

From Minimum to Maximum: Impact of the London Parking Reform on Residential Parking Supply from 2004 to 2010?

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Abstract

This research examines residential parking supply in London before and after the minimum off-street parking standard was replaced by a maximum one in 2004. Based on 11 428 residential developments after and 216 developments before the reform, it is found that parking supply was reduced by approximately 40 per cent. Ninety-eight per cent was caused by the removal of the minimum standard, while only 2 per cent was due the imposition of the maximum standard. However, the parking supply is actually higher in areas with the highest density and the best transit service than in the areas immediately outside; the adopted maximum standard follows a similar pattern. The market-oriented approach to parking regulation can reduce excessive parking, but it depends on the particular sub-markets. Complementary policies such as strict parking maxima, on-street parking controls and parking taxes are often necessary to form an efficient parking market.

Introduction

The debates on the minimum off-street parking standard (hereafter minimum standard) and the maximum off-street parking standard (hereafter maximum standard) have been defining topics in parking policy over the past decade. The former sets up the minimum level of parking that a development has to provide on site in terms of the number of spaces per square feet or per

housing unit, while the latter imposes a cap on parking supply.

There are four competing perspectives. The first perspective believes that the minimum standard is fundamentally inefficient and unfair, often leading to the oversupply and underpricing of parking. The solution is to introduce market mechanisms into the parking market: parking supply should be

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based on costs and benefits rather than government regulations, and parking demand should be constrained by price and budget rather than personal preferences (Shoup, 2005). If the minimum standard is eliminated (deregulation), the overall supply of parking would decline, prices would increase and the market would become more efficient. Proponents of this perspective may or may not support the maximum standard.

The second perspective accepts this market approach, but disagrees that deregulation alone is sufficient to form an efficient market due to the many barriers in the off-street parking market, such as parking spillover to neighbourhood streets, monopoly and the co-operation trap or group inertia among firms or locales such as urban and suburban centres, which explain in part why parking reform in the UK and The Netherlands had to be initiated at the national level. Therefore, complementary policies, such as the maximum standard or shared parking, are often required to help eliminate the excessive supply, correct price distortion and foster an efficient parking market (Barter, 2010).

The third perspective also supports the elimination of the minimum standard and the imposition of the maximum standard, but from a different rationale. It too believes that the minimum standard is problematic, but does not fully accept the market approach. It actually believes in government intervention in the parking market in order to achieve a broader set of policy objectives. The parking freeze in downtown Boston and Manhattan in the late 1970s to meet the Federal Clean Air Act requirements exemplifies this approach. From this perspective, regulation is not the problem and deregulation is not the solution.

The fourth perspective disagrees with the first three in that the minimum standard

does not distort the parking market, particularly in low-density areas with limited transit services (Levinson, 2005; O'Toole, 2011). This view believes that the minimum standard is the result of a functioning market and eliminating it would not reduce parking supply or increase parking price. This perspective does not support the elimination of the minimum standard and is strongly against the maximum standard because it represents excessive regulations in the market.

The various perspectives partly explain the *ad hoc* approaches adopted by local governments to reform their off-street parking policy. Some eliminate the minimum standard but do not impose a maximum standard. According to Shoup (2011), 129 local governments in the US eliminated minimum parking standards for certain types of land use between 2005 and 2011. Some implement the maximum standard but do not necessarily remove the minimum standard. Major cities such as New York City, Los Angeles, San Francisco, Washington DC, Seattle, Portland, Atlanta, San Diego, Chicago, Minneapolis and Phoenix, have applied some type of maximum standard to certain types of development. World-wide, maximum standards have also been instituted in London, Amsterdam, Paris, Zurich, Sydney, Brisbane, Seoul, Ottawa, Vancouver, Toronto, Jerusalem, Haifa, Rotterdam and Frankfurt (Martens 2005). However, the vast majority of localities still remain sceptical of these policy initiatives. Few studies have empirically assessed whether and how they would work, or have provided solid evidence to answer the following basic questions

Q1: Does the minimum standard oversupply parking at all and if 'yes' will eliminating it reduce the excessive parking?

Q2: Is the maximum standard needed at all for an efficient parking market when the minimum standard is removed?

For many policy-makers, these fundamental questions remain unanswered and the elimination of the minimum standard and/or the installation of the maximum standard represent uncharted waters, which explains in part why the traditional minimum standard has persisted despite being under attack for the past two decades (Ferguson, 2004).

The goal of this paper is to provide empirical evidence relating to these two questions, to comment on the four perspectives and to shed light on the current debates on the minimum and maximum standards. Our hypothesis is that the elimination of the minimum standard would reduce if not eliminate the excessive parking (Q1) and that the maximum standard is indeed necessary for an efficient parking market (Q2). The case study is the 2004 London parking reform that switched from the minimum standard with no maximum to the maximum standard with no minimum for all new developments in the Greater London area. No other major cities have adopted a comprehensive parking policy change on this scale. Such a complete policy reversal suggests that the previous policy was probably doing more harm than good. The about-face is uncommon but certainly not rare in urban and transport planning. For example, in the 1950s many cities created one-way street systems to speed traffic through downtowns, but in the 1990s many converted them back to two-way streets to calm traffic (Walker *et al.*, 2007). Similar reversals have also occurred with respect to the elimination and restoration of on-street parking in downtowns (Shoup, 2005) and the renewal and preservation of urban neighbourhoods.

The analysis focuses on new, independent, market-rate residential developments:

11 428 after the reform (2004–10), supplemented by 216 developments before the reform (1997–2000). The present study is one of the first empirical studies to evaluate both the application of a maximum parking standard and the elimination of the minimum standard.

Literature Review: Parking Standards and Parking Supply

Developers make off-street parking decisions based on the trade-off between cost and benefit. Parking can provide a market premium to the development and at the same time increase the development cost. When the benefit exceeds the cost, parking will be provided; otherwise it will not. Because the premium and cost heavily depend on the specific location, development type and other factors, such a trade-off often differs from development to development. Parking standards can potentially change this trade-off and affect the number of spaces provided, the size and location of developments, or even whether a development will occur or not. Their effects often go beyond the parking market (supply, price, unbundling, etc.) and spread to the housing market (number of units, average unit size, price, etc.) (Manville and Shoup, 2010), travel outcomes (car ownership and usage, etc.) (Rye *et al.*, 2011) and area development (for example, infill vs green-field developments) (Scottish Executive, 2002; Rye and Ison, 2007). For this paper, we only review studies directly related to parking supply and leave other topics for future research.

Parking supply is truncated by the minimum or maximum standard, so the effects of the standards can only be revealed after they are not applied. Because elimination occurs in a few cases and very recently, the majority of studies observe the effects

indirectly. One approach is to examine developments exempted from the parking standard or filed under planning variance. The problem is that these developments tend to be special cases such as small developments, affordable housing or irregular lot shape. Another approach is to compare actual supply with the parking standard. If parking is provided exactly at the standard level, such a bounding may suggest, not necessarily prove, a supply forced or capped by the minimum or maximum standards. We reviewed a total of 11 studies: two based on direct observation, four based on exemptions and variance, and five based on the bounding effect. All are on the minimum standard.

Manville and Shoup (2010) investigate the elimination of the minimum parking standard in conversions from old office buildings to residential use in downtown Los Angeles after 1999. For 55 developments, they find that the actual on-site parking supply was 40–55 per cent lower than the original minimum requirement. Unbundling has become more popular because off-site parking accounts for 31 per cent of the total parking for condominiums and 50 per cent for rental buildings. Eliminating the minimum standard appears to boost housing developments in downtown Los Angeles because at least 7300 new housing units were added between 1999 and 2008, which is almost double the total number of new units added between 1970 and 2000 in the same area. Nelson *et al.* (1996) investigate the Special Public Interest Districts (SPIDs) that eliminated the minimum standard for new developments near subway stations in downtown and midtown Atlanta after 1981. Their comparison of 13 new commercial and office developments (seven inside and six outside the SPIDs), totalling 6.3 million square feet, finds that the elimination does not reduce parking supply, which is

actually slightly higher inside the SPIDs than outside.

Exemptions are often included in the minimum or maximum standard. For example, in New York City, small residential developments with five or fewer units or high-density residential developments with fewer than 15 required parking spaces (for example, R7 zoning) are exempt from the minimum standard. Been *et al.* (2012) examine 1019 market-rate residential developments with five or more units built between 2000 and 2008 in the Bronx, Brooklyn, Queens, Upper Manhattan and Staten Island to understand developers' responses to the option of not providing parking. They find that approximately 68 per cent of these developments qualified for a waiver from the minimum standard and that 83 per cent do not provide parking at all. In another study, McDonnell *et al.* (2011) also find that developers sometimes split a single development into multiple smaller developments to qualify for the minimum requirement exemption despite the increased construction cost due to providing more stairs and fire exits.

Also in New York City, King (2011) surveyed 128 residential developments in Brooklyn and found that 75 per cent of the developments were built at or below the minimum standard, which exhibits the effects of exemptions and variances. On average, the 30 condominium buildings surveyed provide 0.50 spaces per unit as opposed to the required 0.53 spaces per unit. The 20 market-rate rental buildings provide 0.47 spaces per unit as opposed to the required 0.54 spaces per unit. In Toronto, Canada, Engel-Yan *et al.*'s (2007) survey of 497 commercial and office buildings found that 40 per cent of the buildings provided less parking than the minimum standard, a reduction of 1–5 per cent, depending on the type of land use. General offices, medical offices and general retail

tend to provide less parking than the minimum standard, while banks, large grocery stores and large retail outlets tend to exceed the minimum standard.

On the bounding effect, McDonnell *et al.* (2011) surveyed the actual parking supply for 38 new residential developments in Queens, New York City, and found that 47 per cent exactly meet the level of the minimum standard and that 29 per cent exceed the standard by less than 25 per cent. Only 13 per cent provided parking that exceeds the minimum standard by 25 per cent. The same pattern is found in suburban areas. Willson (1995) studied 10 office buildings in southern California and found that eight were built with only the minimum required amount of parking. The Chicago Regional Transportation Authority (RTA, 1998) studied office developments in 10 suburban communities and found that developers did not supply more than the minimum required parking.

Of course, evidence also exists that developments often provide more than the minimum standard. For example, between 1970 and 2010, new single-family homes in the US provided 2.6 garage spaces on average, while the average minimum standard for single-family homes was only 2 spaces nation-wide (Ferguson, 2004). In an international context, an Asian Development Bank report (Barter, 2011) comparing actual parking supply with the minimum standard for 84 buildings in 13 Asian cities, found that some provide more than the minimum standard, while others provide less.

In summary, the literature suggests mixed results. The elimination of the minimum standard appears to reduce supply in some parking markets, but to have little effect in others. The lack of consensus or a complete picture is partly due to the various limitations: many of the studies can only detect the effect of the standards indirectly

or target special cases such as conversions of old buildings in downtown, transit-oriented developments in a low-density area and small developments or affordable housing. Together, they only partly answer question 1 and do not address question 2. To date, no studies have actually investigated the empirical effect of a maximum standard on parking supply.

The London parking reform provides rich empirical evidence that could substantially advance our understanding of the effects of parking standards on supply. It involves both the minimum and maximum standards, is applied to all developments instead of a small niche market and is implemented by 33 boroughs separately, offering a rich variation in the local context and standard design. The last feature is particularly valuable because the debate on parking standards is essentially not about the type (minimum vs maximum), but the design. If the minimum standard is low enough or responsive enough to local parking demand, many criticisms will be likely to disappear. If the maximum standard is set too high, it will become essentially useless as a policy. For example, New York City does have a maximum standard for all residential developments, but it is too high (three spaces per unit) and completely ignored.

The London Parking Reform: From Minimum to Maximum

The London parking reform in 2004 is part of a national agenda to transform transport policy-making in the UK that began towards the end of the 1990s. In 2001, the central government published *Planning Policy Guidance 13—Transport* (DCLG, 2001) and stated that the goal of the national transport policy was to “reduce the need to travel, especially by car” (Objectives 4-3). One of the 10 implementation strategies was to

“use parking policies ... to promote sustainable transport choices and reduce reliance on the car for work and other journeys” (Objectives 6-7). The report suggests the following:

Policies in development plans should set maximum levels of parking for broad classes of development. Maximum standards should be designed to be used as part of a package of measures to promote sustainable transport choices, reduce the land-take of development, enable schemes to fit into central urban sites, promote linked-trips and access to development for those without use of a car and to tackle congestion. There should be no minimum standards for development, other than parking for disabled people (DCLG, 2001, sec. 52).

In March 2000, *Planning Policy Guidance 3—Housing* was published (DCLG, 2001), which explicitly states that “developers should not be required to provide more parking than they or potential occupiers might want” and that local parking standards should not result in developments with more than 1.5 off-street parking spaces per dwelling on average (sects 60–62).

Following this national policy, the Greater London Authority (GLA) passed the London Plan in February 2004, which requires local authorities to shift from a minimum to a maximum standard. However, a maximum standard is not new to London. In the early 1970s, the then Greater London Council adopted a maximum standard restricted to private, non-residential parking, which varied from Outer to Central London. In 1986, this standard was abolished in Outer London and was considerably weakened in Inner and Central London due to extensive deregulation in the UK at that time. The 2004 reform strengthens the maximum standard and expands it to residential

developments. For example, residential developments are restricted to fewer than 1 parking space per unit for 1–2 bedroom units; those in areas with good transit accessibility are restricted to less than 1 space per unit; project-wide, parking should not exceed 1.5 spaces per unit on average.

Following the national and regional policies, local governments updated their local plans to replace the minimum standard with a maximum one. These local plans, which were termed Unitary Development Plans (UDP) prior to 2008 and Local Development Frameworks (LDF) thereafter, are to be updated every 10–15 years. Due to schedule differences, local governments might officially adopt the maximum standard in different years as shown in Table 1. Three boroughs still had not adopted a maximum standard by October 2010.

However, local governments do not need to wait for official adoption to apply the maximum standard in reviewing development applications. According to the UK planning system, planning authority is local but overseen by the regional and national governments, which could revise a local planning decision if it does not comply with national and regional policy. Therefore, local governments often consider national, regional and local policies in making planning decisions. When policies are inconsistent, the more recent policies typically receive more weight. National and regional policies are primarily weighted to developments with a regional impact. To determine when the maximum standard is applied in planning applications, we interviewed 19 planning review officers from 13 London boroughs, who confirmed that the maximum standard was widely implemented after 2004. In our sample, the minimum standard is applied to less than 6.4 per cent of the developments.

Table 1. Effects of the shift in standards on changes in parking bands for 22 boroughs prior to October 2010

<i>Borough</i>	<i>Year of shift</i>	<i>Number of parking bands changed</i>			<i>Change in number of spaces/unit</i>	<i>Type of change</i>	
		<i>Reduced</i>	<i>Same</i>	<i>Increased</i>		<i>Minimum standard</i>	<i>Maximum standard</i>
<i>Central London (2)</i>		1 (25 per cent)	2 (50 per cent)	1 (25 per cent)	−0.167		
City of London	2002	1	0	0	−0.500	Uniform	Same
Westminster	2007	0	2	1	0.167	Uniform	Beds
<i>Inner London (9)</i>		13 (33 per cent)	25 (63 per cent)	2 (5 per cent)	−0.202		
Hammersmith and Fulham	2003	0	5	0	0.000	Beds	Same
Haringey	2006	4	0	0	−0.468	Beds	Type, beds
Islington	2002	1	0	0	−0.500	Centre	Uniform
Kensington and Chelsea	2002	0	10	0	0.000	Type, beds	Same
Lambeth	2007	5	1	0	−0.433	Uniform	Centre, CPZ, beds
Lewisham	2004	0	3	0	0.000	Beds	Same
Newham	2001	1	4	0	−0.100	Beds	Same
Southwark	2007	1	2	2	0.180	Uniform	Centre, PTAL
Tower Hamlets	2007	1	0	0	−0.500	Uniform	Same
<i>Outer London (11)</i>		45 (54 per cent)	31 (37 per cent)	8 (9 per cent)	−0.266		
Barnet	2006	3	2	2	−0.143	Type, beds	Same
Bexley	2004	5	6	1	−0.133	Beds	Centre, PTAL, beds
Brent	2004	1	1	2	0.063	Beds	Same
Bromley	2006	6	1	0	−0.643	Type, beds	Type
Greenwich	2006	2	2	0	−0.500	Uniform	Beds
Harrow	2004	5	0	0	−0.060	Previous, beds, price	Beds
Havering	2008	7	1	0	−0.750	Beds	Type
Hillingdon	2002	1	5	0	−0.167	Type, beds	Type
Richmond upon Thames	2005	2	8	0	−0.200	Previous, beds	CPZ, beds
Sutton	2003	0	5	0	0.000	Type, beds	Same
Waltham Forest	2006	13	0	3	−0.388	Beds	PTAL, beds
Total		59 (46 per cent)	58 (45 per cent)	11 (9 per cent)	−0.230		

Note: Beds = number of bedrooms; type = housing type (house, bungalow, flat, Maisonette, etc.); PTAL=public transit accessibility level defined by Transport for London; centre = town centre or central activity zones; CPZ= controlled parking zones or areas with strict traffic restrictions; and uniform= standard applied equally to all units. Parking bands are based on the maximum standards.

For the 33 London boroughs, we are able to determine maximum standards for 30 boroughs and minimum standards for 22 boroughs.¹ The different ways in which boroughs change their parking standards contribute to understanding the design and implementation of the maximum standard. Table 1 compares the minimum and maximum standard designs before and after the reform for 22 boroughs.

The 22 boroughs have a total of 128 parking bands in their maximum standards for residential developments. A parking band is defined as a specific category with a unique standard—for example, 1.5 spaces per unit for a three-bedroom house or 0.5 spaces per unit for a studio apartment each represents a band. On average, the 22 boroughs adopt 5.8 bands with a median of 5 bands. The number of bands ranges from a minimum of 1, a uniform standard applied equally to all units regardless of their attributes, to a maximum of 16 in Waltham Forest. As Table 1 indicates, many boroughs change the types of parking bands under the maximum standard. Most incorporate density, transit accessibility and controlled parking zones into the standards. Before the reform under the minimum standard, only one band was linked to these attributes, but after the reform, there are 76, of which 36 are linked to transit accessibility, 24 to controlled parking zones and 16 to town centres or central activity zones.

In terms of the level of change, the maximum standard for most parking bands either remains the same or is reduced from the previous minimum standard: 59 bands (46 per cent) are reduced, 58 bands (45 per cent) remain the same and 11 bands (9 per cent) actually increase. Reductions appear to be more prominent for Outer London boroughs (54 per cent), while most Inner London boroughs (63 per cent) maintain the same after the shift. On average, the number of parking spaces reduces by 0.230

spaces per unit in the standard after the reform. The average reduction is greater for the Outer London boroughs than for the Inner London boroughs (-0.260 and -0.206 space per unit respectively), while the two Central London boroughs exhibit conflicting patterns. At the borough level, 15 of the 22 boroughs reduce the average maximum standard from the minimum. Seventeen have at least one reduced parking band and 6 boroughs have at least one increased parking band. The latter are scattered among the Central, Inner and Outer London boroughs without any apparent spatial pattern.

Data

The present research focuses on residential developments. First, residential parking dominates the off-street parking market in London. According to a survey performed by Transport for London (TfL, 1999), there are approximately 3.8 million off-street parking spaces in the Greater London area and 71 per cent are residential. Secondly, residential off-street parking is not affected by the earlier versions of the maximum standard for non-residential developments. Finally, residential development is defined as having regional impact and is closely monitored by the GLA.² As a result, local boroughs enforce the maximum parking standard more stringently and the parking data collected tend to be highly accurate.

The primary source of the dataset is the London Development Database (LDD), which records all new development permits with regional impacts in London, including all residential developments. The data are provided by the London boroughs and reviewed by the GLA to ensure consistency and compliance with regional planning policies including the maximum standard. The full set of LDD has become available after March 2004. For each development, the

LDD records its precise location, the number of units, the lot size, the number of bedrooms, the type of housing, the number of affordable units, the number of existing units and the number of proposed parking spaces.

We collected all approved residential developments in LDD from 1 April 2004 to 31 March 2010 for the 30 boroughs that have adopted maximum standards. The total number of individual developments is 35 557. We excluded affordable housing, sheltered housing, senior housing and nursing homes that were not subject to the minimum parking standard before the reform. We also excluded mixed-use developments due to difficulties in calculating parking supply as well as conversions or additions to an existing building. Therefore, the sample includes 11 428 single-use, independent, new, market-rate residential developments with a total of 247 984 units. Because information on the minimum standard is only available for 22 boroughs, a smaller subsample of 8257 developments is used for comparisons between the current maximum and the previous minimum standard. Each development was assigned a parking band code to link it to the corresponding maximum and/or minimum standards.

Approximately 40 per cent of the developments are single-family homes; 38 per cent have 2–10 units; and 12 per cent have 11–30 units. Although only 10 per cent of the developments have more than 30 units, they accounted for 81 per cent of all housing units. The number of new developments each year was steady from 2004 to 2008 (with only 9 months of data from 2004), but appeared to decline in 2009 and 2010. Most developments (89 per cent) are 5 km or more away from the urban centre.

The second dataset includes 216 residential developments in 30 boroughs approved between 1997 and 2000 under the minimum standard. They are collected from the

decision report of each development application available on-line. These reports describe the details of the proposed project and include proposed parking spaces and drawings, the complete negotiation process, correspondence between the planning officer and the developer, input from other stakeholders, a list of the applicable planning policies and an explanation of the final decision and conditions, if there were any. These reports provide the only source of data for the actual parking supply under the minimum standard prior to the reform. The 216 developments are all new, independent, market-rate projects. A stratified random sampling procedure is used such that the proportion of developments for each borough in this sample maintains the proportions found in the LDD. Because the data collection process is time consuming, this sample is relatively small compared with the LDD sample.

The Impact on Parking Supply

Answering the two questions requires a comparison of the actual supply under the minimum standard with the actual supply under the maximum standard for the same sample. However, this comparison could not be performed because no development in London is simultaneously subject to both the maximum and minimum standards. Therefore, we use the actual parking supply under the minimum standard for the 216 developments prior to the reform to infer the ‘expected’ supply under a ‘hypothetical’ minimum standard for the LDD sample after the reform.

Figure 1 presents the five types of change in the LDD sample. Type 1 would be forced to supply parking at the minimum required level but provides zero parking under the maximum standard. Type 2 also would oversupply parking under the minimum standard but dramatically reduces, although

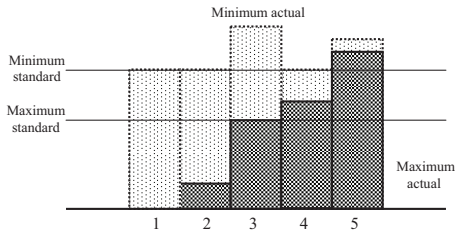


Figure 1. Five types of change in parking supply.

not completely eliminating, the parking supply under the maximum standard. Type 3 would provide parking beyond the minimum standard but is capped at the maximum allowed level due to the reform. Type 4 would provide parking at the minimum required level but reduces the supply significantly under the maximum standard even though it is still above the maximum allowed level. Type 5 would provide more than the minimum required level under both the minimum and the maximum standards due to exceptions. Note that the darker shaded areas with solid lines in Figure 1 depicts the observed actual supply from the LDD sample, while the lighter shaded areas with dotted lines, which overlap the dark shaded areas, are hypothetical supplies for the LDD sample if the minimum standard were not removed, which will be inferred from the 216 developments. The difference between the two is the supply change caused by the reform. The reductions in types 1, 2 and 4 are due to the elimination of the minimum standard, while the reduction in type 3 (if any) is due to the maximum standard.

Overall Change in Parking Supply

To detect the supply change, we start with the post-reform sample of 8257 developments with 204 181 units. These developments provide 128 350 parking spaces (0.63 spaces per unit), although the maximum

allowed level is 188 592 spaces and the minimum required level is 248 628 spaces. Therefore, the overall supply is only 68 per cent of the current maximum standard and 52 per cent of the abandoned minimum standard. The pre-reform sample of 216 developments provides 2666 housing units with 2994 parking spaces (1.12 spaces per unit), which is 94 per cent of the minimum of 3197 spaces required. In other words, the reform reduces the actual parking supply from 94 per cent to 52 per cent of the minimum standard, a reduction of 42 per cent.

Next, we calculate the ratio between the actual parking supply and the *minimum* standard for each development in both the post-reform and pre-reform samples. The average for the post-reform sample is 0.68. This number is greater than the earlier 52 per cent because most of the reduction occurs in the large developments. The average ratio for the pre-reform sample is 1.07; prior to the parking reform, developments provided 7 per cent more parking on average than the minimum required level. In other words, the average ratio of actual parking supply to the same minimum standard declines from 1.07 to 0.68, a decline of 39 per cent. In summary, the overall parking supply is reduced by 39 per cent to 42 per cent following the London parking reform.

We then calculate the extent of the change in parking supply for the five types of change. Table 2 summarises the results. Type 1 has 2023 developments (24.5 per cent) with 27 642 housing units (13.5 per cent) in the post-reform sample. Type 1 provides zero parking under the maximum standard but should have provided at least 30 154 parking spaces under the minimum standard. They might have provided 7 per cent more than the minimum required level (32 265 spaces). Therefore, the total reduction in supply for type 1 is 32 265 spaces. Following the same calculation, type 2 accounts for 30 per cent of the

developments, but 64 per cent of the housing units and 71 per cent of the reduction in total parking supply. Type 3 accounts for 22.4 per cent of developments, but only 4.2 per cent of the housing units and 2.2 per cent of the supply reduction. Noted that this number is based on the assumption that any developments that provide parking at the maximum allowed level would have provided more parking were the cap removed. Therefore, the modest 2.2 per cent reduction might be overestimated. Types 4 and 5 are exceptions from the maximum standard and represent approximately 22.2 per cent of the post-reform sample.³ Type 4 exhibits a 7.2 per cent reduction in parking supply. Type 5 is not affected by both the minimum and maximum standard, and the supply should remain the same. The overall supply reduction is 143 893 parking spaces (see Table 2).

To examine the supply reduction further, we compare the supply distribution curve between the minimum and the maximum standards. We first calculate the ratio between the actual supply and the minimum standard for the pre-reform sample ($N = 216$) and the same ratio between the actual supply and the same minimum standard for the post-reform sample ($N = 8257$), and then plot their distributions on the same scale. The two curves exhibit distinct patterns (see Figure 2). The pre-reform sample curve peaks at 1 with a long tail to the right. Approximately 50 per cent of the 216 developments provide parking at exactly the minimum required level and only 26 per cent provide parking above that level. In contrast, the post-reform sample curve for the maximum standard is heavily skewed to the left with two peaks at 0 and 1. Only 17 per cent provide parking at the previous minimum required level and 67 per cent are below the minimum level. It is clear that, with the minimum standard but no maximum, most

developments do not provide more than the minimum required. With the maximum standard but no minimum, most developments provide less than the maximum allowed. The parking reform dramatically changes the distribution of the off-street parking supply in London.

Effects of Density and Transit Accessibility

Because density and transit accessibility are major factors in discussions of parking policy, we examine how the standard and actual supply vary by different levels of these factors. We calculate the average actual supply, the maximum allowed supply and the minimum required supply in the number of parking spaces per unit for nine density levels (Figure 3) and eight accessibility levels (Figure 4). The Public Transit Accessibility Level (PTAL) is calculated by TfL, taking walking time and service availability into account, to a location for the entire Greater London area.

Both figures reveal that there are considerable differences between the minimum and maximum standards applied to the 8257 developments. The maximum allowed level per unit is consistently below the minimum required level, which is consistent with earlier findings. However, the difference is greatest in the areas immediately adjacent to Central London but the smallest in Central London, which has the highest density and transit accessibility. Although the minimum required level exhibited an increasingly convex curve with declines in density and transit accessibility, the maximum allowed level exhibits an unexpected 'U-shaped' curve, indicating immediate standard reductions as developments move away from Central London, but increases again in Outer London. Areas with the highest density and transit accessibility actually have a higher parking cap compared with the immediately adjacent areas.

Table 2. Five types of changes in parking supply after parking reform

Types	Developments		Housing units		Actual supply under the maximum standard		Minimum required (if projects were occurred before reform)		Expected supply under the minimum standard ^b		Supply reduction	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1	2023	24.5	27 642	13.5	0	0.0	30 154	12.1	32 265	11.9	-32 265	22.4
2	2491	30.2	131 395	64.4	74 724	58.2	161 641	65.0	172 956	63.5	-98 232	68.3
3	1855	22.4	8 641	4.2	10 084	7.9	12 245	4.9	13 102	4.8	-3 018	2.1
4	294	3.6	21 108	10.3	18 386	14.3	26 882	10.8	28 764	10.6	-10 378	7.2
5	1530	18.5	15 198	7.4	24 863	19.4	17 432	7.0	24 863 ^c	9.1	0	0.0
Other ^a	64	0.8	197	0.1	293	0.2	274	0.1	293	0.1	0	0.0
Total	8257	100	204 181	100	128 350	100	248 628	100	272 243	100	-143 893	100

^aThe maximum standard increased from the minimum standard.

^bEquals 107 per cent of the minimum required. (Note that the actual supply for the LDD sample (after March 2004) under a minimum standard does not exist in reality.)

^cNot affected by both minimum and maximum standards.

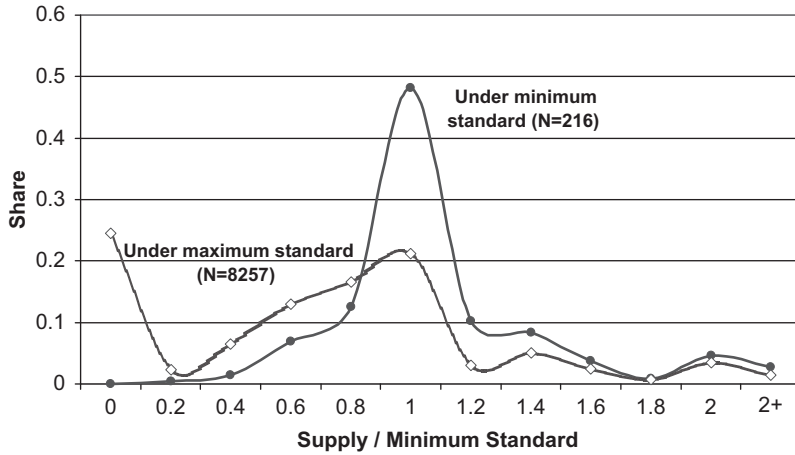


Figure 2. Ratio distributions under the minimum and maximum standards.

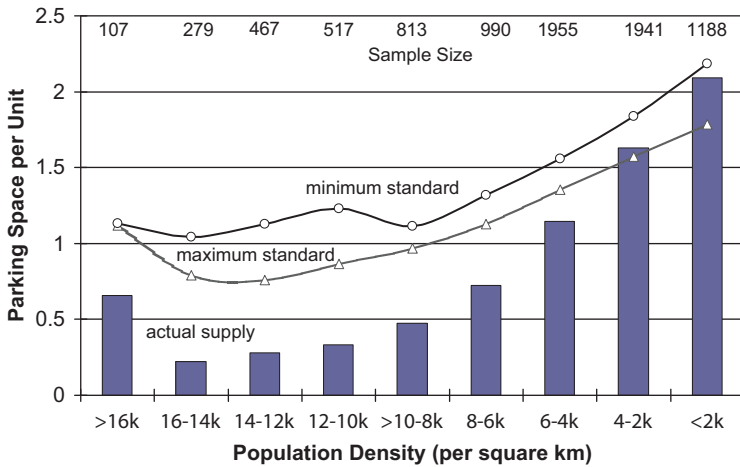


Figure 3. Changes in standards and actual parking supply based on population density ($N = 8257$).

There are two possible explanations. The first is that housing units tend to be larger in Central London than in adjacent areas, which might lead to the application of a higher maximum standard. Indeed, the average unit size in the highest-density area is 2.43 bedrooms, 30 per cent larger than unit size in the second-highest-density area. However, the difference in unit size is smaller than the 41 per cent difference in

the maximum standards. The average unit size in areas with the highest transit accessibility is 2.32, which is approximately 13 per cent greater than the next highest level, but less than the 25 per cent difference in standards between the two areas. A second possible explanation is that local boroughs are reluctant to reduce the maximum standard in central areas because they are concerned about parking spillover onto already

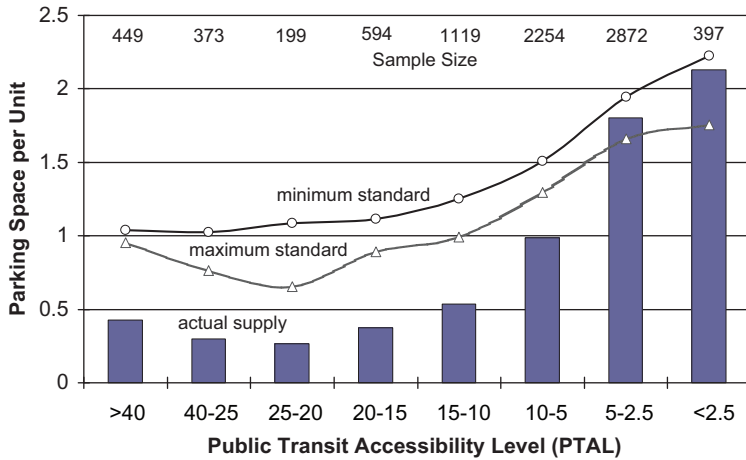


Figure 4. Changes in standards and actual parking supply based on transit accessibility ($N = 8257$).

crowded local streets. We also find some evidence. For example, one planning officer in Westminster, the only Central London borough with significant residential development, explicitly expresses this concern in our interview

[Borough council] members in respect of new private residential developments will normally be seeking car parking provision as close to the maximum standards. [They] do not accept car-free developments. In general, given the high levels of car ownership in the Borough and the pressure that existing on-street spaces experience, new developments should incorporate parking (Westminster planning officer).

This attitude is in stark contrast to the Inner London boroughs immediately adjacent to Central London, such as Camden, that have actively advocated car-free housing developments. Parking-free developments accounted for only 44 per cent of developments in the highest-density areas, but approximately 69 per cent in the second-highest-density areas.

The actual parking supply exhibits a U-shaped curve similar to the curve for the maximum standard and is consistently below the maximum allowed levels (apart from Outer London). The contrast between the highest-density and second-highest-density areas is even greater, with the former providing three times as many parking spaces per unit compared with the latter (0.66 and 0.22 spaces respectively). More developments provide parking (56 per cent compared with 31 per cent) and developments that provide parking also provide more spaces per unit (1.17 compared with 0.71 spaces). Similar differences are found for transit accessibility. The area with the highest level provides 0.43 spaces per unit on average, which is 43 per cent more than the area with the second-highest level. Although 36 per cent of developments in both these areas provide parking, areas with the highest transit accessibility provide more parking per unit (1.19 compared with 0.82 spaces). Differences in housing size might explain some but not all of these differences because at the level of parking space per bedroom, which tends to decrease as

housing size increases, the parking supply is still three times higher in the highest-density area than in the second-highest-density area and 24 per cent higher in the area with the highest transit accessibility than the next level.

Another possible explanation for the differences might be purely market-based. The benefits of providing parking might exceed construction and opportunity costs in areas with the highest levels of density and transit service. Developers might actually obtain a higher premium by allocating some floor space to parking instead of living space. This possibility is plausible for Central London because households in this area have the highest median income in the metropolitan area and the cost of one off-street parking space could equal the cost of a single-family home in other regions (Cowie, 2011; Hughes, 2011). This type of market might not exist in the areas immediately adjacent to Central London.

Discussion and Conclusions

This study has examined the impact of the London parking reform on off-street parking supply in new residential developments. We found that with the minimum standard but no maximum, most developments do not provide more than the minimum required. With the maximum standard but no minimum, most developments provide less than the maximum allowed. Off-street parking in new, independent, market-rate housing developments in 22 boroughs from 2004 to 2010 reduced by an approximately 40 per cent, a total of 143 893 parking spaces. Almost all of the reduction is caused by the elimination of the minimum standard, with a negligible 2.2 per cent reduction due to adoption of the maximum standard. Parking reform has dramatically

changed the structure of the residential off-street parking market.

However, we also found that the parking market actually provides more parking in areas with the highest density and best transit service than the immediate adjacent areas with a lower density and poorer transit accessibility because in the former areas parking can bring a higher premium to developers. The adopted maximum standard also follows this 'U-shaped' curve and accommodates this trend by setting up a higher cap in these areas than in the neighbouring areas. Compared with the minimum, the maximum standard is more responsive to the actual parking supply and does not restrict such demand in areas where it probably should. These findings are sufficient to answer the two research questions:

Answer to Q1: Yes, the minimum standard in London indeed forced developers to oversupply parking and, when it was removed, supply reduced by approximately 40 per cent.

Answer to Q2: Yes, the maximum standard is still necessary for an efficient parking market because the deregulated parking market appears to provide more parking in the densest and transit-richest areas, and does not take into account the high social cost of driving and the opportunity cost of transit.

The findings also shed light on the four different perspectives on the minimum and maximum standards. Each of them could find supporting evidence but to different degrees. The minimum standard indeed did not intervene in many developments in Outer London (perspective 4), but these developments only account for 26 per cent of all developments in London. The majority of the new developments are still

distorted by the minimum standard and responded to its removal dramatically and almost instantly; the same level of reduction occurred in 2004 (perspective 1). However, this reduction does not automatically form an efficient parking market. Complementary policies such as a restrictive maximum standard or a special parking tax are needed to control the 'excessive parking' in transit-rich and dense areas (perspective 2). However, the actually adopted maximum standard in the London reform is quite ineffective: even it is further reduced from the previous minimum standard. Only 22.4 per cent of new developments were capped by the maximum standard, representing a negligible 2.2 per cent housing units. Most of these developments were small developments in Outer London. In Central London, the maximum standard is relaxed to allow more parking, contradicting the objectives of both perspectives 2 and 3. This ineffectiveness might explain the general acceptance of the maximum standard in London even after the standard was repealed as a national policy in 2011.

One possible reason for the ineffective maximum standard is the concern regarding parking spillover in dense areas where local streets are often crowded. Solving this problem requires effective regulation of residential street parking, such as controlled parking zones, parking permits and parking pricing as well as better co-ordination between off-street and on-street parking policies such as car-free developments. Several boroughs have allowed further standard reductions in controlled parking zones where street parking was heavily regulated. Many local boroughs have encouraged car-free developments that not only provided zero parking but also made residents ineligible for street parking permits or admission to public garages licensed by local boroughs. Because car-free developments

accounted for approximately 25 per cent of all developments and 23 per cent of the total reduction in parking, the importance of this type of policy cannot be ignored.

In summary, the London parking reform provided solid evidence to understand two parking policies under heated debate: the minimum and maximum standards. The elimination of the minimum standard was highly effective in removing excessive parking, but still not enough to form an efficient parking market. The maximum standard could be a valuable supplement but without the effective control of on-street parking, its potential will be largely restrained. Efforts to co-ordinate on-street and off-street parking, such as car-free developments and controlled parking zones, might have improved the success of the parking reform and, if further developed, could well enhance the effectiveness of the new parking policies.

Notes

1. Eight boroughs either did not respond to our request or could not find the paper documentation of the minimum standard mostly adopted in the early 1990s.
2. Developments with a regional impact were defined by GLA as follows
 - A change in the number of residential units due to a change of use or conversion.
 - Any new-build residential units
 - A change of use or new-build of 1000 square metres or more of non-residential floor space in any of the non-residential use classes not monitored by the number of bedrooms.
 - A gain of seven bedrooms or more in classes C1 or C2 or in SG hostels or apartment-hotels.
 - A loss, gain or change in the use of public open space.
3. To reach a better understanding of why 22 per cent of the developments exceeded the maximum standard, we randomly selected 134 developments from this group and reviewed their decision reports. We

found that the minimum standard was applied to less than 29 per cent of these developments, or 6.4 per cent (22 per cent x 29 per cent) of the LDD sample.

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