking in 1980. New York's parking maximums (enforced over most of Manhattan) were imposed in 1981, San Francisco first implemented parking maximums in the 1990s and then dramatically expanded them in 2007. No city in Santa Clara County, in contrast, enforces a parking maximum. Parking minimums there are high and ubiquitous.

New York, San Francisco, and Boston also have older built environments than Silicon Valley, meaning they have more structures that predate parking requirements. Systematic data on the age of commercial and industrial structures by MSA is not readily available in the United States, but both data on residential structures and the history of Silicon Valley suggest that almost all the region's growth occurred in the postwar era. Only 6 percent of San Jose's housing predates 1940, compared to almost 50 percent of Boston's, 48 percent of San Francisco's, and 41 percent of New York's. Fully 80 percent of San Jose's housing was built between 1940 and 2000.

Most of Silicon Valley's nonresidential structures, similarly, were built after World War II. Our calculations from assessor data (described more below) show that only about 2 percent of San Jose's land is office space, and 2.4 percent of its manufacturing space, was built before 1940. Nonresidential space in the central cities of New York, Boston and San Francisco is much more likely to be older. In 2010, for example, CB Richard Ellis estimated that the average large office building in midtown Manhattan was 57 years old, in downtown Manhattan 67 years old, and in midtown south 92 years old—meaning many office buildings predate the city's 1961 zoning reform that introduced minimum parking requirements (Li, 2010).

Alone among the nation's powerhouse MSAs, then, Santa Clara County is dominated, even in its center city, by the physical and regulatory landscape of the automobile. It is a region with the economy of a megacity but the zoning of a suburb. *A priori*, this should exact a toll on its productivity. We turn to this issue next.

Parking, Agglomeration, and Proximity

To examine the potential relationship between parking requirements and productivity, we draw on the academic literature related to agglomeration economies (Glaeser, 1998; Storper, 1997; Rosenthal and Strange, 2004; Duranton and Puga, 2004; Ahlfeldt and Pietrostefani, 2019), as well as the related literatures on factor misallocation and land use (Hsieh and Moretti, 2019), the distortionary effects of land use regulation (Glaeser and Gyourko, 2003) and the measurement and impacts of parking provision and regulation (Shoup, 2004; Chester et al., 2017).

The idea that economies thrive on proximity isn't new. Well over 100 years ago, Alfred Marshall (1890) argued that when firms of the same industry clustered three advantages accrued: matching, sharing and learning. In denser areas employers and workers could find each other more easily, reducing labor market frictions (matching). Firms could also share inputs, and allow the formation of other, specialized firms that supply those inputs—not just law firms, for example, but law firms that focused on software patenting (sharing). Perhaps most important, clustering allowed information, and particularly the tacit knowledge that feeds innovation, to flow more easily (learning).

Since Marshall's day, scholars have further observed that density can reduce transaction costs (Ogawa and Fujita, 1980). All else equal, the cost of two firms conducting business grows with the physical distance between them. Technology can, of course, mitigate these costs, and let some cooperation and negotiation occur virtually. Arguably there is less need today for the levels of urban density that prevailed 100 years ago, since technology in various forms--from the automobile to the Internet—let us have access to each other over greater distances (Bryan et al., 2007). Yet even in an age where transportation costs are low, and communication costs essentially zero, important transactions seem to demand face-to-face contact (Storper and

Leamer, 2001). Proximity still matters. At least some evidence, moreover, suggests that proximity is if anything more important for the sort of high-tech service work in which Silicon Valley specializes (Graham et al., 2010).

The productivity returns that result from proximity manifest in different ways, with the most prominent being a wage premium associated with urban density. Marshall's three agglomeration mechanisms suggest that in an industrial cluster workers are more likely to be employed in the position most suitable for them, and more likely to be surrounded by other skilled people engaged in tasks at which they excel. The result will be a growth in both "embodied human capital" (competent people who know their jobs well), and disembodied information (it will be easier to find the answer to an industry-specific question, because knowledgeable people are near each other). In these circumstances workers can accomplish more, and as such are paid more as well.

Scholars have by now documented this density-wage premium extensively, although estimates of its magnitude vary, and sometimes vary substantially. In the U.S., Glaeser and Kahn (2004) find that as metropolitan-level density increases by 10 percent, wages increase around 1.3 percent. For French cities, Combes et al. (2008; 2012) find a density-wage elasticity of 4.9 percent, and for Swedish cities, Andersson et al. (2016) find a regional density-wage elasticity of around 1 percent. Ahlfeldt and Pietrostefani (2019) use a carefully-identified meta-regression and arrive at a much lower elasticity, they find a 0.04 percent wage increase caused by each 10 percent increase in density in the metropolitan areas of high-income countries.

Metropolitan density has also been associated with innovation and information spillovers. Carlino et al. (2007) find that as a metropolitan area job density doubles, patenting per capita increases by 20 percent, while Ahlfedlt and Pietrosetfani (2019) estimate that with every 1 percent increase in density is associated with an additional $800,000 in patent value.

These figures are all metropolitan estimates: they refer to wage or innovation premiums associated with the average density of jobs or people across entire regions. Regionwide average density, however, can conceal substantial and meaningful variations within that region. The Los Angeles metropolitan area is denser than that of both San Francisco and New York, even though (L.A.) lacks a dense central core—it compensates with relatively dense suburbs (Manville and Shoup, 2004; Eidlin, 2010). It would be a mistake to infer, however, that this higher density makes L.A. the most productive of these regions. It is not, or at least not as measured by per capita regional product. L.A.'s GDP per capita is just over $66,000, compared to New York's $70,000 and San Francisco's $87,000 GDP.

A tempting inference from these facts is that the pattern of density *within* regions also matters--that New York benefits from its very dense central area while LA's suffers for its relative absence of one. Some evidence supports this view. Andersson et al. (2016) show that the wage

premium associated with job density is twice as high at the neighborhood as the city-level. It helps, in short, for firms to be *very* close together.

These close-quarters intraregional effects probably arise from knowledge spillovers. The Marshallian agglomeration mechanisms (sharing, matching and learning) likely function at different spatial sales (Rosenthal and Strange, 2001). Labor market effects (matching) tend to be regional: employers and employees can find each other over relatively long distances (e.g., firms in the central business district will hire people who live in the suburbs). Sharing, similarly, can occur over a relatively wide scale: specialized law firms need to be near their clients, but do not need to be on top of them. Knowledge, in contrast, dissipates quickly. A securities firm on Wall Street is more likely to acquire industry information than a similar firm 15 miles away. It is this flow of informal knowledge, such as that which might be passed between workers over lunch, that decays most sharply with distance (Duranton and Puga, 2015; Lucas and Rossi-Hansburg, 2002). For industries as diverse as advertising, software, print and publishing, and fabricated metals manufacturing, the benefits of firm proximity begin to diminish at a distance of as little as a quarter of a mile, and can be completely exhausted at 10 miles (Rosenthal and Strange, 2003; Arzaghi and Henderson, 2008).

We can see the rapidity with which knowledge dissipates by examining the geography of patent citations. Because patent applications include addresses, researchers can use them to document the extent to which innovation clusters. It turns out that patents are clustered not just regionally, but also at finer-grained scales like the neighborhood or even the building (Carlino et al., 2012; Kerr and Kominers, 2015). Moreover, because new patent applications must cite any other patents to which the new invention is related, patent data can let researchers measure the “relatedness” of knowledge between two inventions, and then use the physical distance between the new patent and its antecedents to estimate how knowledge diffuses across space. These estimates suggest that knowledge does not travel far: a patent is around 10 percent more likely to be cited at a distance of less than 1 mile than a distance of 1–3 miles, and roughly twice as likely to be cited at a distance of less than one mile than at a distance of 15–20 miles. Firms not in close proximity to related firms, then, could miss out on important knowledge.

Density also has disadvantages, of course, and its benefits must be weighed against those costs. Clustering can benefit firms within the cluster, but demand for the cluster means that land prices and congestion increases, which in turn means that firms closer to the heart of an agglomeration must compensate their workers for higher housing costs or longer commutes (Ogawa and Fujita, 1980; Duranton and Puga, 2015). Some firms, when confronted with these costs, will choose to locate farther out. They will reduce their access to agglomeration, but also lower their land costs and wages.

What all this suggests, at least in theory, is that firms should cluster together within cities until costs of more density offset the benefits. Each firm balances this tradeoff differently, and in a

regional general equilibrium, each firm is optimally located with respect to these factors. City-level productivity thus becomes the sum of these localized density effects.

This logic assumes, however, that regulations *allow* such optimization across space to occur. They may not. If regulation limits the intensity with which land in productive places can be used, then the clustering of firms and workers might be lower than is socially optimal. Productivity could as a consequence fall.

This falling productivity could occur through two separate but related pathways. One way emphasized in both Hsieh and Moretti (2019) and Ganong and Shoag (2017) is stunted interregional migration. If stringent zoning in productive regions increases housing costs and slows the pace at which people move in, then these regions will be under-sized, as workers who would have otherwise arrived instead stay in less-productive places. The resulting artificially is smaller labor supply constrains the size and growth of the agglomeration. In this way regulations in productive regions can actually misallocate labor, and depress productivity, nationwide.

The second way regulation could depress productivity is *within* regions. Where Hsieh and Moretti argue that the national economy suffers because American workers who should be clustered in San Francisco or San Jose are instead spread inefficiently apart, one could also argue that Santa Clara County loses productivity because its current firms are misallocated across its landscape. Thus, even if a deregulated Silicon Valley attracted no more workers and firms (e.g., Rodriguez-Pose and Storper, 2019), deregulation might still increase productivity, by letting the existing firms and labor be closer to each other. The regional pool of labor and firms might not change, but they would be allocated more efficiently.

Regulations take many forms, and certainly the prevalence of detached single-family zoning contributes greatly to Silicon Valley's relatively low- density. Residential zoning, however, can have only an indirect (albeit potentially large) impact on firm agglomeration. Low density residential zoning can inhibit the supply of labor, but does not directly influence how firms themselves are spatially organized. Firms locate on commercial, industrial and mixed-use parcels, not in residential neighborhoods.

Parking requirements, unlike residential regulations, could directly impact the density of firms. Firms locate on mixed-use (residential and multifamily) parcels, and on commercial and industrial parcels. Parking requirements have been shown to inhibit density on such parcels (Manville 2013; Cutter et al 2012), and theorized more broadly to impede the formation of dense business districts (e.g., Manville and Shoup, 2005). A business district where every parcel has ample surface parking, or every building sits atop an expensive subterranean structure, combines less labor and capital over its land.

Parking requirements arose to minimize vehicle congestion at the curb, and as such are sometimes considered transportation regulations. In practice, however, they are development regulations: their cost falls primarily on owners and developers of regulated land, and they result in less intensive land use (Bertha, 1964; Shoup, 2011). Supplying parking is either land intensive (for surface parking) or capital intensive (for structured or subterranean parking). In either case, the parking consumes resources that developers could have otherwise used to create job- and income-producing space.

Parking requirements will only have this adverse effect if they bind--that is, if they force developers to provide more parking than they otherwise would. Many developments will need at least some parking. Parking is not a pure cost. It provides an obvious benefit to people who drive, so in an automobile-oriented region, parking allows access to income-generating space, and as such *facilitate* agglomeration, not just inhibit it.

What matters, then, is both the private and social value of the marginal parking space. A developer asks if the next space they provides would increase access to the building--and thus the building's value--by more than it reduces the building's income potential (by diverting space or money from the additional rentable area). If it does, then they do not build that space, *unless* zoning regulation forces them to do so. One way to calculate the region-wide cost of the parking requirement, then, is to sum all the parking spaces whose private costs exceeds their private returns—all the spaces that would not exist, but for the zoning. As we discuss in the next section, this is essentially how we measure the cost.

Before moving on, however, we note that this estimate is probably conservative, and could understate parking's costs to agglomeration. Developers worry about private returns on their own parcels. Agglomeration, however, yields *social* returns: it is a collective good that arises from many firms clustering near each other. While individual developers consider (and pay for) their own benefits from this clustering, they likely discount the benefits their location delivers to others, and may in fact try to free ride off those benefits. Consider a dense cluster of buildings, where the density is enabled in part by relatively little parking. A developer adding the cluster's next building would benefit from the density nearby, but precisely because parking is scarce they might find it profitable to build slightly more parking, since it would allow themto offer tenants both access to the cluster *and* easier access by driving, which could yield higher rent. By choosing more parking over more productive space, the developer contributes less to the agglomeration they are joining.[3] To the extent this sort of free- riding occurs, some parking spaces that have net private benefits will also have net social costs, and estimates of parking costs based only on a developer's calculus will understate the social cost of parking.

[3] Still more strategically, some firms may want to manipulate their workers' exposure to an agglomeration. They may try to soak up the embodied knowledge in the region, but keep their own knowledge secret and minimize attempts from competitors to poach their workers.

All these computations also leave aside parking's well-known collective costs related to transportation. A landscape laden with off-street parking is one that encourages motor vehicle ownership and use (Manville, 2017; Manville and Pinski, 2020), and one that discourages walking, cycling and transit use. Thus even parking spaces that facilitate agglomeration carry some costs, if some agglomeration could have been facilitated in a less resource-intensive way.

Measurement and Empirical Approach

Our goal is to estimate the off-street parking inventory of the major cities in Silicon Valley and then estimate the productivity costs associated with that parking. Doing so requires us to estimate the number of parking spaces, determine if those spaces are the result of binding regulation, and then generate a reasonable counterfactual: if the Valley had less parking, would employment, wages, or other measures of productivity be higher?

We emphasize--and will reiterate--that this entire exercise relies on, and is sensitive to, some strong assumptions. Most of these assumptions arise from the empirical challenge of estimating Silicon Valley's parking inventory. In the United States, despite parking's prevalence in both regulations and the built environment, systematic data on it, and especially on private off-street parking, are essentially nonexistent. Parking is almost universally required and almost nowhere recorded. As a consequence, a recurring obstacle in the parking literature is generating accurate counts of parking supply. At smaller geographic scales, researchers can overcome this problem with aerial photography and on-site surveys. Examples include Weinberger et al (2009), Manville (2013), and municipal efforts in Oakland, San Francisco, and Portland (City of Portland, City of Oakland, SFMTA). Akbahir et al (2003) used aerial photos to estimate the paved area of Sacramento. McCahill and Garrick (2012) used aerial photography to estimate the parking supply over time in 12 small-to-medium sized cities, most of them in the northeast. Their estimates suggest that on average, 7 percent of these cities' land area was accounted for by off-street parking visible in aerial photos, with the highest share being 9 percent.

Even in the best of circumstances, however, these methods are time- and resource-intensive, and often yield incomplete estimates. Not all properties respond to surveys, and municipal parking censuses often are not able to count spaces in private garages. Aerial photos might miss or undercount subterranean parking, or covered parking that is less obvious.

At the metropolitan scale, all these approaches become virtually impossible—it is hard to imagine researchers fanning out to count every parking space in the San Francisco or Boston regions, or even using aerial photography to do so. McCahill and Garrick could use photos to estimate the parking supply in Cambridge, MA. But Cambridge is seven square miles. The most restrictive definition of Greater Boston puts it at over 1,300 square miles. At the regional scale researchers have little choice but to use secondary data to infer parking quantities. The quality

and availability of such secondary data, however, varies greatly. One obvious source is cadastral (assessor) data, but property assessment records differ in different places, and many do not record parking inventories. Scharnhorst et al. (2017), for example, used assessor data to inventory off-street parking in five cities (Jackson, Des Moines, Seattle, Philadelphia, New York). Their project had to use slightly different methods for each city, because assessor data was inconsistent from place to place.

Chester et al. (2017) and Hoene et al. (2019) estimated parking inventories in LA County and Metro Phoenix, respectively, using a combination of parking requirements, assessor's parcel data, and a model of building construction and turnover. To simplify greatly, these articles first estimated when a parcel was developed, and then assumed that the parking associated with that development roughly conforms to the parking requirement on the books for that parcel at that time. From there, they generated parking counts. Chester et al. (2017) used this method, along with a second approach for counting on-street spaces, to conclude that in 2010 Los Angeles County had 18.6 million parking spaces. Of these, 3.6 million were on-street, leaving 15 million off-street spaces, of which 9.6 million were non-residential. This 18.6 million space estimate worked out to 3.3 spaces per vehicle, or about 14 percent of the county's incorporated land area. Hoene et al. (2019), similarly, found that there were over 12 million parking spaces in Metro Phoenix averaging at 3 spaces per person. For every personal auto, there were 4.3 spaces, and—similar to Los Angeles—there were more off-street than on-street spaces. The region had 2.6 off-street spaces per person, and 1.7 on-street spaces per person).

Our own approach is similar, albeit less complex. We first secured data from the Santa Clara County Assessor's Office. Because our interest is in the relationship between parking requirements and firms, as a first step we restrict our analysis to the seven largest Valley cities, which hold the vast majority of the region's jobs and economic activity. These cities are San Jose, Sunnyvale, Santa Clara (city), Mountain View, Milpitas, Palo Alto, and Cupertino. We then, within those seven cities, drop any residential parcels with fewer than five units of housing. We do so because the vast majority of these smaller-scale housing parcels are detached single-family homes, and located in areas where zoning only allows detached single family homes. While these homes do provide plentiful parking, the binding constraint to development in these areas is not the parking requirement but the R1 restriction—the blanket prohibition of any other type of structure. Changing parking requirements on these parcels would not change the development density of these parcels, nor the number or distribution of firms or workers. We also drop parcels reserved for transportation, agriculture, open space, cemeteries and mortuaries, recreation and golf, open space, and landfills.

These adjustments leave us with a sample of 19,209 parcels, which represents all commercial, industrial and multifamily residential land in the county's seven largest localities. Our next step is estimating parking provision. Here we encounter a problem: the assessor dataset appears unreliable in many respects, parking among them. The dataset has missing values in many

fields, and many of the values that are present are inconsistent with each other. For example, the rentable square footage (a portion of a building) is sometimes larger than the total square footage (the entire building). Similarly, buildings listed as having rentable area are sometimes also listed as having zero floors, which seems impossible.

The most immediate problem, however, is that the assessor's parking data were unreliable. The dataset included some fields with parking counts, but these fields were mostly empty, and when we used aerial imagery to visually check some of the fields we found the parking counts that were there inaccurate. Rather than rely on those data, our method instead was the following: for each parcel, we estimated the building footprint (by dividing total building area by number of stories) and then subtracted that estimated footprint from the parcel area. This leaves us with the parcel's non-building area.

We assumed, probably conservatively, that 70 percent of the non-building area was parking spaces or areas otherwise devoted to parking (e.g. driveways, ramps), while the remainder was landscaping, green space or other non-building uses. Having estimated that, we can also calculate the share of each parcel devoted to parking, and then derived an estimated count of parking spaces. We assumed, following convention, that an off-street parking space required 300 square feet, once driveways and lanes between rows of spaces are accounted for (Shoup, 2005).

Our method was imperfect. The estimates was biased if a parcel was very heavily or lightly landscaped (e.g., if 5 or 50 percent of non-building area is green space, rather than 30 percent); if a building was heavily stepped back with each additional floor, which would confound our estimate of the building's footprint; if the parking was structured, underground or otherwise covered; if the parcel was largely vacant; or if the parcel was heavily-car oriented–for instance, a service station or carwash--and thus had many paved areas not strictly for parking.

What evidence we have suggested that these potential biases should not represent large threats. The 70 percent estimate is, again, probably conservative--many parcels have little landscaping--and biases our parking counts downward. Figure 2 shows two aerial views of City of San Jose—one looking at an industrial area and one at a commercial/office area. Both suggest that most parcels have little landscaping. Parcels like carwashes will also bias our counts downward. Building step-backs are most common on taller structures, and most buildings in Santa Clara County are not very tall. Eighteen percent of our parcels have no buildings at all, 50 percent are one-story, another 26 percent have two stories, 3.5 percent have three stories, and only 2.5 percent have four stories or more. For the most part, then, our estimates of building footprints should be more or less accurate.

Figure 2: Industrial and Commercial San Jose

Source: Google Maps

Structured parking is a potentially larger confound. Fortunately (for us) much of Silicon Valley's parking appears to be surface. Structured parking is more common with multistory buildings, and over 90 percent of our buildings are two stories or less. Some newer buildings, particularly large office campuses and universities including Stanford, do have structured parking, and we will likely undercount parking on these parcels. We may have also undercounted the parking associated with multifamily housing. Multifamily housing in California often has covered parking, under awnings or in rows of attached garages. These spaces may be counted as part of the building area, therefore, biasing our parking estimates downward.

Most of our likely biases, in summary, will generate parking undercounts, and make our estimates conservative, especially for newer buildings. We still face the problem of missing and

inconsistent data in some fields, but we address this problem by carrying out a second analysis that focuses primarily on office parcels, which have the least missing or inconsistent data. Of the 19,209 parcels we have, 3,648 are office parcels.

We validated our estimates by visually inspecting two subsets of our data: a random sample of 80 parcels, and a sample of outliers: the 113 parcels that by our method had the highest parking estimates: over 2,000 parking spaces. Visually inspecting the randomly-selected 80 parcels using Google Maps aerial imagery generated estimates that were on average within 3 percent of our estimate. Examining the 113 outliers, in contrast, suggested that about half were erroneous: while some actually had large amounts of parking, others included little to none, for a variety of reasons. These reasons included parcels used for manufacturing that had substantial paved area but little parking (for instance, large areas for equipment storage); parts of university campuses with large open spaces; and parcels listed as “vacant urban”, which often lacked buildings, and for which we knew nothing else about the actual use. Fortunately, only about 5 percent of these outlier parcels were office uses; most were industrial or vacant urban. We manually updated the parking estimates for these 113 parcels based on our visual inspection of aerial imagery.

Having estimated the parking inventory, we turn to the question of whether the zoning created the parking. As we discussed above, parking requirements may not bind. It is possible that firms and developers build parking with little consideration of the zoning. Most evidence, however, suggests otherwise. Gabbe (2018), Gabbe, Pierce, and Clowers (2020), McDonnell et al (2012), Manville (2013), Cutter and Franco (2012), Gou and Ren and Li and Guo (2014, 2017) all found evidence that developers, especially in urban environments, build to standards or very close to it.[4]

In general, parking counts of up to 120 percent of the requirement suggest a requirement that binds. Using 120 percent as the upper bound, rather than 100 percent, accounts for idiosyncrasies that can arise when actually providing parking on a site. In some instances, after meeting a requirement a developer is left with a piece of land (or building) that cannot be used for anything else, and so ends up providing extra parking. For example: suppose the developer of a 12-unit building needs 18 parking spaces to satisfy a 1.5 space per unit parking requirement. The developer provides the parking on the building’s first floor, which actually has room for 20 parking spaces. Once the developer has decided to use the first floor for parking (a decision forced by the requirement), it makes little sense not to maximize the amount of parking they can build, even if it means exceeding the requirement.

[4] As an anecdote, consider the Apple headquarters in Cupertino. The firm’s campus has 11,000 parking spaces for 14,000 employees, and devotes more space to parking than to offices (Economist, 2017). These spaces were largely the product of zoning: Apple’s original plan for the headquarters called for 1,200 parking spaces, but the city required far more (Chilton and Breeme, 2017).

We consider any parking below the requirement to be evidence of a requirement that binds. This decision might seem odd, but parking requirements are generally enforced, so parcels with less parking than the zoning would require are usually evidence of a developer making an intentional effort to avoid it. This might involve securing a variance or other permission, or—in the case of City of San Jose—building a Planned Unit Development (PUD) to get lower parking requirements. In these circumstances, the developer deviates from the requirement, but the requirement still binds, in that it is an anchor determining the developer's actions. Indeed, the presence of exemptions and other escape valves for developers suggests a tacit acknowledgment by planners that parking requirements often exceed market demand. So too do incentive programs that let developers build less parking if they supply affordable housing. Whatever the merits of these programs, they suggest that the parking requirement is not just burdensome but also based on how much parking the building needs to be economically viable (Manville and Osman, 2017).

We measure bindingness by first inventorying the parking requirements themselves. For each of the seven cities in our sample, we track the evolution of parking requirements, as best we can, for as many land uses as possible. Cities do not keep reliable records of their older requirements, unfortunately, so some data was missing for some cities for the decades before 1970. We found, however, that the requirements are generally consistent both across cities and across time, as shown in figures 3 and 4. For example, the seven cities' 2019 requirements for office uses range from 3.3 to 4.2 spaces per 1,000 square feet, with a median of 3.5. The 1990 range, by comparison, was 3.3 to 4.4 spaces with a median of 4.0. For a 1-bedroom apartment during 1990-2019, the range increased slightly and the median requirement of 1.5 spaces per housing unit is unchanged. The general impression is one of rules that vary little across space, and that are revisited only rarely across time.

Figure 3: Required Pparking per 1000 square feet of Office space, by City (1970-2019)

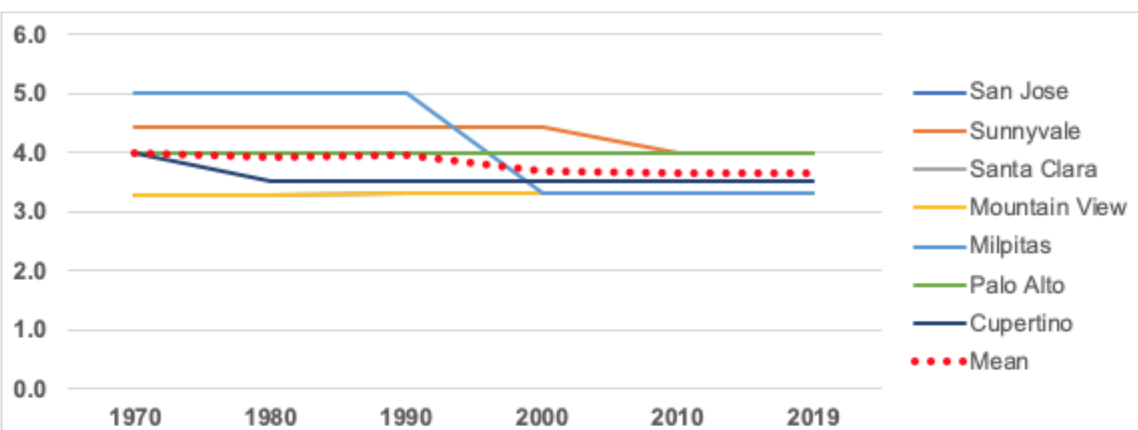
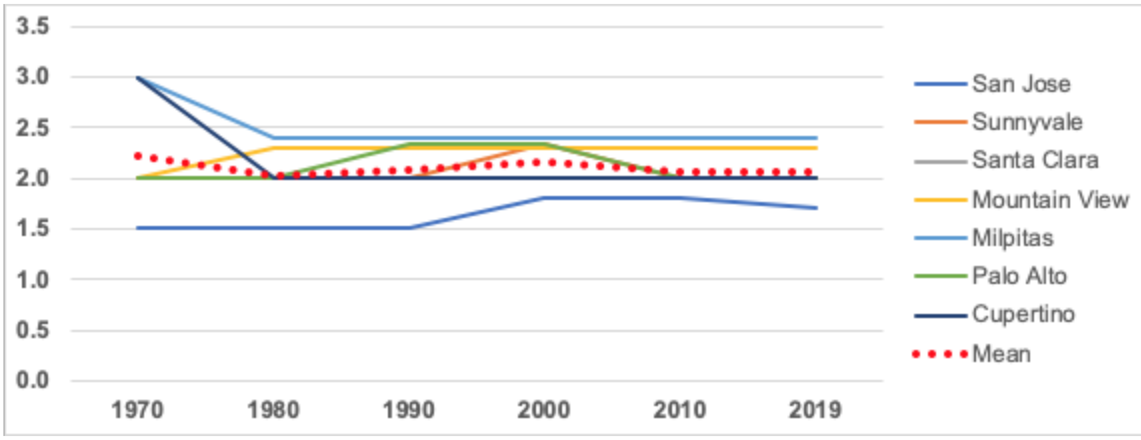


Figure 4: Required Parking per unit for 2-Bedroom Multifamily, including Guest Pparking, by City (1970-2019)



We then match these requirements to each developed parcel, and generate an estimate of each parcel's required parking. For example, a 30,000 square foot office building constructed in 2019 might require 99 parking spaces (3.3 multiplied by 30). We then compare our estimate of required parking on that parcel with our estimate of the actual parking provision there, to determine if the requirement binds.

A missing data problem arises here. The assessor data has no year built for nearly 17 percent of the parcels in our sample. These parcels, moreover, account for about 24 percent of the cities' total parking. The assessor data also provides little further detail about these parcels. Roughly a third are classified as "vacant urban" suggesting they have no buildings. Another 13 percent are churches, and thus fall outside the land uses we are concerned with. We drop both these from our analysis. About 4 percent of parcels with missing dates are classified under an industrial use code that can include parking lots. And 28 percent have land-use codes for retail or office (which can include parking for those uses).

This latter group likely represents a larger problem: some office and retail developments provide parking for their buildings on an adjacent parcel. They use one parcel almost entirely for a building, in other words, and use the next parcel over as a surface parking lot. The parcel with parking, moreover, is assigned a use code related to the adjacent use (office or retail). This means that a strict parcel level analysis could show one office parcel with very little parking, and an adjacent parcel with nothing *but* parking--suggesting that on that parcel the parking requirement does not bind (even if, as is likely the case, the developer acquired the second parcel primarily to meet the parking requirement). Conceivably, we could account for this issue by explicitly linking the parking parcel to the building parcel, but the assessor data have no identifiers making it simple to do so. As a result, we will likely have some parcels where we, inaccurately, consider the parking requirement nonbinding, making our estimates (again) conservative.

As a final step, we aggregate our parcel-level data to the zip-code level, which is the smallest level of geographic detail that lets us see wage, firm, and employment data, as well as data on venture capital (VC) activity, which is a measure of innovation.

With these data assembled, we create a counterfactual scenario that assumes that the seven cities reduced their parking requirements by 50 percent in 2000. We choose the 2000–2019 period to demonstrate the effects of two decades of parking reductions. This time period also roughly parallels the rise in awareness about the high costs of parking requirements and the reduction or elimination of minimum parking requirements (MPRs) in cities such as San Francisco.

The counterfactual proceeds as follows. We assume first that the parking requirements are reduced by 50 percent, and second that any development in our sample with a binding parking requirement (120 percent of the code or less) would build to the new, lower requirements instead. For developments where the requirement did not bind, we assume that lowering the requirement yields no change in parking provision. Based on these assumptions, we calculate a total number of parking spaces not built, then convert that, on a parcel basis, to space saved.

Supplying less parking would allow developers to supply more built area, but for a variety of reasons, ranging from availability of capital to idiosyncrasies of parcels and buildings, not every foregone square foot of parking would turn into a new square foot of a built space. We conservatively assume that half of the saved space in parking could become built area. Note that we also assume, again conservatively, that densities would increase only on parcels that were developed between 2000 and 2017. We ignore the possibility, although it is plausible, that a lower parking requirement might have triggered new development on vacant parcels, or encouraged redevelopment of some parcels developed earlier. This should make our estimates conservative.

We then assume that more built area would let the parcel accommodate more jobs. To estimate how many jobs, we combine our assessor data with data from the Bureau of Labor Statistics and Zip Code Business Patterns database, and divide total built square feet by total employment. This calculation tells us that in our seven cities there is one office employee per 254 square feet of office building space, and one employee per 690 feet of other nonresidential building space (across all built space, the average is one employee per 515 square feet). These estimates are roughly in line with national estimates of commercial space. In 2018, for example, Cushman-Wakefield estimated that office density in most metropolitan areas was slightly below one worker per 300 square feet, but that in more expensive markets was as low as 1 worker per 135 square feet.

Using these ratios, we estimate the additional jobs that would result from built space added as a result of foregone parking. We pay particular attention to increased office jobs both because

office work is arguably the engine of Silicon Valley's agglomeration, and also because--as we have discussed—our office data appear to suffer least from missingness and other ambiguities.

The time period we are considering is relatively short, and also one where relatively little development occurred. The 50 percent parking requirement reduction, moreover, is substantial but not gigantic. As such, we expect the results of this counterfactual to be less dramatic than those of Hsieh and Moretti (2018), who simulated a dramatic 50-year reduction in the overall zoning stringency of the New York, San Francisco, and San Jose metropolitan areas. Hsieh and Moretti assumed that from 1960 forward these regions would have regulatory regimes no stricter than the average US MSA. This is a sizeable change: San Francisco's zoning in 2006, according to the Wharton Land Use Regulatory Index, is 35 times as strict as Chicago's zoning. We are simulating far less dramatic changes, and expect to see less dramatic results.

Results

Across our sample, large shares of land, across almost all land use types, are devoted to parking. The median share of a parcel devoted to parking was about 52 percent, and the median number of parking spaces on a parcel was 26. Table 3 breaks these proportions down by land use. Over 40 percent of the average non-manufacturing industrial parcel, and over half the average retail parcel (52 percent) is devoted to parking. By our estimate the parking share of multifamily parcels is lower—just over a third—but recall that anticipated undercounting parking here, because so much multifamily residential parking is covered, and thus eludes both a building-footprint approach and visual inspection from the air. For offices, the land use category with probably the most reliable data, 52 percent of the average parcel is parking space.

Table 2: Parcels and Parking Land Area by Land use Category

Use Category	Parcels	% of parcels	Median parcel land area (acres)	Parcel land area (acres)	Median % land area as parking
Industrial non-manufacturing	3,687	19%	1.3	9,623	39%
Manufacturing	449	2%	1.1	1,926	39%
Multifamily	4,819	25%	0.3	6,844	41%
Office	4,140	22%	0.2	4,373	42%
Other urban	563	3%	0.5	416	54%
Public/quasi-public	313	2%	1.7	3,679	60%
Retail	5,238	27%	0.4	5,282	44%

If we convert the share of land in parking into an estimated number of spaces, the result suggests that these seven cities have 311,308 multifamily parking spaces attached to housing of five or more units, and just over 1.45 million non-residential off-street spaces. While we did not calculate a parking inventory for residential parcels of four units or less, we can use Census data to estimate this inventory. About 90 percent of these units are in detached and attached single-family homes (specifically, about 73 percent are detached single family homes, and another 16 percent attached single-family). It is not unusual for a single-family home in Santa Clara to have a two-car garage and a driveway. We thus assume, almost certainly conservatively, that each of these homes has off-street parking for three vehicles. This gives three spaces per 368,345 structures with five units or less, or another 1.1 million spaces. Altogether, this exercise suggests that these seven cities have, again conservatively, 2.87 million off-street parking spaces. This works out to about 2.8 spaces per residential vehicle, and two spaces per person. It also suggests that these seven cities have about 31 square miles of off-street parking across just under 249 square miles of land, meaning that about 12.5 percent of their land area is off-street parking. By way of comparison, Chester et al (2016) estimate that L.A. County is 14 percent parking. Their estimate, however, includes all land uses and also includes on-street parking, which they calculate to be 15-20 percent of the county total. Our calculations then, strongly suggest that compared to L.A., a larger proportion of Silicon Valley is off-street parking.

Our estimates also suggest that parking in Santa Clara County is supplied most heavily on parcels developed in the postwar 20th century (although we note again that even after dropping some land use categories, our sample lacks year of development data for 10 percent of parcels, which holds 13.6 percent of the parking). This is summarized in Table 3. Parcels developed before 1940 account for over 7 percent of the parcels in our sample, but less than 2 percent of the parking spaces. For offices, in particular, the relevant proportions are 8.5 percent and 1.7 percent. In the years since 1940, the share of land area in parking on both parcels overall and on office parcels in particular has generally risen, although it has risen less for offices. Most of the region's parking (68 percent) was supplied between 1950 and 2000, largely because most of its buildings (69 percent) were also supplied during this period. Only 15 percent of the seven cities' parking has been built since 2000; these are the parking spaces that are the focus of our counterfactual scenario.

Table 3: Summary of Parcels and Parking Land Area by Decade of Construction

	Parcel count		% of parcels		Parking spaces		% of parking spaces		% land area as parking	
Decade	***All***	***Office***	***All***	***Office***	***All***	***Office***	***All***	***Office***	***All***	***Office***
None	1,913	321	10.0%	8.8%	239,386	29,036	13.6%	10.7%	32%	44%
Pre-1940	1,406	311	7.3%	8.5%	34,079	4,664	1.9%	1.7%	20%	39%
1940	650	133	3.4%	3.6%	16,286	1,785	0.9%	0.7%	38%	40%
1950	2,470	300	12.9%	8.2%	89,278	6,617	5.1%	2.4%	41%	42%
1960	3,794	435	19.8%	11.9%	200,976	18,735	11.4%	6.9%	36%	43%
1970	2,889	502	15.0%	13.8%	347,817	43,950	19.7%	16.2%	37%	42%
1980	2,953	777	15.4%	21.3%	339,654	65,265	19.3%	24.1%	39%	47%
1990	1,124	231	5.9%	6.3%	225,284	35,267	12.8%	13.0%	44%	48%
2000	1,368	492	7.1%	13.5%	162,390	33,331	9.2%	12.3%	44%	44%
2010	642	146	3.3%	4.0%	106,688	32,439	6.1%	12.0%	43%	44%
Total	**19,209**	**3,648**	**100.0%**	**100.0%**	**1,761,838**	**271,089**	**100.0%**	**100.0%**	**38%**	**44%**

Of all the parcels, roughly 62 percent of residential developments and 46 percent of non-residential developments (but 61 percent of office developments) fall into our definition of binding, which is providing less than 120 percent of the requirement. We consider these figures conservative, for reasons we have laid out above.

We use these data to build our counterfactual scenario, which is shown in Table 4. Reducing the parking requirements by 50 percent in these seven cities in the year 2000 would result in 36,726 fewer parking spaces, totaling some 11 million square feet. The average parcel built under lower requirements would devote only 38 percent of its land area to parking, as opposed to the current mean of 44 percent. By our estimate, this new space could be repurposed as over 6,700 additional multifamily housing units, and in nonresidential space that could hold 12,886 additional jobs. Of these jobs, almost 10,400 would be office jobs, since office jobs tend to have much higher densities than other categories. Since these seven cities in actually added 34,636 jobs between 2000 and 2017, office jobs accounted for 92 percent of the net jobs created, this projected increase amounts to a 37 percent greater rate of job growth.

Table 4: Comparison between Actual and Counterfactual

Use category	Parking spaces - Actual	Parking spaces - Counterfactual	Parking change in counterfactual (spaces)	Parking change in counterfactual (sq. ft.)	Additional housing units*	Additional employment**
Industrial and manufacturing	672,137	671,382	(755)	(226,551)	n/a	164
Multifamily	308,372	299,396	(8,976)	(2,692,680)	6,732	n/a
Office	283,640	266,050	(17,590)	(5,276,919)	n/a	10,388
Other urban	28,089	27,576	(513)	(153,804)	n/a	111
Public/quasi-public	120,949	120,949	-	-	n/a	-
Retail	344,556	335,664	(8,892)	(2,667,741)	n/a	2,223
Total	**1,757,743**	**1,721,017**	**(36,726)**	**(11,017,695)**	**6,732**	**12,886**

Two large assumptions that feed our empirics are the size of the change in parking requirements, and the threshold at which we consider a parking requirement binding. Because both measures are arbitrary, we test the robustness of our analysis by running the simulation in three further ways. First, we keep the parking requirement reduction the same at 50 percent, but lower the threshold for bindingness to 100 percent of the original requirement. Second, we reduce the amount of required by only 25 percent, but return the bindingness level to 120 percent of the standard. And third, we run the simulation with a 25 percent reduction in parking requirements and a 100 percent bindingness threshold. These alterations all obviously change the results, and thus reduce the predicted increase in jobs. Across all these scenarios, the new job estimates range between 3,250 and 12,886, with the office job increase ranging between 2,570 and 10,388. These are admittedly large changes in the result. But the robustness checks themselves introduce large changes: we cut the zoning change in half and drop the bindingness threshold by 20 percent. Even with these large changes, however, the low estimate still suggests a job increase that is 43 percent larger than what actually occurred. And remember that all these estimates--including the baseline--are built on consistently conservative assumptions.

Analysis of Office Parcels by Zip Code

We now explore the relationship between density and wages in the San Francisco Bay Area – the broader regional economy within which our 7 cities of analysis are located. (The Bay Area is both the San Francisco and San Jose MSAs). Using employment counts from the Bureau of Labor and Statistics Zip Code Business Patterns, and population counts drawn from the Census Bureau American Community Survey, we estimate a simple model of the wage elasticity of density, similar to those employed by Glaeser and Kahn (2004) and Anderson and Larsson (2016). For each zip code in the Bay Area, we regress the log of wages on the log of job density (the number of jobs in a zip code divided by the zip code’s land area) and the log of population. We employ a fixed effect for the city within which a given zip code is located. We find that, as zip code employment density increases by 10 percent, the wages paid by employers in a zip code increases by 1.3 percent. This relationship is statistically significant with a 99 percent level of confidence. These findings are robust when the City of San Francisco, the densest part of the region, is removed from the analysis. We can use this estimate to calculate the potential impact of parking regulations on the wages paid in our cities of analysis.

Table 5: Wage Elasticity of Density

Log of Job Density	0.133***
Log of Population	-0.102***
Constant	11.284
R-squared	0.751
Number of Observations	305

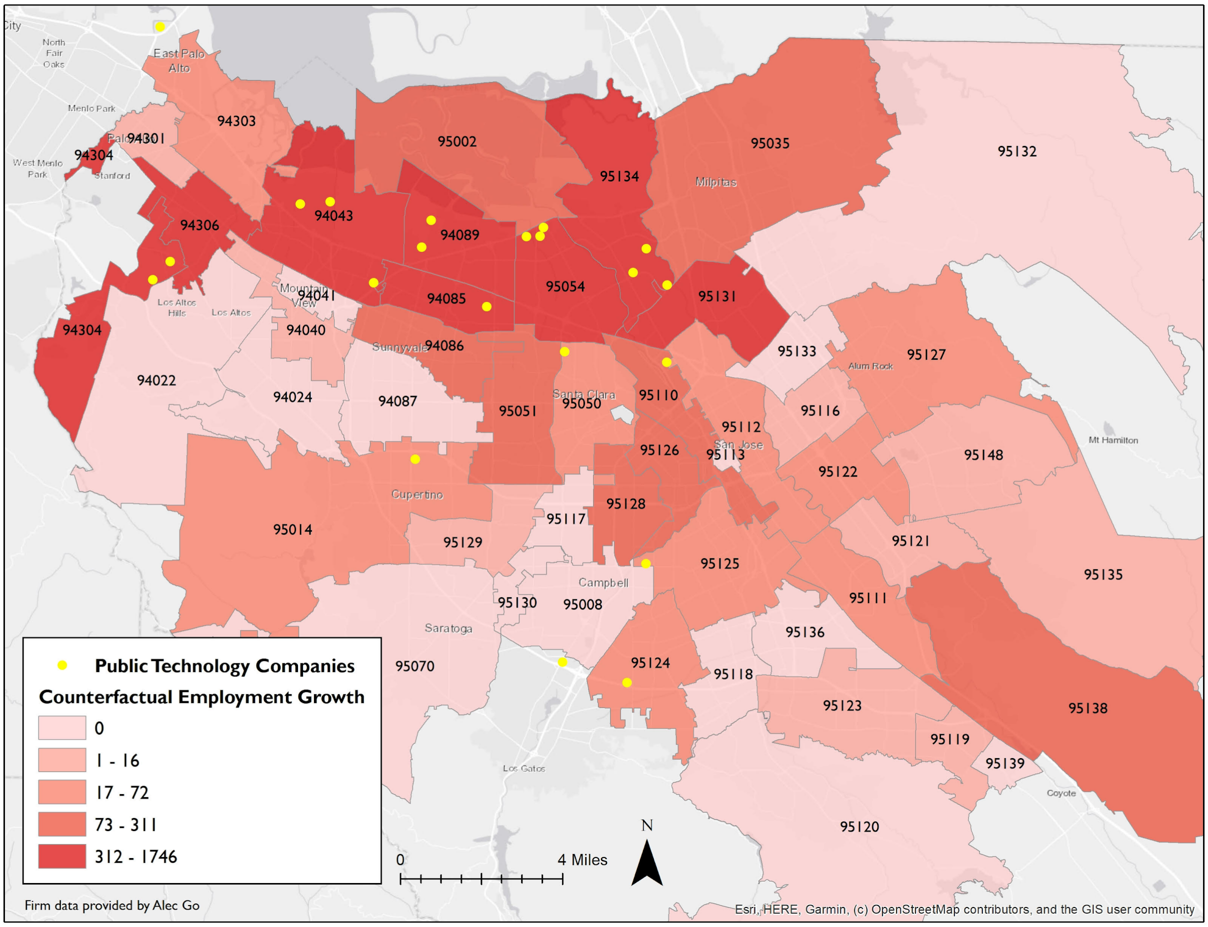
Note: * p<0.1, ** p<0.05, *** p<0.01. Output of city fixed effects are suppressed.

We have 49 zip codes that overlap our seven cities and include office parcels. Summing our parcel-level estimates to the zip code level shows that in our counterfactual scenario, parcels in the counterfactual would have less of their area covered by parking and more covered by building. Parcel parking coverage in the median zip code would drop from 46.3 percent to 44.5 percent. Parking coverage in the bottom quartile of zip codes would decrease from 42.9 percent to 39.9 percent and in the top quartile would decrease from 47.5 percent to 46.6 percent.

The reduction in parking would leave room for additional office space and associated employment. The reduced parking requirements in the counterfactual would increase the number of office jobs in the median zip code by about 16 jobs. While 15 of the zip codes would see no change—these are largely zip codes with few existing jobs and non-binding parking requirements—the top quartile of zip codes would have between 126 and 1,746 additional jobs. About 67 percent (6,997 jobs) of the overall job growth would be in the five zip codes with the most new jobs, and 88 percent (9,173 jobs) of the overall job growth would be in the top ten zip codes. Eighty percent of the new jobs would be office employment.

The zip codes with the most job growth largely straddle the U.S. Route 101 corridor and include offices for global companies including Google, LinkedIn, Cisco, and Intel. Our analysis shows that the zip codes where there would be the most job growth with lower parking requirements are the same zip codes where major Silicon Valley technology companies are currently located (Go, 2019). The zip codes with the most jobs added in the counterfactual include 95134 (North San Jose), 94085 (Sunnyvale), 95054 (mostly Santa Clara), 94089 (Santa Clara), and 94306 (Palo Alto). Visual assessment of these zip codes shows many conventional office parks with sizable parking lots.

Figure 5: Office Employment Change in Counterfactual by Zip Code and Silicon Valley Public Technology Companies



To put some further numbers on this, new office employment by zip code in our counterfactual is strongly correlated with the zip code average wage (r=0.6), and with venture capital investment (0.6). The counterfactual scenario suggests that total employment in these 49 zip codes would rise from 943,592 to 956,478 employees, and that employment density would rise by 1.4 percent. Based on our computed elasticities for the entire Bay Area, this 1.4 percent increase in employment density would be associated with a 0.18 percent or $236 or an increase in average wages in Silicon Valley. Across the county, this would lead to about $220 million in higher wages annually.

Discussion and Conclusion

Our analysis suggests that a substantial share of multifamily and non-residential land in the most economically productive parts of Silicon Valley is consumed by parking spaces and that much of that parking is in surface spaces. A majority of those spaces, furthermore, appear to be

artifacts of binding parking requirements, suggesting that at least some of them are economically superfluous?). This fact, in turn, suggests a large opportunity cost: as a result of government parking mandates, some of the most valuable land on earth is reserved for vehicle storage, rather than employment- or income-generating uses.

Our estimates suggest that had the seven most economically productive cities in Silicon Valley reduced their parking requirements by 50 percent in the year 2000, the region would have added almost 13,000 additional jobs. These jobs, moreover, would have been located overwhelmingly in the highest productivity zip codes of Silicon Valley.

Counterfactual exercises of the sort we do here are always speculative, and always sensitive to the assumptions underlying them. So, our findings are illustrative and not definitive. Nevertheless, at each step of our analysis, we have been conservative. We are conservative in our parking counts, in how we treat missing data or ambiguous parcels, in how we estimate binding requirements, and in how we convert saved space in parking into new built space. There is at least some reason to think our conclusions err on the lower end.

Our research suggests not just the harms of parking requirements, but the persistence of their effects. Santa Clara County cities – like most of their peers across the US – have adopted and maintained relatively similar parking standards for at least five decades. Most of the region's housing and commercial parcels were developed while these requirements were in place. If a policy objective is to reduce off-street parking standards – for reasons of economic productivity, housing affordability, and/or environmental sustainability – it will take decades of reduced standards to significantly move the needle toward a built environment not dominated by off-street parking. Said another way, even if the Silicon Valley cities had halved their requirements in 1999, parking would still be plentiful, and we would only see large reductions in areas where parking requirements have been a binding constraint.

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Data Management Plan

Products of Research
We used parcel-level assessor data, as well as data from the US Bureau of Labor Statistics.

Data Format and Content
Data are in Stata/GIS format

Data Access and Sharing
The project's zip code database can be accessed via Dataverse: https://doi.org/10.7910/DVN/NMWYI1

Reuse and Redistribution
Users will need to get permission from the Santa Clara Assessor's office to access the parcel-level data. The zip code database is available for reuse.