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ABSTRACT

Many cities throughout the United States require developers of new residential construction to provide a minimum number of accompanying off-street parking spaces. Critics argue that these requirements increase housing costs by bundling an oversupply of parking with new housing and by reducing the number of units developers could otherwise fit on a given lot. Furthermore, the requirements reduce the subsequent direct costs of car ownership by forcing up-front, or subsidizing, consumption of parking spaces, which leads to increases in auto-use and related externalities. We use lot-level data and GIS to analyze parking requirements in New York City to determine to what extent they are already effectively sensitive to transit proximity. We also examine developer response to parking requirements by comparing the number of spaces that are actually built to the number required by applicable zoning law. Our results indicate that the per-unit parking requirement is, on average, lower in areas near rail transit stations, but the required number of spaces per square foot of lot area is higher, on average, in transit accessible areas. We also find that by and large, developers tend to build only the minimum of parking required by zoning, suggesting that the minimum parking requirements are binding, as argued by critics, and that developers do not simply build parking out of perceived market need. Our results raise the possibility that there is room to tie the requirements more closely to contextual factors and such changes are likely to result in fewer parking spaces from residential developers.

1. Introduction

A vast majority of cities in the U.S. require that new real estate development include a minimum number of new parking spaces. Rather than leaving parking supply to the developer's discretion, cities use the requirements to ensure that additional parking demand is accommodated by the new development rather than being foisted onto neighboring property owners or absorbed by limited public parking supplies.

Critics argue, however, that parking requirements unnecessarily increase the direct cost of new housing by forcing developers to incur the construction and maintenance costs of providing more parking than otherwise demanded by the market or needed by low and moderate income residents. Required oversupplies of parking, by consuming potential building area, might also reduce the effective density at which developers would otherwise be able to build new housing, possibly restricting the supply of new units and increasing housing costs indirectly. Additionally, if it is requiring the construction of an oversupply of new parking spaces, cities may also be facilitating higher levels of car ownership and thwarting efforts to affect modal shift, reduce traffic congestion and emissions of carbon and other pollutants, thereby undermining environmental goals. Accordingly, if parking requirements are to be retained, many argue, they should be more carefully fit to actual demand and tailored to support, or at least not run counter to, other policy priorities.

In this research, we further the discussion regarding minimum parking requirements through two related empirical investigations. First we analyze the extent to which existing parking requirements may already be sensitive to transit availability by modeling the demands of those in force in New York City. Through Geographical

Information Systems (GIS) and lot-level analysis, we develop two measures of the parking requirements and compare areas near rail transit stations to those further away. Second, we review recent construction projects in Queens and Brooklyn, diverse boroughs of New York City that include both urban and suburban landscapes, to find evidence that parking requirements are in fact driving the production of parking spaces rather than market demand. We conclude with some preliminary policy conclusions and outline further steps that would boost our understanding of the relationship between parking requirements, on the one hand, and housing affordability and transportation behavior, on the other.

2. Literature and Theory

Prescriptive parking requirements are one of several policies U.S. cities adopted in response to increasing congestion associated with the rapid growth of automobile ownership in the first half of the 20th century (1). The simplest minimum parking requirements base the number of required spaces on a new building's use (e.g., apartment building, exercise club, hospital, etc.) and size. For residential buildings, size includes number of units, but also might include the number of bedrooms, or type of housing unit. In many cities, the parking requirements for a given use and size vary from one part of the city to another, reflecting tailoring by planners to address unique neighborhood conditions. Parking requirements often vary across zoning districts (e.g., high density versus low) or cities establish alternative rules to govern special geographic areas, like a central business district or transit accessible areas. In the most complex parking requirement systems, there are also many exceptions, waiver-rights, and further

adjustments reflecting decades of incremental revision. In some cases, cities have eliminated the requirements altogether in particular neighborhoods.

Despite their ubiquity (Weinberger et al (1) characterizes minimum parking requirements as the most prevalent parking policy in the United States) they attract frequent criticism from planners and advocates alike (see:1, 2, 3, 4, 5). Housing and parking costs are bundled, evidence of actual parking patterns is scant (3) and cities contribute to the culture of free parking by under-pricing public parking supplies to appease certain constituents (3, 5). Particularly in areas with older building stock that predates the auto-age, many residents rely on public, on-street parking, and are likely to both oppose increases in public parking rates and to support high minimum parking requirements for new development to prevent any new competition for "their" free or low cost spaces.

Excessive residential parking requirements (putting aside what constitutes "excessive") impose several burdens on homebuyers and tenants. Direct construction costs in the U.S. range from a few thousand dollars per space for surface lots to more than $16,000 per space for above ground parking garages (6). Additional direct costs include acquisition, maintenance and, for larger facilities, staffing. To the extent these costs are being borne for spaces that do not provide commensurate mobility or environmental benefits (through, for instance, decreased congestion from searches for on-street parking spaces), the requirements will unnecessarily increase housing costs or depress housing production.

For these reasons, housing advocates have also been among the fiercest critics of minimum parking requirements, particularly in New York City (7, 8) and California,

areas with relatively high housing costs. Research by Jia and Wachs (9) indicated that single family housing units and condominium units in San Francisco were more than 10 percent more costly if they included off-street parking, controlling other factors. Litman (10) estimates that adding one parking space increases the development cost of an urban unit by 12.5% and a second space by another 12.5%. Other critics (11) suggest that onerous parking requirements are responsible for excluding multi-family rental housing from some jurisdictions. The cost implications of required parking are most acute when the spaces are "bundled" with the units being sold or rented, as is often the case. However, even if accessory parking spaces are leased to tenants or homebuyers, allowing them to choose whether or not to pay for a space, there is no certainty that user fees the market will bear are sufficient to support the entire construction cost.

The indirect costs of excessive parking requirements are more difficult to measure but could also be substantial. In developments at densities insufficient to support structured parking, the surface area consumed by required spaces may be at the expense of additional housing units, or at the very least, green space that would have served as an environmental amenity. More generally, the reduction in the cost of car ownership through oversupplied and underpriced parking may induce additional demand for autos (4, 12, 13) and ultimately for even more parking (13, 14) and higher rates of car ownership (15). Dueker et al (16) point out that that a central connection between parking and transit usage lies in the supply and price of parking; however, that relationship is not well understood (15). Subsidized parking may hinder modal shift to transit or non-motorized forms, further increasing congestion and other externalities such as air pollution (both local and global), noise pollution and energy security which are

created individually but borne collectively by society (17). In contrast, New York City's Department of City Planning concluded in a recent study that minimum parking requirements were not a significant factor in determining household car ownership rates in New York (18).

Given both the direct and indirect costs of building parking spaces, setting the minimum parking requirement is likely more high stakes than municipal planners have realized. If developers, who are presumably reflecting a market demand, choose to build parking in excess of the requirements, the direct and indirect costs are moot and only the social marginal costs are of concern. However, if developers are required to provide more parking than they otherwise would, these costs become increasingly important, especially in the realm of housing affordability. As a result, many researchers have focused on identifying opportunities to relax or even eliminate parking requirements. Cuddy (19) investigates the characteristics of housing units that best predict household vehicle ownership in an effort to develop a "context-sensitive" method for calculating residential parking requirements. Analyzing data from northern New Jersey, he concludes that parking requirements should reflect not just housing type and number of bedrooms (which largely capture demographic attributes), but also locational attributes, including availability of on-street parking, proximity to transit, varied land uses, and access to employers. Other researchers have recommended "adjustment factors" (14), or "transit overlay zones" (1). Willson (20) provides evidence that parking policies often undercut transit-oriented-development efforts and proposes that parking requirements near proposed TOD be tailored to match anticipated transit ridership and car ownership.

Very little of the literature, however, assesses the existing parking requirements of major cities. While it is easy to dismiss the simplest, imitative parking requirements as excessive, the parking management schemes of major U.S. cities with viable alternatives to owner-operated automobile travel offer a more complex challenge. To what extent do parking requirements that are tied to density already function like "transit overlay zones"? In addition, much of the literature asserts that parking requirements are excessive without offering more than anecdotal evidence that private developers would choose to provide fewer spaces. Cuddy (19) cites a 45 year-old study finding that developers in Oakland, California responded to the 1961 imposition of parking requirements with lower density buildings with larger units. There has been little analysis of how developers respond to minimum parking requirements in more recent years. If developers willingly incur the full cost of parking space construction because they believe it is what the market demands, lowering minimum parking requirements will not reduce costs or change transportation patterns. In the next section, we offer evidence from New York City to explore each of these questions.

3. Parking Requirements in New York City

New York City maintains a comprehensive and complex set of minimum parking requirements, despite their possible tension with the City's most recent planning initiatives. The current New York City mayor has articulated a central policy goal of accommodating projected population growth while simultaneously increasing access to affordable housing and improving the City's overall environmental performance. In support of these goals, the City has developed a long term sustainable growth plan,

PlaNYC 2030 (21), is engaged in an active land use and planning program that has rezoned almost a fifth of the City's land area (22), and is spending hundreds of millions of dollars subsidizing the construction or preservation of income-restricted housing.

New York's Zoning Resolution expresses parking requirements for residential buildings as a ratio of parking spaces per new housing unit; for instance, a 50% requirement generally requires one new off-street parking space for every two new housing units. Zoning districts that permit higher density typically have relatively low per-unit parking requirements. Table A, below, outlines the basic requirements for each zoning district in New York.

Table A: Minimum Parking Requirements of Group Provided Parking Facilities

Zoning District (including subdistricts unless otherwise indicated)	**Required Parking Ratio (% of Total Dwelling Units)**
R1, R2, R3, R4, R5A	100
R5	85
R6, R6HF	70
R4/R5 Infill, R5B	66
R7-1	60
R6QH, R6A, R6B, R7-2, R7QH, R7A, R7B, R7X	50
R8, R9, R10	40

New York City's many residential zoning districts reflect the evolving complexity of the Zoning Resolution and do not lend themselves to tidy groupings into building typologies. The various R1 and R2 districts (including those with letter suffixes) permit only detached single family homes. R3 and R4 districts (including those with letter suffixes) and R5A districts permit, depending on the district, attached or detached single and two family homes or small, low rise multi-family homes. Belying New York City's iconic density, these zoning districts, each with a parking requirement of at least 100%, cover just over half of all of the city's lots. New construction in these districts generally

accommodates required parking through small house garages, driveways, or small group surface lots. In higher density zoning districts (R5 and higher, excluding R5A), which permit larger multi-family buildings, parking is more likely to be accommodated with group garages, group parking lots, or, as is often the case, a combination of the two. About 25% of all residentially zoned lots in New York City require a 50% parking ratio or lower (many of the lots in the portions of Manhattan that are excluded from the requirements altogether are commercially zoned, so are not included in this number) (22).

Meeting the parking requirements in New York City is expensive. This is particularly true for higher density development, where surface lots require additional land acquisition or parking is structured. Above ground structured parking in New York City costs more than $21,000 per space to build, without land acquisition or soft costs (6). Below grade parking, common for higher density development in New York, is even more expensive to build, though there are no additional land acquisition costs. Land acquisition is an unusually large expense in New York City. A recent study by Ellen et al. (23) estimated underlying land values using the "teardown sale" value of over 4,000 properties sold in New York between 1996 and 2006. The authors estimated that residentially zoned land values in 2006 ranged from lows of $95 and $132 per square foot in Staten Island and the Bronx, respectively to $132 and $269 in Queens and Brooklyn respectively. In Manhattan, residentially zoned land was estimated at over $1,800. At 300 square feet per parking space, then, even in the parts of the city with relatively low land values, a five space lot requires land worth more than $100,000. In contrast to lower density development and development in other cities, parking spaces for larger projects in New York City are often not bundled with the housing unit but are instead provided to

tenants or owners for a fee. As far as we are aware, no research has examined the fees charged to residents to use accessory parking spaces or whether or not they alone are sufficient to pay for the construction of the spaces.

Reductions and Waivers:

In certain zoning districts, reductions or waivers are offered for small or narrow lots and developments that would result in only a small number of required parking spaces. Certain low density neighborhoods, in contrast, are subject to additional requirements, topping out at two spaces per unit in much of Staten Island and parts of the Bronx. The City adopted these additional requirements in the last decade not only to accommodate high auto ownership in these neighborhoods, but expressly to limit future development to match perceived neighborhood capacity constraints (24). Additionally, minimum requirements are reduced for units in affordable and elderly housing developments (see 25). Despite these reduced minimum parking requirements, practitioners and affordable housing policy analysts advocate for further reductions or elimination of these requirements (1, 7, 8, 11, 26).

Two other studies have recently focused on New York City's parking requirements in an effort to guide local policymaking. Weinberger et al (26), use data from the City's Primary Land Use Tax Lot Output (PLUTO) database to assign parking requirements to the City's residential zoning districts and estimate required off-street parking spaces per acre. The analysis also projects auto ownership and vehicle miles traveled (VMT) for the estimated 265,000 additional dwelling units needed to accommodate one million additional residents by 2030 (21). The authors estimate that the most likely development scenarios (using existing minimum parking requirements)

will produce an additional 1 to 1.55 billion annual VMT and approximately 450,000 annual metric tons of carbon. They conclude that minimum parking requirements are likely to undermine or even reverse the City's goal for carbon reduction. Though the first portion of our analysis roughly mirror's the authors' estimates of required spaces per acre, our analysis produces an estimate of total required spaces produced per lot and we account for certain waivers and transit proximity.

The DCP Study (18) combines vehicle registration data from the New York State Department of Motor Vehicles with new construction data from New York City Department of Buildings Final Certificate of Occupancy filings for 1995 to 2005 to match car ownership to occupants of new housing units in 48 out of the city's 59 Community Districts. The study concludes that car ownership per new housing unit is affected mostly by location (mostly distance from Manhattan) and building type, as well as by income and family structure. The DCP's study ignores much of Manhattan and Staten Island, the City's most and least dense boroughs respectively. Further, while the DCP Study explores the relationship between housing densities and parking requirements, it ignores the potential role of minimum parking requirements as a *de facto* cap on the density of new housing construction independent of other zoning restrictions and the resultant impact on affordability. In contrast to many researchers (26, 27), the study maintains that car ownership is largely exogenous to the local policy process, determined more by socio-economic factors and building type (18, p.51). Critically, it also questions whether government policy should or even can engage in parking demand management (18, p.56). The authors do, however, concede the possibility that the requirements might increase housing costs.

That parking requirements mandate more parking than developers would otherwise choose to provide is assumed by DCP (18), Weinberger et al (26) and the bulk of the existing literature. Though this has intuitive appeal (why else would the requirements be implemented?), DCP's findings that residents of newer building tend to own more cars might also suggest that developers see providing parking as a market necessity. In the second portion of our analysis we use recent Certificates of Occupancy to identify newly constructed residential buildings and for each, we compare the amount of spaces that are required to those that are actually built. If developers respond to parking requirements by building the absolute minimum necessary to comply, we can infer that that requirement is likely effective in producing more spaces than the market alone would. This finding also suggests, however, that more money is being spent building parking spaces by developers and residents than they would otherwise choose, inflating the cost of housing.

The effect on housing prices is mitigated by the unbundling of parking spaces that is common in larger developments (when only one space is provided for every two units, a common minimum parking ratio, the spaces must be allocated). Yet if developers rarely build more than the minimum parking that is required, as we test for, this would suggest that they do not view the provision of parking to their tenants or buyers to be particularly profitable (or at least more profitable than the alternatives). If this is the case, tenants and buyers who do not secure a space may nevertheless be paying some of the cost of parking construction through their rent or purchase price.

4. Data Analysis

How Sensitive to Transit are the Existing Parking Requirements in New York City?

The first stage of our quantitative analysis explores how parking requirements differ across various geographical areas and across different types of lots. Specifically, after estimating parking requirements for each lot (with and without taking into account available waivers for small and narrow lots), we calculate the average parking requirement for the city as a whole, its five boroughs, and areas that are inside and outside a 1/2 mile walk of a rail transit station, which we define as a New York City Transit operated subway station, Metro-North station or Long Island Rail Road station.

For our analysis of each group of lots (e.g., geographic area or type of lots), we calculate two different measures of the average parking requirement, each of which is aimed at capturing different measures of required parking. The first is the average per-unit requirement specified by the Zoning Resolution (which we refer to as average required parking ratio). For groups of lots, we weight this per-unit requirement by the maximum permitted building area for each lot in the group.

The second measure is more complex and is an estimate of the average number of parking spaces that are required per 1000 square feet of mapped parcel land area (i.e., not including public streets and public parks), weighted by the land area of each lot. This measure not only takes account of the per unit requirement of each lot, but the allowable building density as well, to estimate the actual number of parking spaces required per land area. Our specific methodology for calculating these measures is described later in this section.

Our methodology is an extension of one developed for a related project investigating the rate of lot-level underdevelopment and redevelopment in the City between 2003 and 2007 (22). As part of that project, the authors created a database of every parcel of land in New York City (i.e., excluding condominium units and air rights lots) in 2003 and 2007 based upon GIS basemaps from the private data provider LotInfo (for 2003) and PLUTO (for 2007). The authors then joined the database to the 2003 and 2007 versions of the New York City Real Property Assessment Database (RPAD), a proprietary data set maintained by the New York City Department of Finance for property tax assessment purposes that contains detailed information about each unique owned parcel of real property in the City (known as "tax lots"). Included in the data are tax identification number details about each lot's land area, the building area, the zoning district, and several other characteristics about the lot and any building(s) on the lot. The lot database was further augmented with information derived from a GIS analysis performed for each lot in 2003 and 2007, including whether the lot was included in a city-initiated rezoning study area; whether the lot fronted or was within 100 feet of a wide street (with a right of way more than 75 feet wide); whether the lot was in a Special District or Inclusionary Housing Area (areas with specific zoning rules); and the distance from the lot to the nearest rail transit station.

Similar to Been et al (22), we estimate for every 2007 residentially zoned lot in the database the applicable maximum allowable floor area ratio (FAR). A lot's FAR represents the ratio of the gross building square footage built on that lot to the lot's land area. A maximum FAR, set by the Zoning Resolution, effectively caps the amount of building area that can be built on a lot to a multiple of its land area (for example, a 10,000

square foot lot with a maximum FAR equal to 2 cannot be developed with a building larger than 20,000 square feet). In order to estimate a tax lot's maximum FAR, we start with the default maximum FAR specified by the Zoning Resolution for the zoning district in which the tax lot is located (as indicated by RPAD) and then adjust that default maximum FAR based on other lot characteristics that, pursuant to the Zoning Resolution, affect the maximum FAR (generally determined using GIS). The maximum FAR estimates also make several assumptions regarding discretionary and bonus programs in the Zoning Resolution that permit developers to either exceed the base maximum FAR if they include certain amenities (affordable housing, for example), or exclude the square footage of certain building elements (enclosed garages, for example) when calculating FAR. For a full description of the model for determining maximum FAR, including the assumptions it relies on, see Been et al (22). For our analysis, we expand this FAR estimation process to include lots in non-residential zoning categories (e.g., commercial) that permit some level of residential use. For these lots, we perform the estimation process based on the "residential equivalent" category the Zoning Resolution assigns to these other zoning categories.

By multiplying the maximum FAR assigned to each lot by that lot's land area (contained in RPAD), we calculate the maximum amount of residential building area that can be built on it. Although other regulations, including parking requirements, may indirectly limit the amount of building area that can be developed on a lot, for simplicity, we assume that the maximum building area calculated from the maximum FAR is attainable. This assumption effectively ignores the possibility that parking requirements constitute a *de facto* density cap that is lower than the maximum FAR set by the Zoning

Resolution, which is one of the theoretical criticisms of the requirements we discussed above. In further research we hope to investigate whether parking restrictions in fact prevent developers from attaining the maximum FAR.

We calculate our two measures of parking requirements as follows:

Average Required Parking Ratio

For our average required parking ratio measure, we first identify for each lot the required parking ratio that the Zoning Resolution assigns to the zoning category that the lot is in (from RPAD). In doing so, we use the lower parking requirements specified for the "Quality Housing" option available in certain zoning districts (see 22). For lots in Lower Density Growth Management Areas (which we determine using GIS), we apply the higher ratio required by the Zoning Resolution.

To calculate the average required parking ratio for groups of lots (e.g., lots near transit, etc.), we weight each lot by the maximum allowable building area. Our measure, accordingly, is the average required parking ratio (i.e., spaces per residential unit) for a square foot of allowable building area in that geography or group of lots. We use allowable building area for our weight instead of lot area to account for the fact that individual lots have widely variant development potential based on their zoning district.

Average Required Parking Density

For our average required parking density measure, we translate the maximum allowable building area for each lot into a count of required parking spaces, and then further into a rate per land area. To do this, we first use 2007 PLUTO to identify all residential buildings constructed between 1961 (the year the current version of the Zoning Resolution was introduced) and 2007. We then divide these buildings by borough and into three groupings based on their zoning categories, representing high, medium and low density (designated in the Zoning Resolution as residential categories R8-R10, R5-R7 and R1-R4, respectively). For buildings in each borough-zoning group (15 groups in all), we calculate the average gross square feet per unit using unit counts and actual building area in PLUTO.

For each lot, we divide the maximum allowable building area by the average gross square feet per unit for the applicable borough and zoning density group to estimate the maximum number of units that can be built. Next, we multiply this maximum unit count by the applicable required parking ratio to obtain an estimate of required parking spaces for that lot. Finally, we divide the number of spaces by the lot area (from RPAD) to obtain the required number of parking spaces per square feet of land and multiply by 1000. To calculate an average for this measure across groups of lots, we weight each lot's required parking density by its land area.

The Zoning Resolution allows for several full and partial exemptions from the parking requirements in certain zoning districts based on lot conditions or proposed lot uses. Unlike Weinberger et al (26), we estimate the effect of some of these waivers by adjusting our two measures of parking requirements based on the individual characteristics of each lot. We also use our estimate of required parking spaces for each lot (calculated as an interim step in our required parking density estimate) to determine whether a lot is eligible for waivers available to developments that would otherwise require only a small number of spaces (see DCP (18) for a complete list of lot width size and low parking count waivers). Because of data limitations, we do not account for other types of waivers, however, such as those for "infill" housing. Nor do we account for the reductions available to different types of affordable housing discussed above, which are based not on lot characteristics, but on the type of a particular development. However, because the reductions for affordable housing are calculated as a percentage of the applicable requirement for market rate housing, the relative differences in the requirements across different geographies or groups of lots we explore below will generally hold true for affordable housing as well.

In order to investigate how residential parking requirements differ, if at all, when other forms of transportation are nearby we explore the relationship between parking requirements and proximity to rail transit. We use GIS to identify lots that are within half a mile of a rail transit station in the City and then compare the minimum parking requirements for these lots to those outside these "catchment areas." To do this, we select all 2007 lots that are at least partially within ½-mile walking buffers created around

all New York City Transit Subway stations and 45 Commuter Rail stations (Long Island Rail Road and Metro-North).

How Much Parking Do Developers Actually Provide?

The second part of our analysis compares actual parking space counts in recent residential developments to the applicable minimum requirements to test the basic assumption that requirements impose a burden larger than market demands. For this analysis, we focus on recent projects in Queens and Brooklyn, two of New York's five boroughs. Each includes a wide variety of neighborhood and housing types, ranging from relatively dense areas, well served by rail transit, to areas made up of detached single family homes without convenient access to transit, that more closely resemble suburban neighborhoods in major cities across the U.S.

To perform our analysis, we use Certificates of Occupancy data provided by New York City's Department of City Planning (DCP) to identify residential developments in Queens and Brooklyn with at least 20 units that were approved for occupancy (meaning construction was completed) between 2000 and 2008. We exclude developments with fewer than 20 residential units to avoid the availability of automatic waivers for small or narrow lots. Further research will investigate these types of developments. For each of the 394 projects we identified with 20 or more units, we used PLUTO to identify the current zoning designation and the rezoning project descriptions on DCP's website to determine whether any of the lots had been in a different zoning district when the project was developed. For each project we used the rules in the Zoning Resolution, the zoning

district that lot was in when developed, and the number of units from the Certificates of Occupancy data to calculate the minimum number of parking spaces that were required.

To identify the number of parking spaces that were actually built for each project, we use the New York City Department of Buildings' online Building Information System to view a PDF version of each Certificate of Occupancy in our sample. Each Certificate describes the uses of each floor of the building and the parking that the developer is providing. We also use this information to remove observations that contained non-residential uses, such as retail or office space, day care facilities or "community facilities" (a broad category that allows developers to build larger buildings), because these uses have their own parking requirements that are outside the scope of our analysis of residential parking. Finally, we removed observations if the Certificate of Occupancy or documents recorded in the Automated City Register System indicated that the development was for senior residents or was income restricted in order to focus on the parking supplies provided for market rate housing. Of the 394 projects in our initial sample, our data cleaning resulted in a much smaller group of 96 projects that were entirely residential and which appeared to be market rate.

5. Results and Discussion

Required Parking Estimates: All Lots (No Waivers):

As a baseline for our analysis, Rows 1 and 2 of Table B (below) report for New York City as a whole and each borough:

- The average required parking ratio (i.e., the average number of spaces required for each new housing unit, weighted by the maximum allowable building area for each lot); and
- The average required parking density (i.e., the estimated number of spaces per 1000 square feet of lot area, weighted by the land area of each lot).

In both cases, the averages are not adjusted to take into account any of the as-of-right parking waivers described in the previous section. For New York City as a whole, the average required parking ratio for a permitted square foot of development capacity in 2007 was 58%. In other words, for every 100 new housing units constructed in New York City, developers must also build, on average, 58 new off-street parking spaces. Manhattan, much of which has a parking requirement of zero, only requires one new space for every 10 units on average. Staten Island, in contrast, which is dominated by low density zoning districts and is also regulated by lower density growth management areas, requires 134 new parking spaces for every 100 new units on average. In Queens and Brooklyn, the focus of the other component of our analysis, the average parking ratio was about 77 and 69 spaces, respectively, per 100 new units.

The average required parking density results paint a more complicated picture of the City. For New York City as a whole, our estimate of the average required parking density was 0.6 spaces per 1000 square feet of lot area. This means that on average, developing a residential lot to its full zoning capacity (i.e., to its maximum allowable FAR), with average unit sizes, would require the construction of 0.6 parking spaces per 1000 square feet of lot area. Staten Island, which had the highest average required parking ratio, had

the *lowest* average required parking density, at only about one half space per 1000 square feet of lot area. The Bronx had the highest average required parking density at more than 0.8 spaces per 1000 square feet. This somewhat counter-intuitive finding is the result of the interaction between housing unit density (a function of maximum allowable building area and unit size) and required parking ratios. Although zoning districts that allow more unit density have lower required parking ratios, the reduction in required parking ratio from low building density to medium building density zoning categories is not proportional to the increase in allowable units they permit. Consequently, fully built out lots in medium density districts are required, on average, to produce the parking space densities and highest total number of off-street parking spaces.

Required Parking Estimates: Lots by Proximity to Transit (No Waivers):

Rows 3 through 6 of Table B report the results of the same analysis as above, but this time looking separately at lots within a half mile radius of a rail station entrance (rows 3 and 4) compared to lots beyond a half mile from a rail station entrance (rows 5 and 6). In the City as a whole, the average required parking ratio for lots near rail was only about 46%, less than half that of the lots located further away from transit. This large difference is generally the result of the fact that areas with subway access (which outnumber areas served only by LIRR and Metro-North stations) tend to have relatively high density zoning classifications and correspondingly low required parking ratios. On its face, this appears to be consistent with the City's goals of encouraging transit usage, or at least not facilitating car ownership in transit-accessible areas. In other words, even without express "transit overlays," by this measure, the city's minimum parking

requirements are effectively sensitive to transit availability. Looking at the borough level, we see that Manhattan and Staten Island buck this trend. In Staten Island, the average parking ratio is essentially unaffected by transit access, while in Manhattan (which is unique given its large area with a required ratio equal to zero and the fact that over 90% of its residential lots are within half a mile of rail transit), the average required parking ratio for transit-proximate lots is actually higher than that for lots further from transit. In both cases, though, it is still very low.

Once again, however, the results from our estimate of average required parking density are less straightforward. Because of the higher building density permitted for lots near rail stations, at the citywide level, these lots have an average required parking density of almost 0.7 spaces per 1000 square feet of lot area, compared to only 0.5 spaces for lots outside a half mile radius of rail stations. This means that on average, developers fully building out a lot near transit must actually devote more square footage of lot area (or structured parking area) to parking than they would fully building out a lot of equal size located farther from transit. The full build out of the lot near transit would, of course, be a larger building with more units, but the total cost for parking near transit will be higher than further from transit.

Required Parking Estimates: All Lots (With Waivers):

The second half of Table B reports the average required parking ratios and parking densities for the City as a whole and each borough, but this time the results are adjusted to take into account the as-of-right waivers of parking requirements described above, based on 2007 lot dimensions. Comparing top and bottom portions of Table B,

we see that the waivers have a significant impact on our estimates of required parking ratios and densities. For the City as a whole, the average parking ratio falls from almost 60% to under 50%, and the average parking density falls from about 0.6 to 0.5 spaces per 1000 square feet of lot area.

Taking into account the parking requirement waivers also widens the gap in the average required parking ratio between lots near transit and lots further from transit. Specifically, while the average ratio for lots further from transit barely budges (likely because of larger lot sizes in such areas and lower density zoning districts), the average required parking ratio for lots in transit accessible areas drops by 12 percentage points. For the required parking ratio measure, taking into account the waivers effectively erases the gap between lots within and outside a half mile of a transit station by lowering the required density for lots near transit. Incorporating waivers, then, reveals New York's parking requirements potentially to be even more transit-sensitive than was evident from unadjusted average requirements.

Table B: Average Required Parking Ratio and Average Required Parking Density, With and Without Regards to Waivers

			The Bronx	Brooklyn	Manhattan	Queens	Staten Island	New York City
WITHOUT WAIVERS	**ALL LOTS**				***WITHOUT REGARD TO WAIVERS***			
	(1)	Avg. Required Parking Ratio (spaces/unit)	56.6%	68.5%	10.6%	76.9%	134.4%	58.3%
	(2)	Avg. Required Parking Spaces/ 1000 sf lot area	0.84	0.78	0.53	0.52	0.47	0.61
	WITHIN 1/2 MILE OF TRANSIT							
	(3)	Avg. Required Parking Ratio (spaces/unit)	52.1%	64.8%	10.8%	62.9%	136.1%	46.5%
	(4)	Avg. Required Parking Spaces/ 1000 sf lot area	1.01	0.85	0.57	0.50	0.62	0.69
	OUTSIDE 1/2 MILE OF TRANSIT							
	(5)	Avg. Required Parking Ratio (spaces/unit)	77.7%	88.7%	2.4%	98.6%	133.7%	99.5%
	(6)	Avg. Required Parking Spaces/ 1000 sf lot area	0.53	0.59	0.05	0.54	0.42	0.50
APPLYING WAIVERS	**ALL LOTS**							
	(1)	Avg. Required Parking Ratio (spaces/unit)	43.6%	46.6%	5.4%	70.8%	134.4%	47.6%
	(2)	Avg. Required Parking Spaces/ 1000 sf lot area	0.64	0.53	0.27	0.48	0.47	0.49
	WITHIN 1/2 MILE OF TRANSIT							
	(3)	Avg. Required Parking Ratio (spaces/unit)	37.5%	39.7%	5.5%	55.6%	136.0%	33.7%
	(4)	Avg. Required Parking Spaces/ 1000 sf lot area	0.72	0.51	0.29	0.44	0.62	0.50
	OUTSIDE 1/2 MILE OF TRANSIT							
	(5)	Avg. Required Parking Ratio (spaces/unit)	72.7%	84.1%	1.7%	94.3%	133.7%	96.2%
	(6)	Avg. Required Parking Spaces/ 1000 sf lot area	0.49	0.56	0.03	0.51	0.42	0.48

Developer Responses to Minimum Parking Requirements in Queens and Brooklyn, New York:

The 96 residential projects we analyzed were concentrated in 22 of the 32 different community districts (official neighborhoods) in Queens and Brooklyn, likely because of the difficulty of building such large projects in areas zoned for only low density development. The projects ranged in size from 20 units to 208 and the median number of units was 37. For 71 of the projects we estimate that the minimum required parking ratio was 0.5 or lower, again reflecting the relatively high density zoning districts that permitted projects containing 20 or more units.

Table C describes how the number of parking spaces provided in the projects compares to our estimates of the number required by the Zoning Resolution. Of the 96 observations, for 38, about 40%, the developer provided exactly the minimum number. For 18 others, the developer appears to have provided less than what was required, though this may be the result of waivers we did not detect, a variance granted by the city, or a specific housing type, such as senior housing or low income housing, that we were not able to identify when analyzing the projects. Eighteen of the projects (about 19%) provide a small number of excess spaces, representing less than a 25% oversupply individually. With the exception of one particular large project, these small excess space numbers ranged from only one space to four spaces. Finally, 22 projects, less than a quarter of the total, provided more than 25% more parking spaces than our estimate of the minimum requirement. These projects exceeded our estimates of the required minimums by between 7 and 129 spaces. All but three of these 22 projects were located within a half mile of a rail transit station.

Table C: Parking Supply in New Development Compared to Minimum Requirements

	Number of Properties
Built parking exactly equals estimated minimum number of spaces:	38
Built parking is less than estimated minimum number of spaces:	18
Built parking exceeds estimated minimum by less than 25% :	18
Built parking exceeds estimated minimum by more than 25%:	22
Total:	96

6. Conclusion

In the first portion of our analysis we demonstrate that per-unit parking requirements in New York City are lower, on average, in areas near transit than they are in areas farther away. This is true despite the lack of explicit transit-oriented parking provisions. This finding indicates that at least some aspects of context-sensitive or transit-sensitive parking requirements suggested by Cuddy (19) and others are effectively in place already in at least some jurisdictions. In such areas, the risk that requirements are needlessly mandating that parking be constructed for residents who would otherwise have relied on public transit is significantly lessened.

We observed, however, that because of the relationship between density and per-unit parking requirements, the total number of parking spaces that must be built on fully-

developed lots near transit is, on average, higher than on similarly sized lots further away from transit, if we do not assume the availability of waivers applicable to lots with their 2007 dimensions. The implications of this finding are mixed. On the one hand, the fact that increased per-land area construction costs can be spread over more units suggests that this quirk of the requirements does not necessarily result in a relatively high cost burden on renters and homebuyers near transit. Indeed, because per-unit parking requirements are significantly lower near transit, the opposite is likely to be true. However, mandating that the density of parking spaces be high near transit stations threatens to impact those neighborhoods in other negative ways. Specifically, the concentration of parking spaces could lead to diminished air quality and increased traffic congestion if the spaces attract more drivers than would have otherwise been attracted to the neighborhood. Such impacts could hinder the development of these areas to their full densities, frustrating the city's development, transportation and environmental goals. On the other hand, parking availability may have positive externalities, such as reduced search time for on-street parking that, if sustained, could help improve the fate of a transit-accessible neighborhood. In any case, our findings suggest that the focus of advocates and planners in any jurisdiction should be broader than per-unit parking requirements alone. Willson (20) arrives at the same conclusion by emphasizing the importance of parking design and placement in ensuring successful transit oriented development, rather than just on the number of spaces serving a development.

Our second analysis revealed that developers of large buildings usually build parking at or very near the minimum requirements. In Brooklyn and Queens, New York, less than one quarter of large buildings completed since 2000 with market rate units

exceeded the minimum parking requirements by more than 25%. This suggests that, by and large, the requirements are either exactly what the market would have provided independently or, perhaps more likely, that these developers would provide less parking if given the choice. If we believe developers are skilled gauges of market demands, this also implies that the parking requirements are likely higher than what renters and homebuyers would otherwise be willing to consume as well, given the tradeoff with price.

This possible oversupply has implications for both housing affordability and the City's environmental and transportation goals. If developers are providing more parking than they would otherwise, they are incurring extra costs - some of which are likely passed on to residents and potential residents - impacting affordability. If parking were a significant moneymaker for developers when unbundled from the price of housing, we might expect to see developers exceeding the minimum requirement more often than was case. This raises the possibility that parking is never completely unbundled in some areas; that even those who choose to not purchase access to spaces if presented with the choice are being forced to subsidize through rent or purchase price the space consumption by their neighbors, if user fees do not cover the cost of parking space construction. In addition to the direct costs of construction and maintenance, the opportunity cost of the space for parking is the additional residential construction or green space that could have been developed. By limiting supply below what otherwise might have been constructed, housing costs are likely to be higher.

For those interested in eliminating minimum parking requirements, the path is politically difficult for many reasons (5). However, the extension of the automatic waiver

program to a wider range of developments could potentially provide developers of new residential construction with more flexibility in what they can build, again aiding the City's affordability goals. This may be especially justified if those developments are near transit. The impact of targeted waiver programs on aggregate parking provision is evident in our results from our spatial analysis of New York City's requirements. Planners in New York and other cities may also consider formalizing the correlation between relatively lower per-unit requirements and proximity to transit stations that exists today as a result of historic zoning density. Transit overlay zones have already been used by policymakers in places like Montgomery County, Maryland and Milwaukee, Wisconsin (1). These zones supersede the underlying land use, density and parking requirements in areas well served by transit.

Our research is only beginning to explore how developers respond to the minimum parking requirement. Examining large numbers of recent development projects in cities other than New York would broaden our understanding of how binding parking requirements actually are. Taking a closer look at how developers accommodated the requirements, through structures versus surface lots, would allow us to better estimate the costs of compliance. Finally, case study analysis of specific building projects can provide more detailed insight into the exact tradeoffs between building area and required parking spaces that developers may make.

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