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# Turning Housing into Driving: Parking Requirements and Density in Los Angeles and New York

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**Turning Housing into Driving: Parking Requirements and Density in Los Angeles and New York**

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This article examines the idea that residential minimum parking requirements are associated with lower housing and population densities, and higher vehicle densities (residential vehicles per square mile). Cities frequently use minimum parking requirements to manage traffic, but parking requirements accommodate vehicles, suggesting they should lead to more driving and congestion rather than less. If parking requirements reduce congestion, they likely do so not by reducing the number of vehicles in an area, but by reducing the density of housing and people. We support this idea by comparing the Los Angeles and New York urbanized areas. We show that differences in housing, vehicle and population density across and within these urbanized areas are closely correlated with differences in the share of housing units that include parking, and that the share of housing units that include parking is in turn correlated with the stringency of parking requirements. Compared to Los Angeles, New York shifts less of the cost of driving into its housing market. We further show that within New York City, a ten percent increase in minimum parking requirements is associated with a 5 percent increase in vehicles per square mile, a four percent increase in vehicles per person, and an 6 percent reduction in both population and housing density. These relationships remain even after controlling for street layout and proximity to the subway.

Parking Requirements Regulatory Barriers Density Transportation Land Use

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*"Traffic congestion is caused by vehicles, not by people in themselves."*
-Jane Jacobs

**Introduction**

American local governments often manage traffic by regulating new development (Wachs 1990; Downs 2004), and one of the most common ways they do so is through minimum parking requirements. Residential minimum parking requirements, which are in the zoning codes of virtually every local government in the US, typically force developers to provide a set number of on-site parking spaces with each new housing unit they build. The logic behind these laws is that new residential development creates competition for scarce on-street parking, and that without off-street spaces drivers searching for parking would hopelessly congest the street. Requiring off-street parking with new housing resolves this tragedy of the commons, and alleviates the congestion that new density and development bring.

Yet the idea that parking requirements fight traffic contains a contradiction. Parking requirements create room for vehicles, and vehicles *cause* congestion. Thus a law requiring developers to provide on-site parking indirectly reduces the price of driving, and should lead to more driving rather than less. Parking requirements reduce the price of driving in two ways. First, as the supply of parking rises, its price falls. Because parking is a large part of the total cost of vehicle ownership—cars demand a lot of space when they are parked, and most cars are parked most of the time—a lower price for parking reduce the overall cost of vehicle use.[1] Second, as supply increases and on-site spaces become plentiful, developers and landlords might be more likely to "bundle" them—to include parking with the purchase price of housing, rather than sell it separately. Bundling shifts the cost of parking away from drivers and onto housing consumers. Sometimes the housing consumer and driver are the same person, in which case the zoning makes owning and operating a vehicle appear less expensive, because it hides a cost of

[1] Shoup (2005) summarizes this evidence, and provides an overview of parking requirements.

vehicle ownership (parking) in the price of housing. In other cases the housing consumers aren't drivers, so they simply pay a "parking penalty" on their apartment, or become marginally more likely to purchase vehicles. In either case a driving cost is shifted into the housing market.

If minimum parking requirements encourage vehicle ownership, does this mean they can't reduce congestion? Not necessarily. But they may reduce congestion in ways that do more harm than good. Parking requirements fall on housing developers, so the laws could reduce congestion by making dense housing development more difficult, thereby reducing population density. Lower population density often means less congestion. Congestion occurs when many people simultaneously drive on scarce road space, so cities can fight congestion by reducing the amount of driving per person, reducing the total number of people, or both. Parking requirements could reduce the number of people who enter a neighborhood even as they make vehicle ownership easier for those people who do arrive. So long as the reduction in population density outweighs any increase in vehicle ownership and use, local congestion could decline. So too, however, would any benefits associated with higher population density.

Parking requirements blur an important distinction, in other words, between the density of *people* and the density of *vehicles.* The density of vehicles is a better proxy for congestion than the density of people. Parking requirements treat vehicle density as an inevitable cost of population density, and respond by restricting population in order to accommodate vehicles. But population density has benefits as well as costs, and fighting congestion by restricting population density throws the baby out with the bathwater. Population density can encourage innovation, increase productivity, and minimize environmental harm (Glaeser and Resseger 2010; Glaeser and Kahn 2010). Dense development can also make housing more affordable (Glaeser and Gyourkos 2002). Further, the relationship between more population density and more vehicle density needn't be inevitable: public policy can *separate* the two, and help population density grow while keeping vehicle density, and congestion, in check. This article examines the idea that minimum parking requirements do the opposite—that higher parking requirements are associated with lower population densities and higher vehicle densities—fewer people per square mile, and more residential vehicles per square mile.

We test this idea by comparing America's two largest urbanized areas: New York and Los Angeles. Both areas rank among the country's most congested, but New York is also a transportation outlier. It has the country's lowest ratio of vehicles per person, and by itself accounts for more than a third of American public transportation commutes. Yet most of New York's urbanized area is composed of relatively low-density, automobile-oriented suburbs. New York's low overall levels of auto use are almost entirely attributable to New York City, which has (for the US) an extraordinarily high population density and a relatively low vehicle density. New York City has over twice as many people as Los Angeles City, but only 55 percent more vehicles. We argue that New York City's approach to parking helps explain its ability to accommodate so many people with relatively few vehicles.

New York City's residential parking requirements are much lower than those in Los Angeles City, and much lower than those in the suburbs of either urban area. As a result, parking is scarce in New York City and housing units are less likely to have bundled parking. When housing can be built and sold without parking, housing density and population density become less expensive. Likewise when parking must be purchased separately from housing, vehicle density becomes more expensive. New York City's parking policies have allowed it, to a greater extent than LA, to keep the costs of driving out of its housing market.

New York and LA differ in many ways, of course, and we account for other variables that might explain the differences between them. A preview of our argument is as follows: in the next section we discuss the relationship between population density and vehicle density, and explain why vehicle density is an important but often-overlooked metric in transportation planning. It is residents' fear of vehicle density,, not the ratio of vehicles-per-person, that spurs opposition to new housing and higher density. In Section III we show the disparate population and vehicle densities of New York and LA. Section IV examines and rules out the idea that New York's high population density is the result of poverty and crowding. This section also shows that Angelenos do not own more vehicles than New Yorkers because they have more money. Income is one of the strongest determinants of vehicle ownership, but Angelenos are, on average, poorer than New Yorkers. Angelenos instead face a lower *price* for vehicle ownership, because, as we demonstrate in Section V, the housing they buy is more likely to include a parking space. We provide evidence that this difference is a result of parking requirements.

Section VI shows that higher parking requirements are correlated with more vehicle ownership and use, even in places with less income. We also demonstrate in this section that other components of the price of driving—gasoline, registration and vehicles—do not appear to account for differences in vehicle ownership.

A skeptic might argue that we are merely documenting sprawl. New York City is compact and dense, which makes driving hard and its alternatives easy. Los Angeles is consistently dense but never extraordinarily so, which makes driving both unpleasant and necessary. But this observation only raises the question of *why* densities in these places diverge so much. Parking requirements, which can inhibit housing density and increase vehicle density, help provide an answer.

Suppose we accept, however, that development patterns make Los Angeles and New York hard to compare. In Section VII we use regressions to show that even *within* New York City—and controlling for both street density and proximity to the subway—higher parking requirements are associated with lower housing densities, lower population densities, higher vehicle densities, higher levels of driving, and lower levels of transit use. What is true for Los Angeles and New York is also true for Staten Island and Manhattan.

Our results contribute to the existing research on regulatory barriers to housing, and to the broader literature on transportation and land use. They also have implications for planning practice. For reasons of affordability and sustainability, urban governments regularly call for more housing and less driving: increased population density and reduced vehicle density. Both New York City, in its PlaNYC, and the City of Los Angeles, in its Sustainability Initiative, call for denser housing development, more public transportation, and various efforts to reduce peak hour driving. Parking requirements turn these sustainability efforts on their head. Our analysistherefore speak to the urgency of backing the cost of parking out from the cost of housing. At least where parking is concerned, transportation and land use should be *separated*, not integrated.

## II. Population Density versus Vehicle Density

A well-known finding in the transportation and land use literature is that as population density rises, both vehicle ownership and vehicle use per person fall (i.e., Boarnet and Crane 2001). Yet local residents often protest dense development on grounds that it will increase congestion. The resolution of this seeming paradox is that while vehicle use per person declines with population density, the number of vehicles per square mile tends to rise, and vehicles per square mile are a better proxy for traffic problems than vehicles per capita. Vehicles cause problems in part because they consume space, both when stationary and when moving. Development conflicts often erupt around concerns about congested streets and parking spaces. The Los Angeles urbanized area regularly ranks first in measures of traffic congestion, but has a relatively low ratio (0.55) of vehicles per person. And New York City's very low ratio of vehicles per person (0.23) would not convince anyone who has been there that the city isn't congested. Both places, however, have high levels of vehicles per square mile.

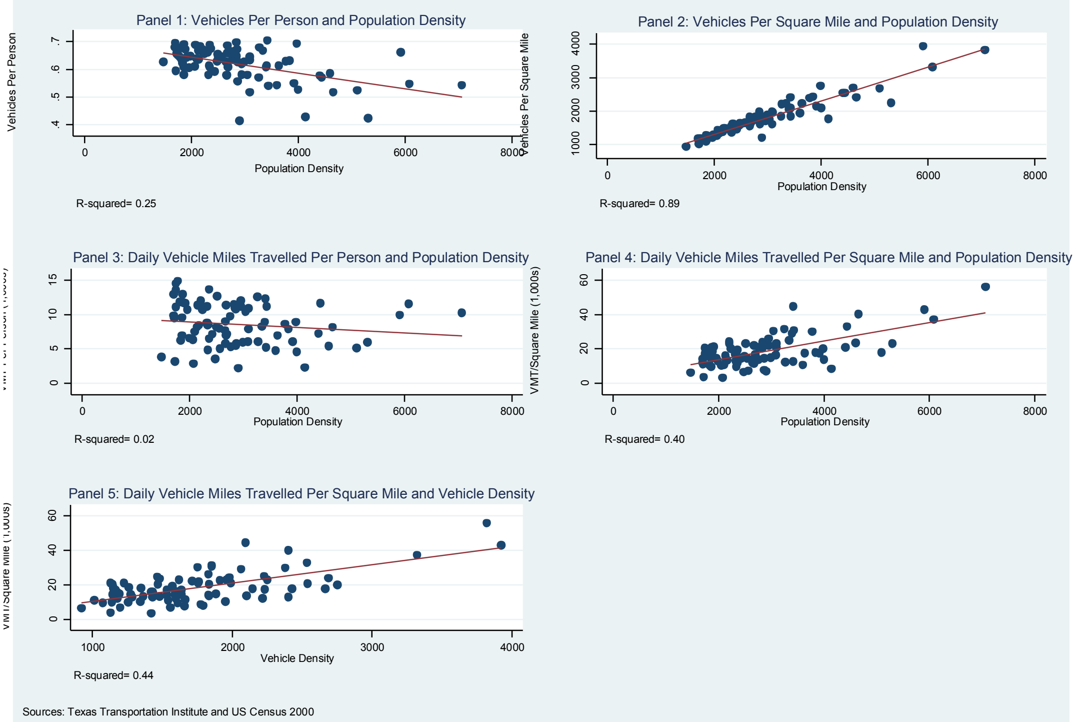
The first four panels in Figure 1 illustrate these relationships for the country's 85 largest urbanized areas in 2000. Panels 1 and 2 contrast the relationship between population density and vehicles per person (a negative but modest correlation), and population density and vehicles per square mile (a positive and much stronger correlation). While a high density of vehicles doesn't automatically mean (although it does imply) a lot of driving, panels 3 and 4 show a similar relationship between density and vehicle miles travelled (VMT). Denser areas have lower levels of VMT per person, but much higher levels of VMT per square mile.[2] VMT per square mile—travel intensity—is a reasonable proxy for congestion; it measures the density of travel in a given area, and correlates strongly (0.65) with the Texas Transportation Institute's well-known index of metropolitan congestion. In sum, higher population density might reduce overall driving, but it also concentrates more of that driving in a smaller area.

These relationships help explain local residents' fear of population density. To residents, a low number of vehicles per person is immaterial if so many people are present that even the small fraction who own cars generate traffic that overwhelms the street. Neighbors who oppose dense development may not be assuaged by the argument that newcomers will own fewer cars on

[2] These relationships hold at the Census tract level as well. Across the 18,080 tracts in the country's 25 largest urbanized areas in 2000, the correlation between population density and vehicles per person is -0.6, while the correlation between density and vehicles per square mile was 0.75.

average. Rather they will be alarmed as the number of vehicles rises while the stock of places to drive and park them remains unchanged.

Figure 1: Density and Vehicle Use, 85 Largest Urbanized Areas, 2000




Yet panel 5 shows (perhaps not surprisingly) that vehicle density predicts travel intensity slightly better than does population density. Because population density has benefits, cities could fight congestion more efficiently by unbundling population density from vehicle density, and pricing them separately. Herein lies the appeal of directly charging for vehicle use. Road pricing and parking charges are efficient ways to fight congestion not only for where they place the costs of driving (on drivers) but also for where they *don't* place it (in the housing market). Direct user fees make rent for vehicles distinct from rent for housing, and can therefore restrict vehicle density without inhibiting population density.

Such direct charges for vehicle ownership and use are rare in the US, however, and more common in Europe (Godansky and Herman 2011) and the dense cities of Asia.[3] Singapore, for example, uses a combination of road pricing, auctioned vehicle permits and high fuel and excise taxes to dramatically constrain its vehicle fleet.[4] The island city-state also has low parking requirements, which it has been steadily reducing. The result is an extremely affluent nation with many people but relatively few automobiles. In 2009 Singapore had 2,068 vehicles per square mile, but 17,276 people per square mile: its vehicle density was only 12 percent of its population density. Gaps of this magnitude between population and vehicle density are unheard of in the United States. Across the 85 largest urbanized areas in the US in 2000, vehicle density averaged 60 percent of population density.

An outlier in the United States is New York's urbanized area, where vehicle density is 27 percent of population density—less than half the US average.[5] What makes New York different? One piece of evidence comes from the relationship between population density, vehicle density and housing unit density. In most of the country these measures move in lockstep. Across the 85 largest US urbanized areas, the coefficient of correlation between population density and housing density is 0.96, while the correlation between housing density and vehicle density is 0.95. Across all the Census tracts in the New York *urbanized area*, these relationships are essentially

[3] Fuel taxes are user charges, but evidence suggests that American fuel taxes are inefficiently low (Parry and Small 2005).
[4] In 2012 the price of a Volkswagen Passat in Singapore (including taxes and fees) was $152,000, just under the median price of a US metropolitan area home (Goodman 2012).
[5] In both Los Angeles and San Francisco, the two urbanized areas with higher population densities than New York, vehicle density is 55 percent of population density.

the same: the correlation between population density and housing density is 0.89, while the correlation between housing density and vehicle density is 0.88. In New York *City,* however, the coefficients differ. The correlation between population density and housing density is 0.9, but the correlation between housing density and vehicle density is 0.6. The strong connection between housing and vehicles that we see in other parts of the US is much weaker in New York City.

**III. Population and Vehicle Density in New York and Los Angeles**

Table 2 compares the population and vehicle densities of the Los Angeles and New York urbanized areas. Despite its longstanding reputation for sprawl, in 2000 the LA urbanized area was the nation's densest, with 7,609 people per square mile, while the New York urbanized area, at 5,309 people per square mile, was third (San Francisco was second). These simple averages, however, don't capture *where* in each urbanized area most people live. Los Angeles is consistently but never extraordinarily dense; the central city is only moderately denser than the suburbs. New York's density, by contrast, is driven by the very high density of New York City. The City of Los Angeles has 20 percent of the LA's urbanized area's land, contains 30 percent of its population, and 33 percent of its housing. New York City, by contrast, sits on 14 percent of its urbanized area's land but accounts for 45 percent of its population and housing. The rest of New York's urbanized area is low-density. As a result, New York City, at over 26,000 people per square mile, has over triple the density of Los Angeles City (almost 8,000 people per square mile). And the densest census tract in New York City (230,000 people per square mile) was more than twice as dense as the densest Census tract in Los Angeles (92,000 people per square mile).

The Los Angeles urbanized area had the nation's highest residential vehicle density, at 3,684 vehicles per square mile. New York, with 1,456 vehicles per square mile, was fifth. Note that differences in vehicle density between these places are substantially smaller than differences in population density, especially in the central cities. New York City has triple the population density of LA City, but its vehicle density, at just over 6,000 vehicles per square mile, is only 55 percent greater than LA City's, at just over 3,900. And the Census tract with the densest concentration of vehicles in New York City is only 10 percent denser than the tract with the most vehicles per square mile in Los Angeles (approximately 50,000 and 45,500 vehicles per square mile, respectively).

Thus the densest parts of each urbanized area have roughly the same number of vehicles, but vastly different numbers of people. What accounts for these differences? Explaining New York City's high population density and relatively low vehicle density requires explaining not just why New York City differs so much from Los Angeles and other large American cities, but also why it differs so much from its own suburbs (or, alternatively, why the City of Los Angeles *doesn't* differ from *its* suburbs).

Table 1: Density of People and Vehicles in Los Angeles and New York

| | Population Density | Vehicle Density |
|---|---|---|
| Los Angeles Urbanized Area | 7,609 | 3,684 |
| New York Urbanized Area | 5,242 | 1,456 |
| Ratio of LA to NY | 1.5 | 2.5 |
| | | |
| Los Angeles City | 7,828 | 3,928 |
| New York City | 26,532 | 6,122 |
| Ratio of LA to NY | 0.3 | 0.6 |
| | | |
| Densest Census Tract, Los Angeles | 92,160 | 45,585 |
| Densest Census Tract, New York | 229,783 | 50,965 |
| Ratio of LA to NY | 0.4 | 0.9 |

Source: US Census 2000. Urbanized areas (UZAs) are the urbanized portions of metropolitan areas.

## IV. Are Density Differences Income Differences?

A high population density implies lots of housing, lots of crowding (more people per housing unit), or both. A high vehicle density implies income to purchase vehicles and parking spaces to store them. Thus one explanation for the disparities between New York and Los Angeles is that people in dense parts of LA are richer than those in the dense parts of New York. If New Yorkers have lower incomes, they will live in more crowded conditions and own fewer vehicles. This will result in New York City having higher population densities, relatively lower vehicle densities, and lower levels of vehicles-per-person.

Table 2 shows housing and income data for the densest Census tracts in the New York and LA urbanized areas, and compares them to the central cities and urbanized areas as a whole. Poverty and population density are strongly correlated, but only in Los Angeles. As population density in LA increases incomes fall, neighborhoods get poorer, fewer people own cars, and housing gets more crowded. In the densest 5 percent of Census tracts in the LA urbanized area, the average poverty rate is almost twice the urbanized area poverty rate, and 1.5 times the central city poverty rate. Similarly, the mean number of persons per room (a rough measure of crowding) in these Census tracts is almost twice that of both the city and the urbanized area (1.3 to 0.7). Mean income per capita is only half that of the urbanized area.

The situation is quite different, however, in New York, where the densest Census tracts are richer and less crowded than their Los Angeles counterparts, and only slightly poorer than the New York area as whole. The densest five percent of Census tracts in New York have three times the population density of the densest five percent in Los Angeles, but a substantially lower average poverty rate (26 percent compared to 36 percent) and less crowding (an average of 0.8 people per room compared to 1.3 people per room). Where LA's denser Census tracts are much poorer than the city as a whole, New York's are, on average, only a few percentage points poorer

(26 percent compared to 21 percent), and have a much higher mean per capita income—suggesting that while some of these tracts are quite poor, others are quite rich.

Perhaps most telling, in the far upper tail of the population density distribution—the ten densest Census tracts in each urbanized area—the average poverty rate in New York is only one percentage point higher than the overall city poverty rate. In the ten densest tracts in Los Angeles, by contrast, the mean share in is more than twice the city share. Across all Census tracts in the Los Angeles urbanized area, the simple correlation between population density and the share of people in poverty is 0.62, while in New York it is 0.48. Mean income per capita in the ten densest Census tracts in New York is over $36,500, well above the urbanized area per capita income of $25,000. In Los Angeles, by contrast, the mean per capita income in the ten densest Census tracts is $9,300, less than half the urbanized area average of $22,150. None of LA's ten densest tracts have a per capita income higher than $11,200; the right tail of the density distribution is uniformly low-income. Yet Angelenos in these ten densest tracts, despite having one-fourth the personal income of their counterparts in New York, have 2.5 times the vehicles per person.

Table 2: Housing and Income Characteristics of Los Angeles and New York, 2000

| | Urbanized Area | | City | | Densest 10 Percent of Census Tracts | | Densest 5 Percent of Census Tracts | | Densest 10 Tracts | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LA | NY | LA | NY | LA | NY | LA | NY | LA | NY |
| Population Density | 7,069 | 5,039 | 7,828 | 26,517 | 34,943 | 106,829 | 43,055 | 130,375 | 80,524 | 199,718 |
| Persons Per Room | 0.7 | 0.5 | 0.7 | 0.6 | 1.2 | 0.7 | 1.3 | 0.8 | 1.4 | 0.8 |
| Persons Per Housing Unit | 3.6 | 2.9 | 2.9 | 2.5 | 3.3 | 2.6 | 3.2 | 2.5 | 2.9 | 2.5 |
| Per Capita Income | $22,150 | $25,091 | $20,671 | $22,402 | $11,602 | $25,092 | $10,357 | $28,085 | $9,229 | $36,560 |
| Percent Poor | 17% | 14% | 22% | 21% | 33% | 26% | 36% | 26% | 46% | 22% |
| Vehicles Per Person | 0.54 | 0.42 | 0.50 | 0.23 | 0.34 | 0.13 | 0.31 | 0.12 | 0.32 | 0.13 |
| Percent of Housing Units in 50+ Unit Structure | 8% | 18% | 11% | 31% | 12% | 41% | 17% | 49% | 25% | 55% |
| N (Census Tracts) | | | | | 244 | 443 | 122 | 221 | 10 | 10 |

Notes: All data from US Census 2000 Summary File 3. Urbanized area and city data are for those areas as wholes. Columns for the densest tracts show the averages across those tracts.

The final rows of the table show that New York has more housing per person than Los Angeles, and denser, taller construction. New Yorkers are more than three times as likely as Angelenos to live in buildings with 50 or more housing units. Thus the data suggest that the source of New York's higher population density is more housing, not more crowded housing, and that LA's higher vehicle ownership is not a result of more personal income.

## V. Parking Requirements as Barriers to Housing and Subsidies to Driving

If Angelenos don't have higher average incomes than New Yorkers, they may nevertheless face a lower *price* for driving. Local governments can subsidize driving by requiring that more space be set aside for automobiles; setting aside space for vehicles can also reduce space for people. Thus if Los Angeles's parking requirements are higher than New York City's, they could simultaneously make vehicle ownership less expensive and housing development—particularly the sort of tall, dense housing development lacking in LA—more expensive. This could, in turn, contribute to LA City's lower population densities and relatively higher vehicle densities.

How plausible is this story? Virtually every study of parking requirements finds they reduce development intensity. Brinkman (1948) studied parking requirements' introduction to Los Angeles, and observed that "in many instances, the number of garage units actually controlled the number of dwelling units which could be accommodated on a lot." Bertha (1964) found that the introduction of minimum parking requirements in Oakland reduced housing unit density by 30 percent. Fulton (1999) observes that parking ordinances are frequently the binding constraint on housing density: "Project size," he writes, "is driven by the parking requirement, not by the allowable density or the setback requirements." When Ithaca, New York, considered abolishing parking requirements, a City Council member warned of unintended consequences, because "the minimum parking requirements in some zoning districts are being used to limit building size and building occupancy."[6] Parking requirements are particularly onerous in dense areas, since building up in housing requires first digging down in subterranean parking, often at well over $40,000 per space (McDonnell et al 2011; Manville and Shoup 2004).[7]

An argument that New York's higher population density and relatively low vehicle density result from its low parking requirements rests on two assumptions. The first assumption is that housing in Los Angeles is more likely to include parking than housing in New York. Parking included in the rent or purchase price of a home is a sign both of abundant parking, and of parking whose cost is borne in the housing market rather than the market for driving. The second assumption is that parking requirements can explain these differences in the supply of bundled parking.

We use the American Housing Survey (AHS) to examine the first assumption. The AHS observes a representative sample of the housing stock in the New York and Los Angeles metropolitan areas every four-to-six years. For each housing unit, the survey records whether a garage, carport or other off-street parking space is included in the purchase or rental price. Only parking spaces included in the housing price are counted; the survey treats housing units where people pay separately to park, either on the same property or nearby, as lacking off-street parking. The AHS data do not, unfortunately, say *how many* spaces are available—only if at least one space is present. Nevertheless, the survey offers information about parking from a representative sample of housing units.

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[6] Seth Murtogh, Ithaca Planning and Economic Development Commission, June 13, 2012.

[7] For example, the City of San Francisco estimates that off-street parking in its downtown costs between $50-60,000 per space (Lee 2012).

A drawback of the AHS is that it defines metropolitan areas differently than the Decennial Census. The Los Angeles Census urbanized area comprises the urbanized portions of both Los Angeles and Orange Counties, while in the AHS each county has its own survey. We therefore combine the 2002 Orange County and 2003 Los Angeles County AHS surveys.[8] Because over 99 percent of the housing units in both counties are in the urbanized portions, the resulting geography is a reasonable replication of the Census urbanized area. The Census urbanized area for New York, however, is more difficult to recreate with AHS data. The New York urbanized area includes portions of New York, northern New Jersey and southern Connecticut. The AHS separately surveys metropolitan New York City and northern New Jersey—and we combine these surveys—but has no coverage of Southern Connecticut. Nevertheless, our combined New York/New Jersey AHS area should be broadly consistent with New York's Census urbanized area, particularly if much of the variance in parking supply is, as we suspect, a result of scarce parking in New York City.

Table 3 shows our results. The AHS confirms that the dramatic differences in density between New York and Los Angeles, and between New York and its suburbs, are mirrored by differences in the provision of residential parking between these places. Sixty-five percent of the housing units in the New York metropolitan area include at least one parking space in the rent or purchase price; in the Los Angeles metropolitan area 94 percent do. The contrast is even larger in the central cities. Only 31 percent of the housing units in New York City have a parking space included in the rent or purchase price, compared to 90 percent of the housing units in Los Angeles City. Housing units in New York's suburbs are almost three times as likely as housing units in New York City to include at least one parking space. Housing units in LA's suburbs, by

[8] 2003 was the last time New York, Northern New Jersey and Los Angeles were surveyed in the same year.

contrast, are only 8 percentage points more likely than housing units in LA City to include a parking space.

Table 3: Residential Parking Provision in Los Angeles and New York, 2002-2003

| | Percent of Occupied Housing Units with at Least one Parking Space | | |
|---|---|---|---|
| | Urbanized Area | Central City | Suburbs |
| Los Angeles | 95 | 90 | 98 |
| New York | 63 | 31 | 86 |

Source: American Housing Survey, Metropolitan Samples, 2002-2003. Data only count parking included in rent or purchase price of unit. Los Angeles urbanized area is a combination of Los Angeles and Anaheim AHS metropolitan surveys. New York urbanized area is a combination of new York and New Jersey metropolitan surveys. Central cities refer to New York City and City of Los Angeles. Suburbs are all areas outside central cities. Table shows occupied units; proportions are essentially unchanged if vacant units are included.

The table suggests that much of the difference between the New York and Los Angeles urbanized areas is driven by New York City.[9] So why are New York City's housing units less likely to include parking? We document four reasons:

1. Compared to LA City, more of the housing stock in New York City predates minimum parking requirements
2. New York City's parking requirements are lower than LA's
3. Parking requirements in New York City are easier for developers to avoid, and

[9] Newark, which we count as a suburb, also contributes to this difference. If Newark is removed, 91 percent of the housing New York's suburbs have bundled parking.

4. In some areas New York City has maximum parking limits rather than high minimum parking requirements.

**Building Age and Parking Requirements**

Los Angeles has newer buildings and older parking requirements. In New York, by contrast, buildings are older and parking requirements newer. The City of Los Angeles introduced residential minimum parking requirements in 1935, and in 2000 only 17 percent of the city's housing stock was built before 1940. Even in the city's densest tracts, fewer than 20 percent of the housing units, on average, predate 1940. Moreover, since LA was an early adopter of the automobile and its infrastructure (Bottles 1991) an unknown but likely significant share of buildings constructed prior to 1935 have at least some parking.

New York is different. For multiunit structures, New York City didn't *allow* parking spaces with residential buildings before 1938, and didn't introduce binding parking requirements until 1961.[10] In 2000, fully one-third of the city's housing stock predated 1940, and in the densest five percent of Census tracts the average share of housing built before 1940 was 40 percent. Over two-thirds of New York City's housing stock predates 1960; in the densest five percent of the city's Census tracts the average share of pre-1960 housing was 70 percent. Thus for a substantial share of housing in New York City, and a large share of housing in the city's densest areas, the city either prohibited or didn't require off-street parking.

**Contemporary Parking Requirements in New York and Los Angeles**

[10] The city introduced some parking requirements in 1950, but the 1961 Zoning resolution is generally considered the advent of parking requirements in New York City (New York City Planning Department 2009).

History alone can't explain the disparities between New York and LA. New housing in the New York urban area is also less likely to include parking than new housing in Los Angeles. The AHS examines, at the metropolitan level, the characteristics of units built in the previous four years. The 2003 survey shows that 78 percent of the housing units built in the New York urbanized between 1999 and 2003 included at least one parking space in the rent or purchase price; in Los Angeles *all* sampled units included a parking space.[11]

These differences, too, appear to be functions of the central cities. The AHS metropolitan surveys do not distinguish between the central city and suburbs when looking at recent construction. However, the 2003 AHS microdata show that 95 percent of the sampled housing units built in New York City between 1999 and 2003 did not include parking with rent or purchase. In Los Angeles City all sampled housing included parking in the rent or purchase price.

Why would new housing in New York City include less parking than new housing in LA City? Parking requirements vary within cities as well as across them, but New York City's parking requirements are uniformly lower than those in Los Angeles City, and also lower than those in New York's suburbs. Table 4 shows parking requirements in New York City and Los Angeles City, as well as in Long Beach, California (the "second city" of the LA urbanized area) and in a sample of cities from two suburban New York counties on Long Island: Nassau and Suffolk. The bottom row of the table shows, from the AHS, the share of housing units in each of these areas that include at least one residential parking space with purchase.

In those areas of New York City with residential minimum parking requirements (some areas have parking maximums, as we discuss below), the multifamily requirements range from

[11] This figure doubtless reflects some sampling error—surely a housing unit without included parking spaces was built *somewhere* in LA—but the difference between the two areas is nevertheless substantial.

0.4 spaces per unit in high-density areas to 1 space per unit in low-density areas. The Los Angeles citywide requirements, by contrast, are higher:  for condos, 2.25 to 2.5 spaces per unit. For apartments, Los Angeles requires 1 space for each unit with less than three "habitable" rooms (including kitchens); 1.5 spaces per unit for 3 habitable rooms; and 2 spaces per unit for over three habitable rooms. Thus one-bedroom apartments with kitchens must have two spaces. In addition, neighborhoods in Los Angeles can require parking over and above the citywide code. The zoning in North Westwood Village, for example, near UCLA, requires 2.5 spaces for any unit with four habitable rooms or less, and 3.5 spaces for any unit with more than four habitable rooms.  The lowest residential parking requirement in LA, which applies to apartments in the downtown and its bordering neighborhoods, is 1 space per unit with less than three habitable rooms, and 1.25 spaces per unit for three or more habitable rooms.

Table 4: Residential Parking Requirements in New York City and Los Angeles City, and Select Suburbs

| City of Los Angeles | | New York City | | City of Long Beach, CA | | Nassau County, NY | | Suffolk County, NY | |
|---|---|---|---|---|---|---|---|---|---|
| Zoning Category | Parking Requirement | Zoning Category | Parking Requirement | Zoning Category | Parking Requirement | Zoning Category | Parking Requirement | Zoning Category | Parking Requirement |
| Single Family Homes | 2 spaces per DU | Low Density Areas | 1-1.5 spaces per unit | Two Bedrooms or More | 2 spaces/DU | Single Family Homes | 2 spaces/DU | Duplex/Single Family | 1-2 spaces/DU |
| Condos | Discretion of planning advisory committee; usually 2 to 2.5 spaces per DU | Mid-DensityAreas | 0.5-0.85 spaces per unit | One Bedroom | 1.5 - 2 spaces/DU | Duplex | 1-2 spaces/DU | Apartments/Condos | 1-2 spaces/DU |
| Apartments | 1 space per unit of less than three habitable rooms; 1.5 spaces per unit of three habitable rooms; 2 spaces per unit of over three habitable rooms | High Density Areas | 0.4-0.5 spaces per unit | Zero Bedrooms | 1 space/DU | Apartments/Condos | 1-2.5 spaces/DU | Senior Citizen Housing | 1.5 spaces/DU |
| Apartments - Central City | 1 space per unit for units of less than three habitable rooms; 1.25 spaces per units for units of 3+ habitable rooms | Manhattan Community Districts 1-12, Long Island City | No Parking Minimums, Parking Maximums | Senior Housing | 0.5-1 space/bedroom | Apartments - Exception or Senior Citizen Areas | 1-1.6 spaces/DU | Nursing Home | 1 space/3 beds |
| Apartments - Westwood | 2.5 spaces per unit for any unit of 4 habitable rooms or less | | | | | Rooming House | 1 space per rentable room | Dormitories | 1 space/2 beds |
| Share Housing with Parking | 92% | | 31% | | 90% | | 92% | | 95% |

Notes: Parking requirements for LA, NY and Long Beach are drawn from each city's municipal codes, and from New York City Department of Planning (2009), "Residential Parking Study." Long Beach parking requirements are found in Section 21.41.216 of city zoning ordinance. Los Angeles parking requirements are in Section 12. 57 of Los Angeles City Code. Parking requirements for Nassau County are drawn from municipal codes of Glen Cove (Sec 9-112); Hemsptead (Ch 31; Sec 319); and North Hempstead (Sec. 70-103).
Parking requirements from Suffolk County are drawn from municipal codes of Babylon (Sec. 213-118); Brookhaven (Sec. 85-350); East Hampton ((sec. 255-11-45); Huntington (Sec. 198-47); Riverhead (Sec. 108-1); Smithtown (Sec. 322-61); Southampton (Sec. 116-14); and Southold (Sec. 280-78). Share of housing units with parking is from American Housing Survey (2003). DU = Dwelling Unit. A number of the jurisdictions in the table also require guest parking, usually at ratios of 1 space per four units.

To illustrate these differences, consider a 20-unit apartment building in the lowest-density area of New York City. This building would require at most 20 parking spaces. In a high density area where parking requirements are present it could require as few as eight.[12] The same building constructed in the *densest* part of Los Angeles, however, would require *at least* 20 parking spaces, and in a lower-density area could require over 50.

Parking requirements help explain not just why population and vehicle densities differ between Los Angeles and New York, but also why LA City's densities are relatively similar to those of its suburbs, while New York's are so dissimilar from its suburbs. Parking requirements in Nassau and Suffolk County look more like those in LA City than New York City, and perhaps unsurprisingly the share of residential units with parking spaces in these places is also similar to LA. Los Angeles is a dense city with suburban parking requirements, perhaps because when it adopted parking requirements it had less than a third of its current population density. New York, by contrast, was only slightly less dense in 1940 (over 20,000 people per square mile) than it was in 2000. LA has retained its suburban-style parking ordinances even as it has grown dramatically more urban.

**Exemption from Parking Requirements**

In addition to being lower, New York City's parking requirements are also easier to avoid than LA's. "Easier to avoid," is not, we emphasize, the same as "easy to avoid." Nevertheless, small sites in New York can obtain waivers that exempt them from providing parking. The precise conditions for waivers vary, but in general the city waives parking requirements if complying with them would result in a low absolute number of spaces. Thus the waiver prevents developers from incurring heavy expense (i.e., excavating a subterranean garage) to build only 4-

[12] This building would also qualify for a waiver from parking requirements, as we discuss below.

5 parking spaces. But waivers are therefore less available for buildings with many units. As a result, developers sometimes subdivide their lots, and build separate buildings, to secure waivers. The New York City Planning Department offers the example of a Bronx developer who wanted to build 24 housing units in a district that had a 0.5 space per unit parking requirement and a parking waiver for any building that would generate fewer than 5 spaces:

> "…[The] developer subdivided a site into three separate zoning lots with three, 8 unit buildings, each of which waived out of the 0.50 spaces per unit parking requirement under the five spaces waiver in R6 zoning districts. As one building, the parking required would be 12 spaces, and no waiver applies." (NYC Planning Department 2009:26).

Developers appear to use waivers frequently. Been et al (2012) examined 1,000 residential developments built between 2000 and 2008, and found that over two-thirds were able to waive out of parking requirements entirely. The waivers offer two lessons. First, the lengths developers will go to avoid building parking are powerful evidence of how onerous minimum parking requirements, even low requirements like New York's, can be. When developers subdivide their properties, they sacrifice economies of scale: instead of one building with one entrance, one elevator and two internal staircases, they build three entrances three elevators six staircases, and so on. They also incur the time and regulatory costs associated with subdivision approval. Yet the total cost of these efforts must be less than the net cost of the required parking, or else developers would forego the waiver.

The second point is that the waiver option, burdensome though it may be, is an *advantage* New York developers have over their LA counterparts. Developers in New York who pursue waivers incur great expense, but if successful they build housing without parking. This escape valve is not available to developers in LA. Los Angeles developers can request variances to reduce their parking requirements, but the variance process is, in the words of the LA City Planning staff, “lengthy, expensive and uncertain” (2011:7). And variances usually allow developers only to reduce required parking, not completely forego it. Constructing an apartment building without parking spaces in Los Angeles is extremely difficult—as the AHS statistics on new construction suggest.

**Parking Maximums**

Some of New York City’s densest areas have parking maximums rather than parking minimums. Since 1982, Manhattan Council Districts 1-8, which in 2000 accounted for 62 percent of Manhattan's land, 72 percent of its housing, and almost 65 percent of its population, have had parking maximums. In addition, Long Island City, in Queens, has had parking maximums since 1998.

Parking maximums, like parking minimums, vary across neighborhoods. For residential development below 60th Street, off-street spaces cannot exceed 20 percent of the number of new dwelling units or 200 spaces, whichever is less. For the rest of the Manhattan core, the ratio is 35 percent or 200 spaces, whichever is less. Thus a 50-unit apartment building that in downtown Los Angeles would require at least 50 on-site parking spaces could in lower Manhattan have at most 10 parking spaces. In the densest neighborhoods Los Angeles requires five times more parking as a minimum than New York allows as a maximum.

How might parking maximums affect population density? A parking maximum could both enable and protect high population density by halting an “arms race” in parking. The vitality created by Manhattan’s extraordinary density is a collective good, and the value of that vitality is capitalized into the price of Manhattan's land. Like all collective goods, however, the vitality is the result of mutual restraint; the high density that creates the vitality exists, in part, because all developers construct housing rather than parking. Constructing parking could siphon resources away from housing and increase vehicle densities to a point where neighbors opposed further increases in population. Yet as parking becomes increasingly rare, individual developers will be tempted to free ride on the vitality their competitors create. If every developer but one refrains from building parking, the vitality is preserved and the lone developer, in possession of the scarce resource that is additional parking spaces, can charge monopoly rents.  But if all developers think this way, then every individual developer, in an effort to profit from Manhattan's density, will actually undermine it. A parking maximum can thwart such free riding, and solve the cooperation problem. A ceiling on parking could enable more floors of housing.

Determining if New York's parking maximums play such a "peacekeeper" role is difficult, however, for two reasons. First, the areas with parking maximums are also the only areas without parking minimums, so separating the presence of a parking ceiling from the absence of a parking floor is hard. If the maximum isn't binding and developers voluntarily construct little parking, then the maximum is unnecessary. At least some evidence, however, suggests maximums are binding. Luxury developers frequently request variances to build additional parking in Manhattan, and planners have denied enough of these requests that in a 2011 the Real Estate Board of New York, a lobbying group for developers, campaigned to have the maximums rolled back (Kazis 2011a; 2011b; 2011c).

A more difficult problem is that any causal relationship between population density and parking maximums could run at least partly in the opposite direction. Parking maximums might enable greater residential density, but city officials may have looked for areas that were already dense, or that had few vehicles, when they implemented parking maximums. Municipal parking ordinances, in other words—maximums or minimums—might respond to local conditions rather than shape them. What we know of the areas with maximums, however, suggests this isn't the case. New York City implemented maximums in 1982 not in response to local demand, but to comply with a clean air mandate from the federal Environmental Protection Agency. Nor does it appear that the areas chosen for parking maximums were inordinately dense to begin with. Table 5 shows, for 1970-2000, characteristics of the 187 Census tracts in Manhattan with parking maximums ("No MPR"), and compares them to Manhattan as a whole. Before the city imposed maximums, these tracts had slightly lower population densities than Manhattan, slightly higher housing densities, and an essentially equal share of households without cars. These tracts also had lower levels of transit commuting and higher average household incomes.

Between 1980 and 2000 housing density—despite starting from a higher base—grew faster in the parking maximum tracts than in Manhattan as a whole (9 percent compared to 6 percent) while population density grew at essentially the same rate. Average household income in both areas more than doubled, but grew more in the tracts with maximums, even though the maximum tracts were richer to begin with. Despite these large increases in income, the share of households without vehicles declined no faster in the maximum tracts than in Manhattan as a whole, and the share of commuters using public transportation grew faster than it did in Manhattan as a whole. Lastly, while the share of households with three or more cars grew across all tracts, it grew more slowly in tracts with parking maximums.[13] Maximums therefore appear *not* to have been placed in areas with lower vehicle use or higher population density, yet

[13] 1970 might be a more appropriate baseline, since the City probably used 1970 Census data when it decided the location of parking maximums. But using 1970 as the baseline doesn't change the results, and if anything reinforces them.

nevertheless appear to be associated with faster growth in housing and population density and transit use. Moreover, the larger growth in personal income in the parking maximum tracts does not appear to have translated into more vehicle ownership.

Table 5: Selected Attributes of Census Tracts in Manhattan and Lower Manhattan Before and After Parking Maximums

| | 1970 | | 1980 | | 1990 | | 2000 | | Pct Change, 1980-200 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All Tracts | No MPR | All Tracts | No MPR | All Tracts | No MPR | All Tracts | No MPR | All Tracts | No MPR |
| Population Density | 66,751 | 61,908 | 61,961 | 61,535 | 64,563 | 64,725 | 66,719 | 66,007 | 8 | 7 |
| Housing Density | 31,004 | 32,102 | 32,744 | 35,605 | 34,077 | 38,699 | 34,642 | 38,903 | 6 | 9 |
| Share Taking Transit to Work | 66% | 61% | 59% | 54% | 57% | 51% | 61% | 58% | 3 | 7 |
| Average Household Income | $47,965 | $56,992 | $38,946 | $47,908 | $65,877 | $85,723 | $80,606 | $106,022 | 107 | 121 |
| Share Households with 0 Cars | 79% | 78% | 80% | 80% | 78% | 77% | 77% | 76% | (4) | (4) |
| Share Households with 3+ Cars | 0.2% | 0.3% | 0.2% | 0.2% | 0.3% | 0.3% | 0.5% | 0.5% | 236 | 229 |

Source: Decennial Census, 1970-2000. Population density is persons per square mile. Housing density is housing units per square mile. Share taking transit to work is the percentage of people over age 16 in the labor force who commute by public transportation. "All tracts" refers to all Census tracts in Manhattan. "No MPR" refers to the 187 Census tracts in Lower Manhattan with parking maximums. Parking Maximums were implemented in 1982.

## VI. Parking Requirements, Income and Vehicle Ownership

Parking maximums also offer a window into the relationship between parking requirements and vehicle ownership. Table 6 shows the mean per capita personal income (PCPI) and the mean ratio of vehicles per $10,000 of aggregate personal income for all Census tracts in the nation’s largest 25 urbanized areas, as well as for Census tracts in New York and Los Angeles. The table also shows the mean share of households without vehicles, and the mean share of commuters driving to work alone. Across all Census tracts in the nation's 25 largest urbanized areas, mean PCPI is just under $25,000, while average vehicles per $10,000 of aggregate personal income is 0.24. The Los Angeles urbanized area is slightly poorer than the 25-urbanized area average, but has a slightly *higher* ratio of vehicles to aggregate income (0.29), and a higher share of commuters driving to work alone as well.

Table 6: Income, Vehicle Ownership and Drive-Alone Commute Share, 2000

| | All Census Tracts, 25 Largest Urbanized Areas | All Census Tracts, Los Angeles Urbanized Area | All Census Tracts, New York Urbanized Area | All Census Tracts, Manhattan | All Manhattan Census Tracts With Parking Maximums |
|---|---|---|---|---|---|
| Mean Per Capita Income | $24,852 | $22,150 | $25,091 | $43,097 | $59,447 |
| Mean Vehicles Per $10,000 of Aggregate Income | 0.24 | 0.29 | 0.17 | 0.04 | 0.03 |
| Mean Share of Occupied Housing Units with Zero Vehicles | 17% | 12% | 30% | 76% | 76% |
| Mean Share of Commuters Driving to Work Alone | 65% | 69% | 47% | 8% | 7% |
| *N* | 18,080 | 2,446 | 4,429 | 296 | 187 |

Source: U.S. Census 2000

The last three columns of Table 6 show statistics for all Census tracts in the New York urbanized area, for all tracts in Manhattan, and for those tracts in Manhattan with parking maximums. The story here is the reverse of Los Angeles: New York is income-rich but car-poor. Across Manhattan's Census tracts, mean PCPI is over $43,000—well above the national average—but the average number of vehicles for each $10,000 of personal income is only 0.04. Similarly, across the 187 Census tracts that have parking maximums, mean PCPI is more than twice that in the Los Angeles urbanized area, but both the mean number of vehicles per $10,000 of income and the mean share of commuters driving to work alone is *one-tenth* that of LA.

One might argue that Manhattan's low vehicle-to-income ratios are a function of the denominator rather than the numerator; a result not of fewer cars but more money. Even wealthy people (usually) want only so many vehicles, so rich places will naturally have lower ratios of vehicles to income. If high income entirely explained Manhattan's low ratios, however, most affluent households would own a vehicle, and many commuters would drive. The third and fourth rows of the table show that we don't see such evidence. The Manhattan drive-alone share is tiny—less than one-eighth that of LA—and three-quarters of Manhattan households have no vehicles at all.[14]

Parking is of course only one piece of the price of driving. As Table 7 shows, however, in many ways driving is more expensive in Los Angeles than New York. The two places have an essentially equal combined state-local gas tax, and from 2000-2010 gasoline was consistently (although modestly) more expensive in LA. California's vehicle taxes and fees are more than five times those in New York State. And data from the 2000 Consumer Expenditure Survey suggest that the average net price of a new or used vehicle (purchase price minus trade-in value) is slightly higher in the Los Angeles metropolitan area ($2,933) than in the New York metropolitan area ($2,776).

[14] An example of a denominator-driven vehicle-to-income ratio is Greenwich, CT, which is in the New York urbanized area. Greenwich has a higher PCPI ($74,000) than lower Manhattan, and triple Manhattan's vehicles per $10,000 of personal income (0.10). Unlike Manhattan, however, Greenwich has a 70 percent drive-alone commute share, and 95 percent of its households have vehicles.

Table 7: Direct and Indirect Costs of Vehicle Ownership and Use, Los Angeles and New York

| | Los Angeles | New York |
|---|---|---|
| Fuel Tax[a] | $0.45 | $0.45 |
| Average Per-Gallon Price of Gasoline, 2000[b] | $1.66 | $1.67 |
| Annual Vehicle Registration Fees[c] | $200 | $51.75 |
| Combined Vehicle Registration Fees and Vehicle Property Taxes[c] | $1,055 | $67 |
| Average Vehicle Purchase Price (Net of Resale Value)[d] | $2,933 | $2,777 |
| Lane Miles of Roads per Sq. Mi. (Urbanized Area)[e] | 7.6 | 3.5 |
| Lane Miles of Roads Per Sq. Mile (Central City)[f] | 55.7 | 40.6 |
| *Share of Occupied Housing Units* [g] | | |
| Near Public Transportation (Urbanized Area) | 88% | 82% |
| Near Public Transportation (Central City) | 90% | 96% |
| Near "Satisfactory" Public Transportation (Urbanized Area) | 19% | 41% |
| Near "Satisfactory" Public Transportation (Central City) | 25% | 70% |
| With Bundled Parking (Urbanized Area) | 95% | 65% |
| With Bundled Parking (Central City) | 90% | 31% |

[a]Includes all state and fuel excise taxes, plus local fuel taxes in largest county (Los Angeles County and Kings County, respectively). Data from Washington Department of Transportation, 2011.

[b]US Energy Information Agency. Average nominal gasoline prices 2000-2011 were $2.56 in Los Angeles and $2.38 in New York.

[c] Idaho Department of Transportation, 2011.

[d] US Consumer Expenditure Survey, 2000-2001. Data include airplane expenditures, but these generally account for less than 1 percent of the category.

[e]US Highway Performance Monitoring System, 2000

[f]New York and Los Angeles City Planning Departments

[g]American Housing Survey, 2002 and 2003. Transit quality is subjective assessment of occupant.

Los Angeles devotes more land to roads than does New York. When it is plentiful, road space—like parking—can make driving easier and reduce its time costs, particularly during non-peak hours. For four reasons, however, we believe the provision of parking explains more of the differences between LA and New York than the provision of streets. First, the disparity in road space is not as large as the disparity in bundled parking. Second, vehicles spend more time parked than moving. Third, residential parking is a *private* cost of vehicle ownership, similar to the price of gas, while the roads are a common resource. Lastly, while a larger share of land in roads could help explain LA's higher vehicle ownership, it would not explain the city's relative absence of dense housing development. A large share of bundled parking, by contrast, could help explain both, as it makes vehicle ownership inexpensive *and* housing development more expensive.

Another large difference between New York and Los Angeles is the supply of public transportation, particularly rail transit. According to the AHS, households in the LA urbanized area are slightly more likely than households in the New York urbanized area to be within a half-block of public transit—reflecting the higher density of LA's suburbs. Within the central cities, however, the situation is reversed: 96 percent of New York City households report being within a half-block of transit, compared to 90 percent of households in Los Angeles City. This difference grows substantially when households are asked about transit quality. Only 25 percent of LA city residents report being near "satisfactory" public transit, compared to 70 percent of New York City residents. Yet even this large difference is smaller than the difference in bundled parking between the two cities. Nor is it clear what households mean by "satisfactory." To the extent travelers prefer rail over bus (because rail can avoid congestion) then New York's superior rail system could explain differences in satisfaction. But if perceptions of transit quality are influenced by the ease of driving, then LA's transit could seem inconvenient because driving in LA is relatively cheap—and driving is relatively cheap in part because parking is abundant.

## VII. Parking Requirements, Vehicle Density, and Population Density: Econometric Evidence

Ideally we could identify the relationship between parking requirements and density through a neighborhood-level regression analysis of the LA and New York urbanized areas. Unfortunately, neighborhood-level data on parking requirements are exceedingly rare, and to our knowledge exist only for New York City. Thus in this section we analyze New York City alone. Although we would prefer to include Los Angeles, restricting the analysis to New York does allow us to address the concern that LA and New York, by virtue of history or geography, simply aren't comparable.

The New York data come from McDonnell et al (2011), who used parcel-level data to calculate the average effective minimum parking requirement for 2,191 of New York City's 2,219 Census tracts in 2007 (the requirement is "effective" because it accounts for parcels' eligibility for waivers). We combine these data with spatial data as well as demographic information from the 2005-2009 American Community Survey (ACS), and estimate regressions that more precisely examine the relationship between minimum parking requirements, vehicle ownership and use, and population and housing density.

Our regressions test three hypotheses:

1. Higher levels of vehicle ownership and use will be associated with higher parking requirements.
2. Lower population and housing densities will be associated with Higher parking requirements.
3. The association between parking requirements and vehicle ownership and use will be similar to the association between personal income and vehicle ownership and use.

In sum, the regressions examine the core ideas of the article thus far: that residential parking requirements reduce the price of vehicle ownership by placing some of parking's costs in the housing market, and that as a result any association between parking requirements and reduced congestion is a consequence not of fewer vehicles, but less housing and population density. Table 9 summarizes the variables we use in our analysis.

Table 8: Summary Statistics for New York City Census Tracts, 2005-2009

| | Mean | Std. Dev. | Min | Max | N |
|---|---|---|---|---|---|
| *Dependent Variables* | | | | | |
| Vehicles Per Square Mile | 10,321 | 5,009 | 78 | 39,946 | 1,939 |
| Vehicles Per Capita | 0.27 | 0.14 | 0.02 | 0.79 | 1,939 |
| Fraction of Households with Zero Vehicles | 0.48 | 0.24 | 0 | 1 | 2,160 |
| Fraction of Households with Three or More Vehicles | 0.04 | 0.06 | 0.00 | 0.73 | 2,160 |
| Fraction of Workers Driving to Work | 0.32 | 0.19 | 0 | 1 | 2,156 |
| Fraction of Workers Commuting by Public Transportation | 0.54 | 0.17 | 0 | 1 | 2,156 |
| Housing Unit Density (Units/Sq. Mi) | 19,967 | 18,429 | 0 | 139,401 | 2,216 |
| *Independent Variables* | | | | | |
| Tract Average Effective Minimum Parking Requirement (Spaces/Unit) | 0.65 | 0.39 | 0 | 1.5 | 2,189 |
| Tract Median Effective Minimum Parking Requirement (Spaces/Unit) | 0.67 | 0.42 | 0 | 1.5 | 2,189 |
| Intersections Per Square Mile | 450 | 327 | 43.4 | 3,811 | 2,216 |
| Percent of Housing Units Built Before 1940 | 43.7 | 23.8 | 0 | 100 | 2,164 |
| Percent of Housing Units Built 1940-1960 | 27.6 | 18.4 | 0 | 100 | 2,164 |
| Population Density (Persons/Sq. Mi.)* | 48,972 | 37,327 | 0 | 217,253 | 2,216 |
| Per Capita Personal Income ($1,000s) | 29.0 | 22.8 | 2.5 | 213.8 | 2,160 |
| Percent of Households with Children | 30.4 | 12.6 | 0 | 100 | 2,160 |
| Percent of People Age 65 or Older | 12.5 | 8.3 | 0 | 100 | 2,167 |
| Percent Black | 26.9 | 31.8 | 0 | 100 | 2,167 |
| Distance from Tract Centroid to Nearest Subway Station (Thousands of Linear Feet) | 4.4 | 7.6 | 0 | 69.9 | 2,217 |

Notes: Minimum parking requirement data is from McDonnell et al (2011). Subway data derived from King (2011). Demographic data from ACS 2005-2009 estimates. Intersection data from NY City Planning Department. Some tracts have zero population and are dropped from the analysis.
*Also used as a dependent variable.

We carry out eight regressions. In every equation the unit of analysis is the Census tract. The dependent variables in Models 1 and 2 are vehicles per square mile and vehicles per person, We examine these variables with Ordinary Least Squares (OLS) regressions. Unfortunately, the ACS 5-year estimates have data on these variables for only 1,937 Census tracts. To make use of the full sample of 2,191 tracts for which we have parking requirement data, in Models 3-6 we analyze four additional metrics for which the ACS has complete data: the share of households that don't own vehicles, the share owning three or more vehicles (a variable that strongly suggests ample parking), and the share of commuters who drive and take transit to work. Because these dependent variables are proportions, we estimate these regressions as Generalized Linear Models with logit links. Lastly, we estimate two final OLS models examining population density and housing density.

In each equation the independent variable of interest is the census tract's average residential minimum parking requirement. The control variables are factors normally associated with vehicle ownership and use: population density, income, the share of people over age 65, the share of households without children, and the share African-American.[15] We also include the share of housing units in buildings constructed before 1940, when most off-street parking was prohibited, and the share constructed from 1940-1960, when parking was permitted but not required. (The share of pre-1940 housing is also a crude proxy for pre-automobile urban form). We control for street design by including each tract's number of intersections per square mile; research suggests that more intersections discourage driving and encourage walking and transit use (Ewing and Cervero 2010). Lastly, we control for transit accessibility by including the distance in linear feet from the center of the Census tract to the nearest subway station.

Table 11 shows our results, which support all our hypotheses. Residential minimum parking requirements are strongly and positively associated with the density, presence and use of residential vehicles, and negatively associated with population and housing density. Vehicle density and vehicles per person, which vary inversely with each other, both vary positively with parking requirements. Further, the association between parking requirements and vehicles is similar in magnitude and direction to the association between income and vehicles, reinforcing the idea that high parking requirements can make driving more affordable. In Model 1, for

[15] African-Americans own fewer vehicles than other groups, possibly as a result of discrimination in vehicle financing (Ayres 2001; Giuliano 2003). Buehler (2011) reviews the determinants of vehicle ownership and use.

example, the fully standardized (beta) coefficient for average minimum parking requirements is 0.45, while the beta coefficient on personal income is quite similar (0.39). This parking coefficient is over 7 times the size of the beta coefficient associated with distance to a subway station (-0.06). Similar large effects are found through the remaining models.

Are parking requirements a good way to manage traffic? Population density is positively associated with vehicle density and negatively—though less powerfully—associated with vehicles per person, suggesting that reduced population density can in fact be associated with reduced congestion, even as they enable people to have more vehicles. And Models 7 and 8 show that parking requirements are associated with reduced density: a 1-unit increase in parking requirements is associated with a 24,000 person-per-square mile reduction in population density and 12,000 unit-per-square mile reduction in housing density. But Models 1 and 2 show that the same increase in parking requirements would be associated with an *increase* of 6,000 vehicles per-square-mile and 0.14 vehicles per-person, holding all other variables constant. An area with high parking requirements might therefore have less congestion. But this effect would only occur because the zoning was associated with fewer *housing units* and *people*, not fewer cars.

Moreover, the relative size of these effects suggests that any reductions in congestion would be minimal. To help clarify our results, the bottom rows of the table show two sets of interpretations. The first are elasticities for each dependent variable with respect to minimum parking requirements, personal income, and distance from a subway station. The values of all other variables are held at their sample means. Thus a 10 percent increase in minimum parking requirements is associated with a 5 percent increase in vehicles per square mile, a 5 percent increase in vehicles per person, and a 6 percent reduction in both population and housing density (assuming the observed rates of increase are constant). Decreases in housing and population are almost perfectly matched by increases in vehicles. The same 10 percent increase in parking requirements would be associated with a 2 percent reduction in the transit commute share. Note that even the transit use variable is more powerfully associated with parking requirements than with proximity to the subway (Model 6).

In sum our results suggests that using parking requirements to reduce density is a roundabout and inefficient way to fight congestion. Yet simply increasing density might also be a poor way to manage traffic, since higher density is associated with fewer vehicles per person but more vehicles per square mile. Lower parking requirements, however, are associated with fewer vehicles per square mile *and* fewer vehicles per person, and might therefore offer more promise in reducing vehicle use.

Table 9: Estimated Effect of Minimum Parking Requirements on Census Tract-Level Vehicle Ownership, Travel Behavior and Population and Housing Density, New York City

| Model | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable | Vehicles Per Square Mile | Vehicles Per Person | Fraction of Households with Zero Vehicles | Fraction of Households with 3+ Vehicles | Commuter Drive Share | Commuter Transit Share | Population Density (Thousands) | Housing Unit Density (Thousands) |
| Tract Average MPR | 6036.2858*** | 0.1367*** | -1.1237*** | 1.3878*** | 1.0120*** | -0.4571*** | -26.4250*** | -13.4322*** |
| | (355.4293) | (0.0080) | (0.0811) | (0.1827) | (0.0811) | (0.0725) | (2.7574) | (1.2654) |
| Population Density (thousands) | 130.8685*** | -0.0010*** | 0.0081*** | -0.0176*** | -0.0061*** | 0.0052*** | | |
| | (2.7541) | (0.0001) | (0.0006) | (0.0021) | (0.0006) | (0.0005) | | |
| Per Capita Income ($1,000s) | 89.7897*** | 0.0015*** | -0.0095*** | 0.0111*** | 0.0008 | -0.0033*** | -0.2672*** | 0.0991*** |
| | (4.5599) | (0.0001) | (0.0010) | (0.0029) | (0.0010) | (0.0007) | (0.0336) | (0.0154) |
| Distance to Nearest Subway Station | -35.4722* | 0.0076*** | -0.0756*** | 0.0271*** | 0.0433*** | -0.0448*** | -1.0592*** | -0.4773*** |
| | (16.6949) | (0.0004) | (0.0047) | (0.0038) | (0.0033) | (0.0034) | (0.1474) | (0.0676) |
| Intersections per Square Mile | -0.1970 | -0.0000 | 0.0001* | -0.0003** | -0.0001** | 0.0001*** | -0.0096*** | -0.0046*** |
| | (0.2518) | (0.0000) | (0.0001) | (0.0001) | (0.0000) | (0.0000) | (0.0020) | (0.0009) |
| Percent Housing Built Before 1940 | -7.7009 | 0.0001 | -0.0034*** | 0.0026 | -0.0004 | 0.0005 | 0.1475*** | 0.0268 |
| | (4.0538) | (0.0001) | (0.0009) | (0.0020) | (0.0009) | (0.0008) | (0.0337) | (0.0154) |
| Percent Housing Built 1940-1960 | 32.8826*** | 0.0010*** | -0.0068*** | 0.0035* | 0.0033** | -0.0011 | 0.2192*** | 0.0969*** |
| | (5.5073) | (0.0001) | (0.0012) | (0.0018) | (0.0010) | (0.0009) | (0.0449) | (0.0206) |
| Percent of Households w/Children | -13.0911 | -0.0003 | -0.0114*** | 0.0043 | 0.0107*** | -0.0082*** | | |
| | (8.0235) | (0.0002) | (0.0020) | (0.0051) | (0.0020) | (0.0019) | | |
| Percent Black | -2.8832 | -0.0003*** | 0.0020*** | 0.0017* | -0.0013** | 0.0048*** | | |
| | (2.4709) | (0.0001) | (0.0005) | (0.0008) | (0.0004) | (0.0004) | | |
| Percent Age 65 or Older | 52.6069*** | 0.0025*** | -0.0057 | -0.0047 | 0.0190*** | -0.0156*** | | |
| | (13.5769) | (0.0003) | (0.0040) | (0.0063) | (0.0032) | (0.0028) | | |
| Constant | -3433.2515*** | 0.1147*** | 1.3912*** | -4.2513*** | -1.7141*** | 0.6370*** | 71.6761*** | 26.1416*** |
| | (602.5160) | (0.0135) | (0.1392) | (0.4271) | (0.1285) | (0.1114) | (3.3539) | (1.5392) |
| Elasticity of DV With Respect To: | | | | | | | | |
| MPR | 0.50 | 0.42 | 0.46 | 0.85 | 0.40 | -0.15 | -0.57 | -0.65 |
| Per Capita Income | 0.35 | 0.47 | 0.14 | 0.31 | 0.02 | -0.04 | -0.20 | 0.40 |
| Subway Distance | 0.38 | 0.17 | 0.24 | 0.11 | 0.09 | -0.12 | -0.23 | -0.20 |
| Predicted Mean of DV At: | | | | | | | | |
| MPR = 0 | 6,191 | 0.17 | 0.63 | 0.01 | 0.19 | 0.61 | 67.8 | 29.4 |
| MPR = 1 | 9,209 | 0.24 | 0.51 | 0.03 | 0.28 | 0.56 | 54.6 | 22.7 |
| MPR = 1.5 | 15,245 | 0.38 | 0.27 | 0.09 | 0.50 | 0.45 | 28.2 | 9.2 |
| *Actual Sample Mean of DV* | 10,317 | 0.27 | 0.48 | 0.04 | 0.32 | 0.54 | 50.4 | 20.6 |
| N | 1,936 | 1,936 | 2,144 | 2,144 | 2,143 | 2,143 | 2,144 | 2,144 |
| Adjusted $R^2$ | 0.62 | 0.77 | n/a | n/a | n/a | n/a | 0.39 | 0.48 |

Notes: Standard errors in parentheses. Results do not change if robust standard or clustered errors are employed. All regressions include county fixed effects. DV= Dependent Variable. MPR = Minimum Parking Requirement. Models 1, 2, 7 and 8 are Ordinary Least Squares. Models 3-6 are generalized linear models with logit links, to account for the dependent variables being proportions. Elasticities report the proportional change in the dependent variable for a proportional change in the listed independent variable, holding other variables constant at their means. The simulation results show the predicted mean of the dependent variable if the average minimum parking requirement were 0, 1 or 1.5, while all other independent variables were held constant at their means. Sources: MPR data from McDonnell et al (2011). Subway data adapted from King (2011). Intersection data from NYC Planning Department. All other data from US Census Bureau, ACS 5-year estimates 2005-2009.

Our second set of interpretations show predicted means for each dependent variable if average tract minimum parking requirements were uniformly 0, 1, or 1.5 spaces per unit, with all other variables held at their sample means. The simulation allows us to draw some comparisons with Los Angeles. A New York City where the average tract parking requirement was uniformly 1.5 spaces per unit (comparable to requirements in LA) would have less than half the tract average housing density, and 44 percent less population density, than the current New York. Census tracts in this high-parking-requirement New York would also average 48 percent more vehicles per square mile, 41 percent more vehicles per person, and a 20 percent lower transit commute share. This New York would, in short, begin to resemble Los Angeles.

These results are robust to a variety of permutations. The coefficients don't change substantially if the median parking requirement is substituted for the average, nor if all models are run with the smallest sample (1,937 observations). Accounting for unobserved changes in zoning by controlling for the share of housing built in every consecutive decade from 1940 to 2010 doesn't alter the results. Neither signs nor statistical significance change if we use robust standard errors, or if we cluster standard errors at the Census tract.[16] If we exclude Staten Island (which has high parking requirements and no subway stations) or Manhattan (which is, well, Manhattan), the coefficients vary but not dramatically, and signs and statistical significance remain unchanged.

The coefficients *do* change if we include each tract's share of owner-occupied housing. In the presence of this variable, the parking requirement coefficient remains statistically significant but falls sharply, usually by 40-50 percent. The owner-occupied variable itself is large and statistically significant, similar in sign and magnitude to the parking requirement coefficient.

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[16] Because we use spatial data, our linear regressions may suffer from spatial autocorrelation due to omitted variables. However, we believe our independent variables capture enough spatial variance to minimize this risk.

Superficially this makes little sense; with income and family membership controlled for, there seems little reason for housing tenure to influence the number of vehicles *and* reduce the influence of zoning.

So what explains this result? Owner-occupied housing in New York City is more likely than renter-occupied housing to have bundled parking. The 2003 AHS shows that 60 percent of owner-occupied housing in New York City has bundled parking, compared to only 19 percent of rental units.[17] Owner-occupied housing might have more bundled parking because it tends to be in areas with higher parking requirements. In the 132 Census tracts where the average parking requirement exceeds 1 space per unit, the mean share of owner-occupied housing is 60 percent. In the 1,768 tracts where average parking requirements were under 1, by contrast, the mean share owner-occupied is 29 percent. Thus the powerful association between tenure and vehicles: in areas where owner-occupancy is common parking is not just more prevalent, but also more likely to be included in the price of housing.

A final concern is endogeneity. If New York based its parking requirements on existing densities, then the implied causality in Models 7 and 8 might be backward—the density influenced the parking requirement and not the other way around. We have neither the space nor the data to rule this out possibility. We note, however, that a parking requirement designed around an area's density can still influence density going forward, by preventing it from changing (particularly in areas where the 1961 zoning ordinance remains dominant). Further, recall from Table 5 that New York did *not* implement parking maximums in areas with higher densities. Yet if we re-estimate our regressions for Manhattan's tracts alone, the parking requirement coefficients remain large and statistically significant.

## V. Conclusion

[17] AHS New York 2003, pages 59 and 109.

When local governments require on-site parking with all new housing, they make room for vehicles in the name of fighting congestion. This approach is unlikely to work. Increasing the supply of parking makes parking less expensive, and encourages developers to bundle parking into the price of housing. This in turn makes owning a vehicle artificially cheap, even as it inflates the development cost and purchase price of housing. Parking requirements hide parking's cost in the housing market, and shift money nominally spent on housing toward vehicles instead. Thus if parking requirements reduce congestion, they do so by making housing development and population density more difficult, not because they are associated with fewer vehicles. To the contrary, we have demonstrated that parking requirements are associated with *more* vehicles—making them a peculiar tool for managing traffic. We have shown this to be the case at two scales: between the LA and New York urbanized areas, and within New York City. Further research can demonstrate if these relationships are present in other places and at other scales, but our analysis suggests that over time, parking requirements can help create (or perpetuate) lower-density, auto-centric development. Public policies should expose rather than hide the costs of automobility; shifting costs of driving into housing only distorts the markets for both. The war against traffic should be waged on the street, not in the housing market.

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