Minimum Parking Requirements, Transit Proximity and Development in New York City

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ABSTRACT

New York City policymakers are planning for a city of over 9 million residents by 2030, a large increase from today. A central goal of City officials is to accommodate this increase while simultaneously improving the City's overall environmental performance, addressing externalities arising from traffic congestion and providing increased access to affordable housing. The requirement in the City's zoning code that new residential construction be accompanied by a minimum number of off-street parking spaces, however, may conflict with this goal. Critics argue that parking requirements bundle the cost of unnecessary new parking with new housing, not only increasing the cost of housing, but also reducing the density at which it can be built. Facilitating car ownership by requiring parking may also lead to increases in auto-related externalities. In this research, we combine a theoretical discussion of parking requirements in New York City with a quantitative analysis of how they relate to transit and development opportunity. Using lot-level data and GIS we estimate two measures of the parking requirement for each lot and at a City, borough and neighborhood level. Our results indicate that the per unit parking requirement is, on average, lower in areas near rail transit stations, consistent with the City's development goals. However, we also find that the required number of spaces per square foot of land area is higher, on average, in these areas. This raises interesting questions about the role of parking requirements in determining the use of scarce land resources in transit-rich neighborhoods.

1. Introduction

Among the central policy goals of the current New York City mayoral administration is accommodating rapid projected population growth while simultaneously improving the City's overall environmental performance, addressing externalities arising from traffic congestion and providing increased access to affordable housing. In support of these goals, the City has developed a long term sustainable growth plan, *PlaNYC 2030* (City of New York, 2008), is engaged in an active land use and planning program, and is spending hundreds of millions of dollars subsidizing the construction or preservation of income-restricted housing.

Potentially running counter to these related goals, however, is the longstanding requirement in the City's zoning code that new residential construction in most neighborhoods be accompanied by a minimum number of off-street parking spaces. Such parking requirements, critics argue, could increase the cost of new housing by forcing developers to incur construction costs building more parking than otherwise demanded by the market or needed by low and moderate income tenants. Required oversupplies of parking, by consuming land area, might also reduce the density at which developers would otherwise be able to build new housing, restricting the supply of new units. If requiring the construction of an oversupply of new parking spaces, the City may also be facilitating higher levels of car ownership and thwarting efforts to reduce traffic congestion and emissions of carbon and other pollutants.

In this research, we explore residential off-street parking requirements in contemporary New York City, the most transit-accessible city in the U.S. We begin with a brief description of New York City residential parking requirements, their evolution and a discussion of their possible unintended consequences, including frustrating transportation, environmental policy and housing affordability goals. We present this discussion in the context of prior academic research regarding parking requirements and related topics. Next, by analyzing the New York City zoning code and using Geographical Information Systems (GIS), we describe the geographical implications of the current parking requirements at the City, borough and neighborhood level, and the requirements' relationship to transit accessibility and underdeveloped sites. We conclude by outlining the further steps that would boost our understanding of the relationship between parking requirements, on the one hand, and transportation behavior and housing affordability, on the other. In this way, we add to the growing debate about the role of minimum parking standards and their potential to undermine some of the City's other key policy goals.

2. Background and Past Literature

New York City's zoning code (the "Zoning Resolution") specifies for each zoning category a minimum number of off-street parking spaces developers must provide for each type of use permitted in that district. For residential buildings, the Zoning Resolution expresses the requirement as a ratio of parking spaces per new dwelling 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. In addition, new construction in most of Manhattan (the City's densest borough) requires no off-street parking at all because of air quality concerns going back to the early 1980s (New York Times, 1981). In fact, new off-street parking in this zone is generally prohibited. Lower density districts, in contrast, have higher per-unit parking requirements, topping out at 2 spaces per new unit in parts of Staten Island and, to a lesser extent, some parts of The Bronx. These regulations are designed to accommodate higher auto ownership and limit future development to match perceived neighborhood capacity constraints (DCP, 2006). In certain zoning districts, reductions or waivers are offered for small or narrow lots, developments that would result in only a small number of required parking spaces, and affordable and elderly housing developments (DCP, 2009).

Although New York City was the first large city to implement a zoning code (DCP, 2006), it was not until just before the Second World War, with the advent of growing car ownership, that policymakers began to regulate off-street parking. Because New York City's relatively old housing stock was generally built without accommodation for off-street car storage, increases in car ownership in the City resulted in heightened competition for the limited supply of common pool parking space (e.g. unregulated on-street) during this period (Sterner, 2003; Fogelson, 2003). Even today, the median age of the City's building stock is over 70 years old, dating much of it to a time when car ownership was less than prevalent (Furman Center, 2009). Faced with increased competition for these unregulated public spaces, policymakers could respond in two possible ways: by increasing the public supply of parking spaces (on-street or municipally financed public garages) or by incentivizing private sector parking provision. This latter response could either take the form of regulations and mandates (i.e., requiring private developers of "parking generators" to build new spaces) or leaving parking provision to market forces.

In the middle of the 20th Century, City policymakers did attempt to provide additional public parking capacity through the provision of additional spaces (e.g. constructing municipal parking lots) and more efficient use of existing public spaces (through metering) (Fogelson, 2003). However, these interventions were limited in scope and not directly aimed at increasing the supply of public parking available to residences. In the face of increased pressure from residents to restrict demand to existing supplies of public parking, policymakers began first to facilitate, and then mandate, the provision of private off-street parking for new developments (in 1938 and 1954, respectively) (NYCCPC, 1954; Sterner, 2003; Fogelson, 2003; DCP, 2006). By 1961, with the overhaul of the zoning resolution, the "existence of the automobile" was further acknowledged (Felt, 1961); minimum off-street parking requirements were increased and imposed for all residential, commercial and manufacturing districts. Excepted from the new requirements were congested areas in Lower Manhattan where policymakers feared additional traffic and where the requirements would impose "uneconomic and impractical" restrictions because of higher building densities (Felt, 1961).

The common pool nature of existing parking stocks has militated against leaving the provision of parking solely to market forces. Researchers since Shoup and Pickrell (1978) have argued for the introduction of price signals to regulate demand for on-street parking. However, policymakers generally continue to respond to perceived parking shortages by requiring developers of new parking demand generators (including new housing) to provide associated off-street parking (DCP, 2009; Sterner, 2003; Fogelson, 2003; Shoup, 1999). Existing users of a local pool of on-street parking (typically local residents or businesses) have a vested interest in keeping the price of parking low. These users also exert influence on local policymakers to limit the demand for that pool of parking because of their ability to only exert usership rights over that space; that is, ownership while the space is occupied. As demand increases, the heightened competition can result in one of the most difficult and politically explosive local issues (Epstein, 2002). The political outcome is that elected policymakers tend to enact legislation to require that developers of new parking generators mitigate the potential impact on the existing pool of public parking spaces.

However, this responsiveness to local and short-term concerns about additional demand for existing spaces may have unintended and distorting longer-term consequences in the realm of land use and transportation, consequences that are not well understood (Shoup and Pickrell, 1978; Weinberger et al, 2008). Minimum parking requirements essentially require developers to "bundle" parking costs with residential costs. This bundling can change the incentives for car ownership amongst residents by reducing the costs of car ownership below market rates. In effect, automobile owners may be subsidized by their non-car owning neighbors through the higher dwelling costs associated with the direct construction and maintenance costs of the parking spaces themselves and the opportunity costs of that space (e.g. extra dwelling units forgone). Non-car owning residents may not be able to decide how much "parking space" they want to purchase independently of the residential units. At a practical level, critics have argued that minimum parking requirements would not be needed if they did not increase the off-street parking supply beyond what the market would provide independently (Shoup, 2005). The reduction in the cost of car ownership through underpriced and plentiful parking may also induce additional demand for autos (Downs, 1992; Mukhija and Shoup, 2006). Accordingly, a cycle of increased demand for parking may be created which, in turn, can lead to policymakers requiring the provision of additional parking as a result of perceived local shortages (Mukhija and Shoup, 2006; Litman, 2007).

The result of this bundling has implications for the City's transportation, environmental and housing affordability agendas. *PlaNYC 2030*, the City's sustainability plan, envisions a pattern of growth characterized by high density living in transit-rich neighborhoods intended to lessen the environmental footprint of each new resident and the City as a whole. To combat chronic traffic congestion, the mayoral administration expended significant political capital unsuccessfully championing a road congestion pricing plan for much of Manhattan (City of New York, 2008). Additionally, policymakers have sought to increase access to affordable housing both by spending hundreds of millions of dollars to create or preserving 165,000 affordable units by 2014 (HPD, 2004), enacting a limited inclusionary zoning scheme, and otherwise allowing

higher densities of residential construction in some areas through changes to the zoning code.

If parking requirements do indeed lead to the construction of more parking than otherwise would have been provided by the market, and this oversupply has a corresponding impact on transportation and development patterns, the requirements may interfere with some or all of these policy initiatives or otherwise lead to socially suboptimal outcomes. Increased car ownership as a result of subsidized parking may hinder modal shift to transit or non-motorized forms, a crucial component of the City's transportation and environmental goals. Dueker et al (1998) point out that that a central connection between parking and transit usage lies in the supply and price of parking. If car ownership and, by extension, use is subsidized through parking requirements, the already underpriced nature of private car use will be exacerbated, further increasing congestion and other externalities. These externalities, including traffic congestion and air pollution (both local and global), noise pollution and energy security, are created individually but borne collectively by society (Hensher and Brewer, 2001; Sterner, 2003).

Parking requirements may also impact housing affordability in multiple ways. Firstly, if the mandatory bundling of parking spaces with housing results in the provision of more spaces than would otherwise have been provided, the construction and maintenance costs of this oversupply must be passed onto homebuyers and renters (AIA, 2003; Salama et al, 2005). Research by authors such as Jia and Wachs (1999) indicated that San Franciscan single family housing units and condominium units were more than 10 percent more costly if they included off-street parking. Secondly, the required oversupply of parking carries high opportunity costs where land is scarce or development budgets tight, particularly significant for developers in the affordable housing sector. While there are reduced minimum parking requirements for certain classes of affordable housing, practitioners still advocate for a further reduction or even elimination of the minimums (AIA, 2003; Salama et al, 2005; Lubell, 2009; Weinberger et al, 2008).

More broadly, parking requirements may also create de facto density caps below what otherwise would have been permitted by the applicable zoning requirements. This has implications both for housing affordability and transportation and land use. Requiring lower density, in this case through parking requirements, can restrict the supply and increase the cost of new housing (Glaeser et al, 2005). It is also well understood that higher densities are generally associated with wider selections of accessible mixed use destinations and more sustainable transportation patterns (USEPA, 2006). Density is also correlated with lower car ownership; some research has found that with each doubling of residential density, auto ownership declines by 32-40% (Holtzclaw et al, 2002).

Minimum parking requirements and their impact on transportation and development patterns are receiving an increased focus from policymakers and academics alike. At present, New York City does not have any accurate estimate of the number of parking spaces actually constructed as a result of the requirements (nor, for that matter, does it estimate the number of on-street parking spaces, despite the Climate Protection Act (2007) which requires the NYCDOT to provide on-street parking information for every

block in the City; (Council for the City of New York, 2007)). However, researchers such as Weinberger et al (2008) for *Transportation Alternatives*, an advocacy group, and New York City's Department of City Planning (DCP, 2009) have explored different aspects of minimum parking requirements. The first of these analyses uses data from the City's Primary Land Use Tax lot Output (PLUTO) database to assign parking requirements to the City's residentially zoning districts and produces an estimate of required off-street parking spaces per acre. The analysis also create projections of auto ownership and vehicle miles traveled (VMT) for the estimated 265,000 additional dwelling units needed to accommodate one million additional residents by 2030 (City of New York, 2008). 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 and conclude that minimum parking requirements are likely to undermine or even reverse the City's goal for carbon reduction. While a key contribution to the debate, the analysis does not use lot-level characteristics to estimate parking requirements, relying instead on zoning districts to assign parking requirements to larger areas. Nor does it focus on minimum parking requirements in relation to transit accessibility, something this research explores in detail.

The DCP Study (DCP, 2009) combines vehicle registration data from the New York State Department of Motor Vehicles with new construction data from 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 59 Community Districts in New York City. The study asserts that car ownership per new housing unit is affected mostly by location and building type, while income and family structure are also important influences. However, its focus is on recently constructed units, and while it analyzes car ownership near transit, it focuses only on access to subways, ignoring both the Long Island Rail Road (LIRR) and Metro-North. Both commuter railroads, in fact, constitute very significant elements of the transit network, especially further from the Manhattan CBD. It also 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 researchers like Clark (2007) and Weinberger et al (2008), car ownership is assumed to be largely exogenous to the local policy process, determined more by socio-economic factors and building type rather than transit accessibility and/or minimum parking requirements (DCP, 2009, p.51). Critically, it also questions whether government policy should or even can engage in parking demand management by influencing "the public's propensity to own cars" as an alternative to simply accommodating it (DCP, 2009, p.56). This accommodating strategy is also counter to *PlaNYC 2030*, which foresees a role for active policy intervention to direct development to transit-rich areas to facilitate more sustainable transportation patterns.

The research presented in this article extends our existing understanding of parking requirements in New York City in several ways. Although we do not address head on the impact of parking requirements on development or comment on their absolute level, by

developing two measures of the requirements, we are able to compare the relative burden the requirements impose on different groups of lots, and the relationship between variations in the requirements and transit accessibility. Because our analysis is based on lot-level data, we are also able to estimate the affects of waiver provisions that reduce parking requirements for certain types of developments and to calculate the average requirements applicable to currently (as of 2007) underdeveloped lots, those with the greatest potential for redevelopment as new housing. These tools should provide an important foundation for further investigation of parking requirements in New York City.

3. Geographical Analysis Methodology

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), we calculate the average parking requirement for the city as a whole, its five boroughs, and areas that are inside and outside 1/2 a mile 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. Building upon the work of Been et al (2009), we also explore the relationship between underdeveloped sites in New York City and the parking requirement to better understand which levels of the requirement apply to those lots most likely to be redeveloped.

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 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). 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 unit of 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 (Been et al, 2009). As part of that project, the authors created a database of every physical 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 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. This annually updated database contains detailed information about each unique owned parcel of real property recognized by the City of New York (known as "tax lots"). Included in the data are tax identification numbers, details about each lot's land area, the building area on the lot, the zoning district the lot is in, 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 (2009), we estimate for every 2003 and 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, determined 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 (2009). 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. In further research we hope to investigate the claims by critics that 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 Been et al, 2009). 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., the City as a whole, a borough, or 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 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 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 R1-R4, R5-R7 and R8-R10, 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 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 previous research, 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. Specifically, we use RPAD data to estimate lot size and width to determine whether a lot qualifies for a full or partial waiver for small and narrow lots. 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, 2009) 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 affordable, elderly or "infill" housing.

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 *intersect* with ½ mile buffers created around all New York City Transit Subway stations and 45 Commuter Rail stations (Long Island Rail Road and Metro-North).

Building upon the work of Been et al (2009), we also investigate the parking requirements of lots that were significantly underdeveloped as of 2007 (developed to less than 50% of their permitted maximum building area, determined by their individual maximum FAR and lot land area).

4. Results

All Lots (No Waivers):

As a baseline for our analysis, Rows 1 and 2 of Table A (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, 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%. Indicating that, for every 100 new housing units constructed in New York City, developers must also build, on average, 58 new off-street parking spaces. However, this number varied widely from borough to borough; 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.

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 - equal to about 26 spaces per acre. This measure, too, varied widely from borough to borough. 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. It must be noted that this 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 highest densities, and highest total number of off-street parking spaces.

(Proximity to Transit; No Waivers):
Rows 3 through 6 of Table A 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 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. 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. The top portion of Map 1 shows the average required parking ratio for all of New York City at the census tract level (without regard to any waivers) and the location of rail transit stations.

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. The top portion of Map 2 maps the average required parking density for all of New York City at the census tract level (without regard to any waivers) as well as the location of rail transit stations.

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

		The Bronx	Brooklyn	Manhattan	Queens	Staten Island	New York City
	ALL LOTS						
(1)	Avg. Required Parking Ratio	56.56%	68.49%	10.55%	76.88%	134.42%	58.25%
(2)	Avg. Required Parking Spaces/1000 sf	0.84	0.78	0.53	0.52	0.47	0.61
	WITHIN 1/2 MILE OF TRANSIT						
(3)	Avg. Required Parking Ratio	52.10%	64.79%	10.78%	62.86%	136.08%	46.48%
(4)	Avg. Required Parking Spaces/1000 sf	1.01	0.85	0.57	0.50	0.62	0.69
	OUTSIDE 1/2 MILE OF TRANSIT						
(5)	Avg. Required Parking Ratio	77.66%	88.68%	2.35%	98.55%	133.72%	99.50%
(6)	Avg. Required Parking Spaces/1000 sf of Land Area	0.53	0.59	0.05	0.54	0.42	0.50

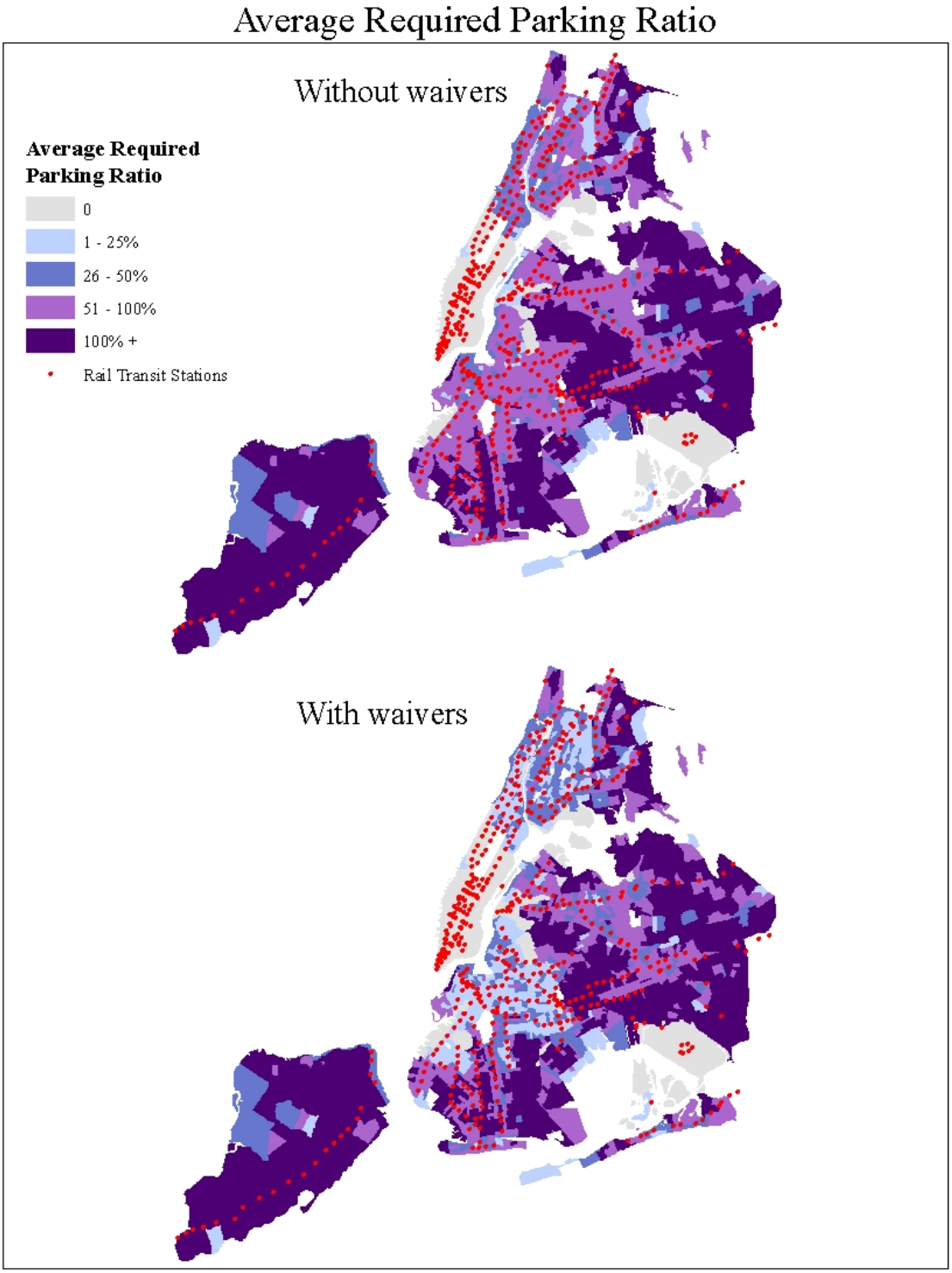
All Lots (With Waivers):
Table B reports the average required parking ratios and parking densities for the City as a whole and each borough, but this time the results are adjusted to take into account the as-of-right waivers of parking requirements described above, based on 2007 lot dimensions. Comparing Table B to Table A, 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. In Brooklyn the drops for both measures are particularly steep; Staten Island, in contrast, is almost unchanged, likely because its lots tend to be larger (both in size and width) or in zoning categories that do not permit lot and building size parking waivers. The bottom portions of Maps 1 and 2 map the average required parking ratio and density, respectively, for all of New York City at the census tract level, after adjusting for waivers, and the location of rail transit stations.

(Proximity to Transit; With Waivers):
Taking into account the parking requirement waivers also widens the gap between the average required parking ratio for lots near transit and that for lots further from transit. Specifically, while average ratio for lots further from transit barely budges (again, 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.

As noted above, our estimates of the effects of waivers are based on the dimension of lots as of 2007. However, developers often change lot dimensions in anticipation of new construction by merging lots into adjacent parcels or subdividing lots into smaller pieces. Accordingly, using 2007 lot dimensions as the basis for this estimate may not accurately reflect the requirements that developers will in fact face. Accordingly, these estimates are merely suggestive about how significant a role waivers may play in new development. Better understanding whether and how developers manipulate lot lines in order to qualify for waivers is a topic for future research.

Map 1: Average required parking ratio, with and without adjusting for parking waivers, and rail transit stations, 2007



Map 2: Average required parking density, with and without adjusting for parking waivers, and rail transit stations, 2007

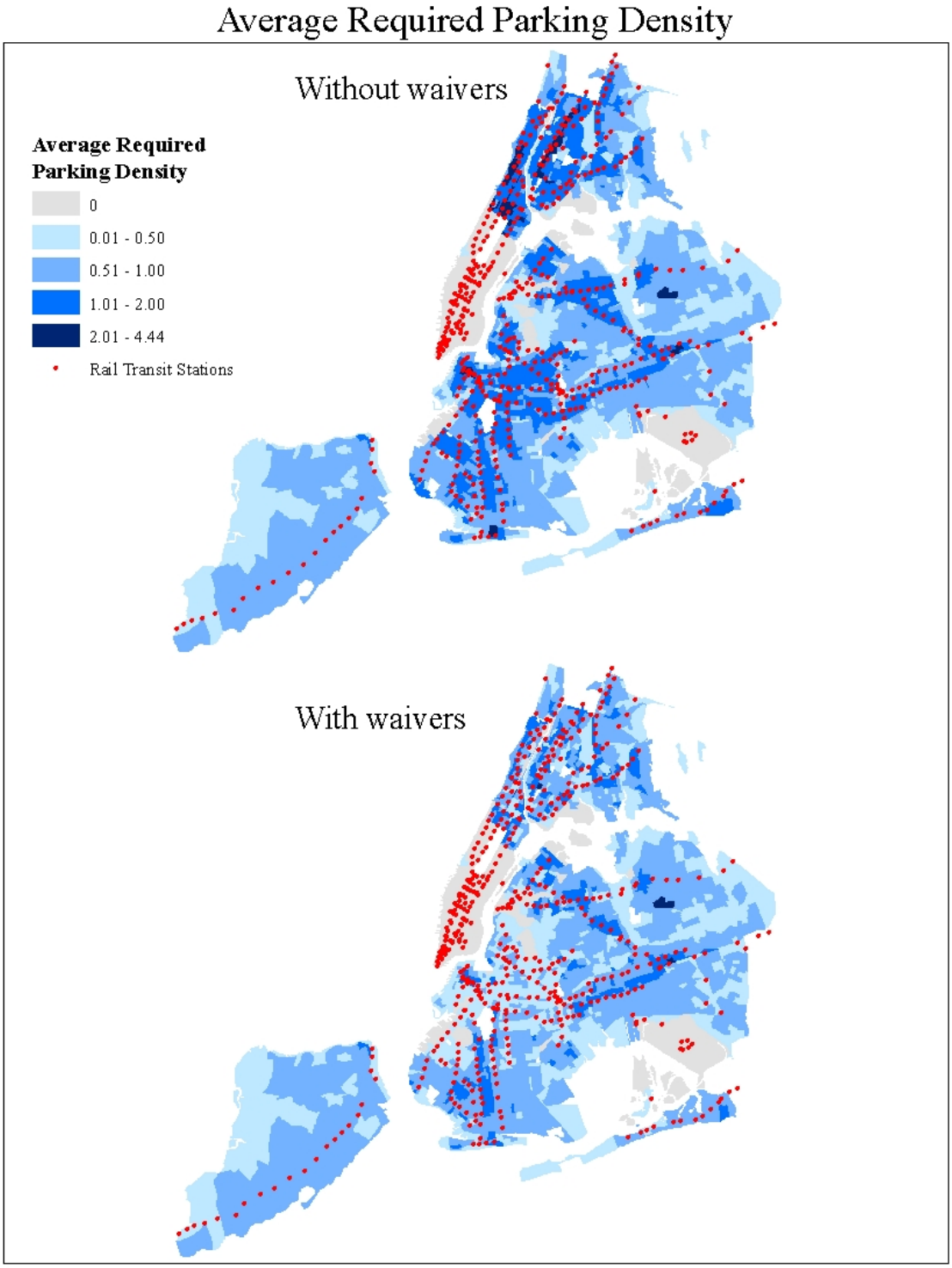


Table B: Average Required Parking Ratio and Average Required Parking Density, with Lot/Building Size Waivers

		The Bronx	Brooklyn	Manhattan	Queens	Staten Island	New York City
	ALL LOTS						
(1)	Avg. Required Parking Ratio	43.60%	46.56%	5.41%	70.78%	134.37%	47.60%
(2)	Avg. Required Parking Spaces/1000 sf	0.64	0.53	0.27	0.48	0.47	0.49
	WITHIN 1/2 MILE OF TRANSIT						
(3)	Avg. Required Parking Ratio	37.45%	39.68%	5.51%	55.58%	136.00%	33.72%
(4)	Avg. Required Parking Spaces/1000 sf	0.72	0.51	0.29	0.44	0.62	0.50
	OUTSIDE 1/2 MILE OF TRANSIT						
(5)	Avg. Required Parking Ratio	72.73%	84.06%	1.65%	94.27%	133.68%	96.22%
(6)	Avg. Required Parking Spaces/1000 sf of Land Area	0.49	0.56	0.03	0.51	0.42	0.48

In addition to analyzing the results for all lots in our selected geographies, we also calculate our parking requirement measures for the subset of lots that were underdeveloped as of 2007, recognizing that they are likely sites for future development. Building upon the work of Been et al (2009), we define as underdeveloped all lots that were built out at less than 50% of their maximum allowable FAR. Again, we separate these lots into those near rail transit and those beyond a half mile, taking into account the lot and potential project size waivers. Table C reports the results of these calculations.

We see that the average required parking ratio for underdeveloped lots is only 38% for the City as whole, noticeably lower than the 48% shown in Table B for all lots. This suggests that, on average, for every 100 units built on the lots that were underdeveloped in 2007, fewer than 40 new off-street parking spaces would be required. For New York City as a whole and for its three most populous boroughs individually (The Bronx, Brooklyn and Queens), underdeveloped lots near rail transit had an even lower average required parking ratio.

At 0.3 spaces per 1000 square feet of land area, the average minimum parking density for the City as a whole is also much lower for underdeveloped lots than for all lots. But just as was the case for the entire sample of lots (Table B), for underdeveloped lots, the

relationship with transit proximity is mixed. In the Bronx and Manhattan, the average required parking density for underdeveloped lots close to rail stations is significantly higher than for lots with less transit accessibility. In other words, in the Bronx, developers fully building out an underdeveloped lot near transit would be required, on average, to build many more parking spaces than they would have build fully building out an underdeveloped lot of equal size further away from a rail station. The fully built out lot near the station would have many more units, on average, but this still raises interesting questions about the role of parking requirements in determining the use of scarce land resources near fixed transit infrastructure. For underdeveloped lots in Queens, in contrast, the average required parking density is lower near rail stations than it is further away, just as it was for the sample of all lots (underdeveloped and further away and developed).

Table C: Average Required Parking Ratio and Average Required Parking Density for Underdeveloped Lots (With Waivers)

		The Bronx	**Brooklyn**	**Manhattan**	**Queens**	**Staten Island**	**New York City**
	ALL LOTS						
(1)	Avg. Required Parking Ratio	32.77%	33.58%	4.81%	44.25%	103.64%	37.67%
(2)	Avg. Required Parking Spaces/1000 sf	0.41	0.30	0.19	0.25	0.32	0.29
	WITHIN 1/2 MILE OF TRANSIT						
(3)	Avg. Required Parking Ratio	28.26%	30.13%	4.88%	36.04%	110.38%	27.80%
(4)	Avg. Required Parking Spaces/1000 sf	0.48	0.30	0.21	0.22	0.52	0.30
	OUTSIDE 1/2 MILE OF TRANSIT						
(5)	Avg. Required Parking Ratio	51.71%	52.92%	2.78%	63.96%	100.73%	70.63%
(6)	Avg. Required Parking Spaces/1000 sf of Land Area	0.29	0.28	0.03	0.31	0.26	0.28

5. Conclusion

Using GIS and lot-level assessor's data, we analyze the spatial distribution of parking requirements in New York City in order to understand how their variation relates to transit accessibility and development opportunities. While we do not comment on the average parking requirement citywide, we find that that the per unit parking requirement is, on average, significantly lower for lots within a half mile of a rail transit station. This

appears consistent with the City's goal of encouraging transit ridership and transit oriented development. We also find that per unit requirements are lower for the many lots which, as of 2007 were underdeveloped, indicating that the sites of future building projects will require relatively few new parking spaces even without regulatory changes.

However, because of the interaction between permitted building density and per unit parking requirements, a second measure of parking requirements we calculate reveals a more complicated picture. Although per unit requirements are lower, developers are required to build just as many spaces per unit of land, on average, in areas near transit stations as they are in areas less accessible by transit. Of course, these areas are likely to permit larger developments, but because New York City land is finite and developable land scarce, this raises important questions about the possible opportunity costs of parking requirements.

Our research leaves many related questions unanswered. Because of data limitations, we are currently unable to track how many parking spaces developers have actually built in recent years as part of residential projects. Discerning whether or not developers build the absolute minimum of spaces, build more than zoning requires, or change lot lines and project sizes to qualify for waivers is a crucial step in better understanding the relationship between parking requirements and development. Case study analysis of specific building projects can provide further insight into the exact tradeoffs between building area and required parking spaces that developers may make.

Parking requirements in New York City highlight a significant disconnect between neighborhood-level planning demands and citywide development goals. On one hand, local residents and business owners wish to prevent additional competition for a finite supply of public parking spaces and are likely to support requirements for new off-street parking. On the other hand, City planners recognize that any growth in automobile use, facilitated by new and possibly below-market parking spaces, may interfere with environmental and congestion mitigation goals. How the political process responds to these competing pressures may help determine in what form the City grows.

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