The price to park: Assessing the determinants of Garage prices and their interaction with curbside regulation

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ABSTRACT

Curbside parking regulation has been widely implemented in cities around the world and increasingly they are adopting market-oriented perspectives. However, policy-makers face a complex task when they seek to foster efficiency in this market due to its intrinsic distortions (most notably, cruising in search of a parking space and garage market power). Theoretical studies stress that the right price differential between curbside and garage parking fees is critical in addressing this task; yet, the interactions between the two have received little attention to date in the literature. By drawing on a new self-constructed database for all the garages in the city of Barcelona, we empirically explore the determinants of garage prices. Our results indicate that prices are mainly influenced by fixed and variable cost drivers, the dominance position of the garage in its surrounding market and the garage's interaction with curbside parking. In this regard, we find that prices react to the scarcity of parking spaces in the street and to the curbside price fixed by the public authority. In short, this paper stresses the importance of the interactions between the curb and off-street garages when considering policy alternatives that might establish the optimal price differential.

Keywords: Garage parking; Curbside parking; Price; Parking regulation

JEL Codes: D40, L90, L98, R41, R42, R48

1 Introduction

Parking policy forms an integral part of mobility management strategies for tackling congestion and improving the environmental quality of big cities. Yet, policy-makers face a severe challenge when having to design efficient parking policies in a scenario of scarce resources, high supply expansion costs and an increasing attention to quality of life (see Mingardo et al., 2015). Curbside parking regulation has been widely implemented (and even expanded), but prices have typically been held relatively low. To address excessive curbside demand, parking supply has been expanded through the provision of garage facilities, despite economists' recommendations of the need to solve the common-property resource problem (Anderson & De Palma, 2004; Shoup, 2005).

Although curbside regulation has begun to adopt market-oriented perspectives[1], the question of parking charges remains controversial from a political economy perspective. Some interest groups, including retailers and motorist associations, lobby for lower prices, while others, most notably environmentalists, seek the introduction of policies that will limit private transport use, seeing parking prices as a readily and more feasible alternative to road pricing. Private operators already provide a sizable off-street parking supply, to the extent that the vast majority of parking spaces in European cities are provided by off-street parking garage facilities (Rye & Koglin, 2014). Municipalities are responsible for curbside parking and in many instances they also manage a significant share of the garage supply[2]. Yet, the interactions between curbside and garage parking have received little attention from either researchers or practitioners in spite of its crucial role in the parking policy puzzle (Gragera & Albalate, 2016).

Theoretical studies on the spatial competition between privately operated garages and curbside parking stress the need to maintain an appropriate price differential between curbside and garage fees. By doing so, it should be possible to achieve social optimum eliminating cruising for parking by allocating excessive curbside demand to available garage supply (Arnott, 2006, Inci & Lindsey, 2015 and Arnott et al., 2015). The external cost of cruising is very relevant, as shown by Van Ommeren et al. (2011) and Inci et al. (2015); and the role of the price differential is supported by the evidence of the lengthy cruising times experienced in cities where there is a large differential in favor of garages (Shoup, 2005) and the short cruising times for those that face higher curbside

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[1] See Ottosson et al. (2013) and Pierce & Shoup (2013) for evaluations of the cases of Seattle and San Francisco, respectively.

[2] See ITDP (2010, 2011) and Gragera & Albalate (2016) for reviews of the US, Europe and the specific case of Barcelona, respectively.

fees (Van Ommeren et al., 2012). The importance of this is further stressed by the fact that drivers have been shown to be willing to pay more for curbside parking (Kobus et al., 2013 and Gragera & Albalate, 2016). This further exacerbates the pricing distortion when garage fees are higher than those at the curbside and leads logically to calls for an integrated market approach.

This paper contributes to the literature by exploring the determinants of private garage prices in a big European city, focusing specifically on cost shifters and on the impact of curbside regulation on garage price-setting decisions. As such, the paper contributes to the scarce literature on garage prices and offers the first analysis of the interactions of these prices with curbside regulations (fees and the regulated use of spaces). We estimate a price equation that accounts for a variety of price determinants including (1) cost drivers; (2) the market structure of the surrounding area; (3) specific garage characteristics that customers might value; and (4) the specific curbside regulation of the given area. Our results are useful for examining potential policy alternatives for setting the optimal price differential capable of counterbalancing private garages' localized market power. To the best of our knowledge, this is the first empirical paper to investigate the interactions between curbside and garage parking prices.

The paper is organized as follows. Section 2 reviews the relevant literature on the question addressed herein. Section 3 briefly presents the data and the model considered. Section 4 presents and discusses the results of the model, while section 5 offers the main conclusions and presents the policy implications of our results.

2 Literature review

Few empirical studies of competition in the garage market have been published and those that have draw on empirical analyses of industrial organization: see, for example, Froeb et al. (2003), De Nijs (2012), Choné & Linnemer (2012) and Lin & Wang (2015). One of the common findings of these studies is that the relevant market is restricted to an area covering no more than a few blocks, as drivers are reluctant to walk further due to walking costs. These analyses also find that the intensity of competition seems to be negatively related to overall price levels and positively related to price discrimination with respect to the duration of parking.

Lin & Wang (2015) is the only previous study to have examined price determinants, with a specific focus on the relationship between competition and price discrimination in Manhattan's garage market. They investigate how market concentration affects overall garage prices and the curvature of their hourly price schedules. First, they estimate a price equation for 602 garages and the 1 hour fee for a car entering each garage at 12 pm. They assume that drivers only park within a certain distance of their eventual destination, defining the relevant market as the area circumscribed to a buffer with a 0.3- or 0.5-mile radius. They assume a log-linear relationship between prices and

explanatory variables, which include various competition measures (market concentration and the fraction of garages in the market owned by the observed garage company) and neighborhood characteristics (land value, median family income, zoning density and dummies). Their results suggest that competition drives the overall price level down so that a unitary decrease in the HHI[3] reduces the price by 95%, while a unitary increase in the owned share of competitors increases the price by 53%. They also show that zoning density is positively associated with garage prices.

Second, they estimate the price curvature parameter with respect to parking duration, computing 1- to 24-h prices at each garage for cars entering at 12 pm and 8 am. They then seek to explain this estimated parameter by means of a competition measure. Their results show that price discrimination diminishes as competition intensifies, indicating that prices for short-term parking decrease at a proportionally higher rate than prices for long-stay parking. They account for their findings in terms of the differences in the respective search behaviors of short- and long-stay parkers. The latter are assumed to undertake more intense searches, as their expected gain is greater and more likely to be repetitive.

Similarly, De Nijs (2012) applies a difference-in-differences estimation using 1- to 12-h price menus before and after the merger of garages in Paris, using the identification strategy proposed by Choné & Linnemer (2012) to construct the counterfactual group for retrospective merger evaluation. He found that the takeover of GTM by Vinci, which reduced competition in the French capital, increased the price level by 5%, while proportionally larger discounts were applied to long-stay parkers resulting in further price discrimination. Using their data on market characteristics, we can roughly compute that the merger gave rise to a 0.07 increase in the HHI index of the garages' market share. This implies that a unitary increase in the HHI represents a 68% increase in prices. Likewise, Choné & Linnemer (2012) reported that the merger increased city-owned garage prices by 3%[4].

Froeb et al. (2003) analyze the role of capacity constraints in the welfare effects resulting from the merger of parking lots. Their computational experiments suggest that when capacity is binding on the merging firms this factor attenuates merger price effects much more than the corresponding effect in a scenario without a merger, due to the prevention of share-stealing quantity responses.

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[3] Herfindahl-Hirschman index (HHI) is computed in this particular case as the squared fraction of facilities managed by each company within the relevant market buffer around each garage.

[4] The authors stress that city-owned garages under concession contracts are subject to price-cap regulations, even though this constraint has never been binding.

However, garages do not only compete with each other, they also compete with curbside parking spaces. Previous empirical studies have not specifically integrated this competition in their analyses[5], although the relevance of this interaction has been both empirically and theoretically addressed by the transport economics literature. The relationship between garage and curbside parking has been empirically tested by Kobus et al. (2013) and Gragera & Albalate (2016). Both studies conclude that these goods are not perfect substitutes and that drivers prefer curbside parking. Likewise, they both find that users are willing to pay a premium for curbside parking, ranging from €0.37 to €0.60 per hour in Almere (Netherlands) and €0.55 per hour in Barcelona. Additionally, Gragera & Albalate (2016) show that curbside parking regulations are a key determinant of garage demand, and that the characteristics of curbside parking spaces (parking allowance and time limits) play only a minor role while the pricing strategy is the most efficient trigger of behavioral change.

The evidence derived from theoretical studies supports claims for an integrated market approach. Indeed, spatial competition models that integrate both garage and curbside parking have been proposed by Arnott (2006) and Inci & Lindsey (2015). Both studies show that the equilibrium in the garage market is reached when the full price of parking at the curb (including the search cost) is equated to the full cost of parking in a garage (including the walking cost) and adjusted through the variation in the levels of cruising for curbside spaces.

Inci & Lindsey (2015) propose a Salop model with two types of driver visiting destinations that are uniformly distributed around a circle. Garages are privately operated and discretely located at uniformly spaced distances, while curbside parking is publicly operated and is ubiquitous. Garage parking is not capacity constrained. The utility derived from curbside parking is endogenous as it decreases with the number of drivers choosing the curb. This generates interdependence between submarkets as garages do not compete for customers with each other directly but rather via curbside parking. The parking market is distorted by both the negative externality associated with cruising for empty curbside spaces and the garages' localized market power attributable to their discrete location, which they exploit by setting fees above the marginal cost. Garage operators take advantage of curbside congestion, as they do not internalize the search externality. Inci & Lindsey (2015) stress that the market failure level varies with the distance between garages, the unitary search costs associated with cruising and the level of curbside fees.

A common finding reported by both Arnott (2006) and Inci & Lindsey (2015) is that first-best pricing, through the allocation of excessive curbside demand to garage parking,

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[5] Only Froeb et al. (2003) include an outside/no-purchase option, though it is not specifically considered as curbside parking, and they assume that garage parking is always preferred to the outside option.

can be achieved by setting optimal curbside fees whenever garages set their prices at the marginal cost. Efficiency can also be achieved by simply setting the right fee differential between garages and the curb, as even garages set their prices freely. Inci & Lindsey (2015) suggest that this can also be achieved regardless of curbside fees by regulating garage prices. However, Gragera & Albalate (2016) claim that such regulation is largely unfeasible due to political constraints, which discourage private investment and compromise overall off-street parking supply. The authors also advocate the need to investigate the possibility of introducing public competitors so as to discipline the private sector and to explore the use of public-private partnerships that can take advantage of the curbside revenue cross-subsidy to achieve the optimal fee differential.

In the presence of price differentiation, Inci & Lindsey (2015) suggest that efficiency can be achieved by maintaining the appropriate fee differential for each driver type (short-/long-term). They acknowledge that curbside differentiation might be difficult due to current meter technology[6] and political constraints and suggest that generally only second-best pricing can be achieved by implementing a uniform hourly fee.

In general, optimal parking policies depend on city-specific conditions, which determine the way in which competition affects garages and curbside parking (Inci & Lindsey, 2015). The complex relationship between these policy instruments highlights the need to implement an integrated market regulation approach (Gragera & Albalate, 2016).

The aim of this paper is to investigate the pricing behavior of private garage operators, expanding the empirical evidence presented in the previous literature by including both cost shifters and the characteristics of curbside parking regulation. In this way, we hope to provide practitioners with insights as to how to address policy interventions that might overcome distortions in the parking market. As suggested above, the pricing behavior of private garage operators is critical in this task, but it is an aspect that has been largely neglected in the empirical literature.

3   Garage price determinants

3.1   The model

To analyze private garage operators' price-setting behavior, we estimate a price equation for a cross-section of garages as shown in (1). We assume that the price of each "home" garage (p_i) is a function of its characteristics (c_i), market structure conditions (m_i), curbside parking regulation (k_i) and public transport availability (t_i) within a given catchment area around each facility (with buffer radius D). The price

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[6] Note that parking payment apps, which are now available, can solve this issue.

equation is estimated by least squares, using cluster robust standard errors to account for any possible remaining heteroscedasticity. We chose a log-linear functional form[7], as also adopted in Lin & Wang (2015).

The price function also depends on area specific effects – most notably, potential demand and cost shifters, which we introduce to control for unobserved heterogeneity. In our case, we introduce district level specific effects. This strategy also allows us to control for the potential endogeneity of curbside fees, given the expectation of higher curbside prices when higher garage fees are in place (although these might be fixed by the public authorities, as suggested in Madsen et al., 2013). However, it does not allow us to fully control for the potential endogeneity of market concentration measures, where there might be a bias towards zero[8]. The price function also depends on an idiosyncratic error term (ε_i).

$$p_i = f(c_i, m_i, k_i, t_i, \alpha_i, \varepsilon_i) \qquad (1)$$

where

c_i = matrix of garage characteristics (capacity, operating hours, associated activity)

m_i = matrix of garage market structure characteristics (market concentration, ownership share)

k_i = matrix of alternative curbside parking regulation (parking spaces, types and fees)

t_i = matrix of public transport availability (train or metro stations)

α_i = area-specific fixed effects

ε_i = idiosyncratic error term

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[7] We also tested two alternative functional forms (linear and log-log) and opted for goodness-of-fit (log-likelihood).

[8] Lin & Wang (2015) also highlight that area specific effects might only partially solve the problem of $\text{Cov}(\varepsilon_i, c_i) \neq 0$, as performance might feed back into market structure (Evans et al., 1993). This could be solved by means of instrumental variables, but we have no information about variables that correlate with market structure while being uncorrelated with unobserved factors that affect garage prices. Even the garage market faces huge entry barriers (high sunk costs) and past evidence shows extremely low entry/exit rates in Barcelona. We must therefore be cautious when making any interpretation of the market concentration variable even it is not the focus of our analysis. However, we include it in the model for sake of comparability with Lin & Wang (2015).

This approach expands the considerations made by Lin & Wang (2015) by including both cost shifters and curbside regulation characteristics, which have not previously been taken into account in the empirical literature.

3.2 The data

In order to estimate this model, we conducted a cross-sectional inventory survey of all public access garages currently operating in Barcelona[9]. For each garage, we gathered information on their physical characteristics and price menus. The physical characteristics that were not directly observable were self-reported by garage employees to our interviewers. The same approach was adopted for price menus that were not openly displayed. The information was gathered in two waves. The first was conducted from 9-27 February, 2016. The second was organized to correct missing information and corroborate data, and took place from 1-15 March, 2016. We collected complete information on prices for 508 garages, representing a total of 114,417 parking spaces.
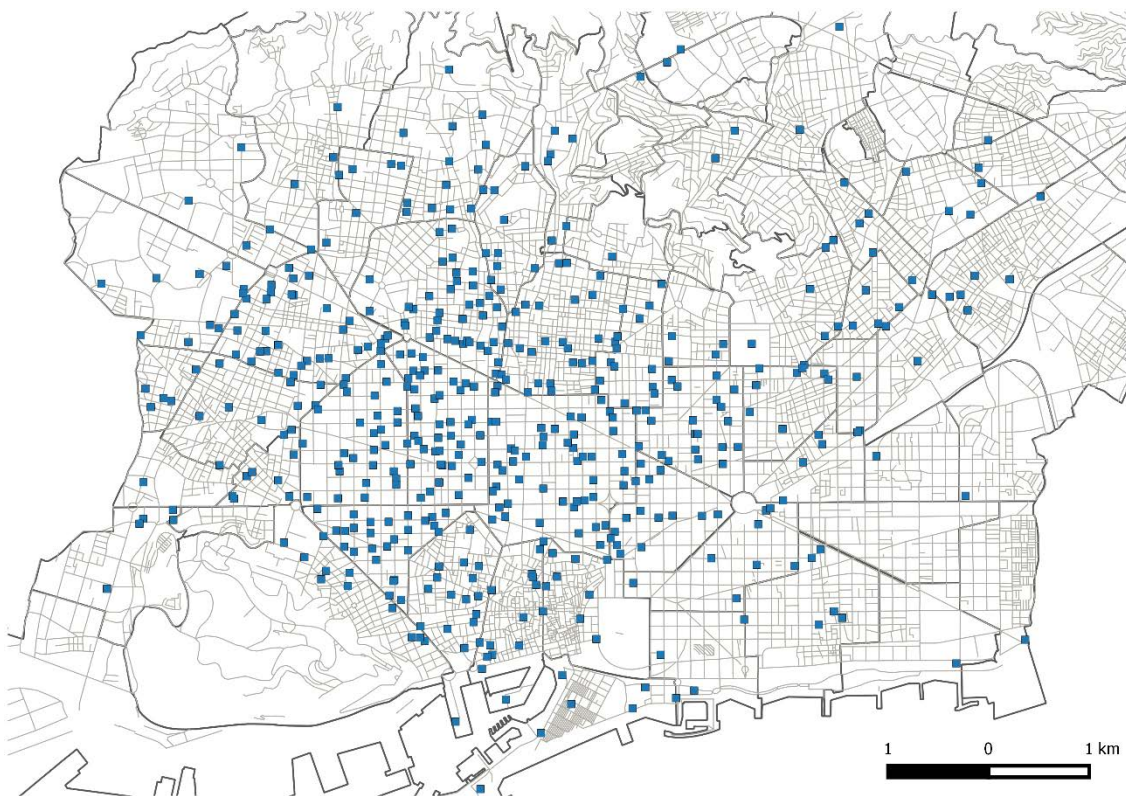

Figure 1. Public access garage inventory in Barcelona (Source: Survey)

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[9] BSM provided us with various price studies, but sample homogeneity was not maintained across these studies and information gathering characteristics varied. This precludes us from using this data to conduct a panel approach.

The garage market in Barcelona is led by the public sector, with a public operator (BSM) directly managing 40 facilities and indirectly participating in a further 15 in an institutional public-private partnership (PPP) known as BAMSA. The principal private operator, SABA, participates as the sole private shareholder in this PPP. In addition, Barcelona City Council owns a further 50 facilities that are operated under a concession regime subject to price cap regulation. Despite its very limited presence, there exists another public operator owned by the provincial entity "*Consell Comarcal del Barcelonès*" (REGESA), which owns four facilities in the city.

The private sector is atomized in Barcelona, with only NN (a local real estate company) and SABA (world leading parking operator) managing a relatively large number of garages – with 26 and 17 facilities, respectively.[10] Other multinational parking operators, including INDIGO, EMPARK and INTERPARKING, manage/own between four and five facilities each. However, almost 80% of the private facilities are managed by a garage operator that is affiliated to the garage union (*Gremi de Garatges de Barcelona*[11]). The global Herfindahl-Hirschman index (HHI) for market concentration, computed as the square of the share of managed facilities, is just 0.01[12], given that 289 garages are managed by single-facility companies. It should also be stressed that the leading role played by the public sector is a reflection of the market's inherent entry barriers that are largely dependent on land acquisition costs. The public sector has been able to reduce these by placing garages underground on public land.

Although we collected information for 508 garages, our dataset is restricted to just 391[13], as we do not include the garages of the public operator and those operating under concessions in the estimation. The reason for this is that the prices charged by public garages are fixed by the public authority and respond solely to political

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[10] It is relevant to stress that only three of the facilities managed by SABA are out of the concession regime

[11] http://www.gremiodegarages.net/

[12] Figures derived from the information available in de Nijs (2012) and Lin & Wang (2015) suggest that the case of Barcelona might be somewhat extreme. For the case of Paris, we can compute an equivalent market concentration figure yielding an HHI of 0.11 before and 0.18 after the Vinci/GTM merger. For the case of New York City this is not possible, but the authors report that four companies control about 50% of facilities, the six biggest controlling 60%, with 15% being controlled by companies that own more than one garage (20) and the remaining 25% being operated by single-garage companies. The equivalent figures for Barcelona are 20, 22, 20 (37) and 57%, respectively.

[13] Note that we further eliminated from the simple eight facilities that only partially reported relevant information and show missing values for the explanatory variables included in the model.

decisions, not to demand or changes in market structure[14]. Here, it should be stressed that in the case of Barcelona all concessions are subject to price cap regulation, which is usually binding, in contrast to the situation reported by Choné & Linnemer (2012) for the case of Paris. In short, we study the determinants of those garage prices that are freely set by private operators.

Price information is typically visible to drivers on entering the garage. Price menus establish a differentiated fee per minute depending on parking duration, generally decreasing with the length of the stay (though from the customers' point of view the calculation of the price to be paid is far from straightforward). There are also discounts for overnight stays of 8, 12 and 24 h, but these are not always clearly stated. Discounts for subsequent days are also quite generally applied. However, price differentiation with respect to the time of the day is practically non-existent in Barcelona. Discounts are also offered to frequent costumers, purchasable in advance, and special rates or valet services for commercial and recreational activities. All in all, it should be stressed that drivers, in general, lack perfect information about both prices and the facilities available to them (Albalate et al., 2016). However, note that here the dependent variable in our model is measured as the price for the first hour of parking computed according to the "official" fees and not applying any specific discount. In this regard, we follow the approach taken in Lin & Wang (2015).

We introduced all this information, plus curbside parking and neighborhood characteristics, in a database using geographic information systems software (QGis). In order to compute spatially related explanatory variables, we specify the catchment area around each garage facility as a buffer of 500m[15]. The curbside information has been provided by BSM and the neighborhood data is made publicly available by the Barcelona City Council Statistics Department.

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[14] BSM sets a uniform price for all its facilities, aiming at cost recovery and spatial fairness based on a City Council Agreement (i.e., Mobility and Security Commission Act, 12 July 2007). Contracted-out facilities set prices based on the price cap regulation applied.

[15] We estimated the model for a continuum of buffers, yet we only report the results for the 500m (0.3 mile) buffer. This is our preferred relevant market definition as it is the largest buffer with statistically significant estimates for the variables at stake. Note that the minimum feasible radius is constrained to the existence of sufficient variation in the data for these variables. This 500m radius allows us to compare our results with Lin & Wang (2015) and matches the maximum acceptable outdoor walking distance criterion described in Smith & Butcher (1994). Additionally this distance is generally used by practitioners as a rule of thumb for a garage catchment area.

3.3 Variables

We considered a variety of garage price determinants. In this section, we describe the variables employed in the analysis and discuss their expected impact on our dependent variable. Table 2 shows their descriptive statistics.

3.3.1 Garage characteristics (costs and quality drivers)

First, we account for garage capacity (CAPACITY) by including the number of parking spaces in each garage facility. This variable is expected to capture the cost component associated with investment costs related to construction (potential scale economies), but it also reflects the scarcity of the offer in relation to potential demand. The question of scarcity may also play a role in price determination, as garages will tend to set higher mark-ups the higher the potential demand is with respect to their available capacity.

Similarly, we include a land value proxy computed as the real estate average selling price (LANDVALUE) in euros per square meter[16]. This is expected to capture the differences in investment costs but also, in part, the intensity of demand in different areas. The inclusion of this variable precludes us from using other neighborhood characteristics so as to avoid issues of multicollinearity (i.e., zoning density, level of economic activity, etc.). It should be stressed, however, that the correlation between CAPACITY and LANDVALUE is low (-0.07), so while both variables proxy investment costs they capture different dimensions of it, with CAPACITY capturing garage size and LANDVALUE capturing the investment cost per unit for the corresponding garage size.

We also include the number of operating hours per week (OPERHOURS), in order to account for personnel costs and other expenses associated with the operation of the facility. We expect to find a positive impact of both variables on garage prices.

Additionally, we include other garage characteristics that can be expected to impact price-setting behavior. Using dummy variables, we test whether garage type (within a building, stand-alone or associated with a specific activity), payment options (manual, automatic or teletac) as a proxy of technology and price salience (visible from the outside, only visible inside or not made visible at all) translate into a price differentiation. Similarly, we would also expect garages that invest more in technology (occupancy sensors, guiding systems and more advanced payment tools) to show a different pricing behavior, based on higher investment costs (albeit presumably lower personnel needs). Moreover, there is an expectation that high technology garages will

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[16] Source data are provided at the neighborhood level, so we compute the weighted average real estate selling price proportional to the neighborhood area that overlaps with the relevant market buffer.

attract drivers with a higher willingness-to-pay due to a perception of greater quality (e.g., some companies offer teletac to employees using company cars to facilitate the control of the firm's expenses). Price salience is not expected to yield any differences, given that prices categorized as visible are typically not seen by drivers until they actually enter the facility. As such, drivers appear to rely heavily on previous knowledge (Albalate et al., 2016).

3.3.2 Market structure

Our model also accounts for market structure factors by including a market concentration measure, specified as the Herfindahl-Hirschman index (HHI). We compute this index as the squared fraction of facilities managed by each company within the relevant market buffer around each garage[17]. This figure moves between 0 and 1, with the latter value denoting a monopoly firm.

We also include the share of competitors owned by the same company as that which owns the home garage (SHOWN) within the relevant market buffer, as a measure of its market power. In addition, we test whether the actual level of competition induced by the presence of contracted-out garage facilities (SHCONCES) within the relevant market buffer has an impact on the pricing behavior of private operators. This variable is measured as the proportion of competitors to the home garage that are contracted out by the City Council (recall, all concession terms establish a price cap). Likewise, we include alternative specifications in order to check whether publicly managed (BSM), mixed (BAMSA) and contracted-out facilities have any impact, taken separately or grouped, on private sector prices. The leading role played by the public sector in Barcelona suggests the need to test whether the actual pricing strategy followed by the City Council helps bridge the pricing efficiency gap, as reported in Gragera & Albalate (2016).

Finally, the garage union dummy is included to determine whether the behavior of affiliates differs from that of non-affiliates. We consider affiliation to be relevant as the union has, in the past, been fined by the Antitrust Agency owing to the garage subscription and hourly price recommendations made to its affiliates[18]. Note, however, that any collusive behavior analysis falls outside the scope of this paper.

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[17] Alternative specifications were also computed using the share of garage parking spaces. The specification chosen is equivalent to that used in Lin & Wang (2015) but with the opposite sign; however, they suggest that this is the one most closely related to garage pricing behavior

[18] See *Comisión Nacional de los Mercados y la Competencia* (CNMC) Expte. 336/93

3.3.3   Curbside parking and transit (outside options)

Our main contribution is the inclusion of curbside regulation features in the model in an effort to account for the impact of on-street alternatives to garage parking. We account for the level of supply using the density of commercial and mixed-use parking spaces (DENSPACES) set within the relevant market buffer, measured in spaces per hectare[19]. We also include the weighted curbside price per hour (CURBFEE) to capture the way in which private operators respond to curbside price setting, as both theoretical and empirical studies stress its relevance in the allocation of parking demand.
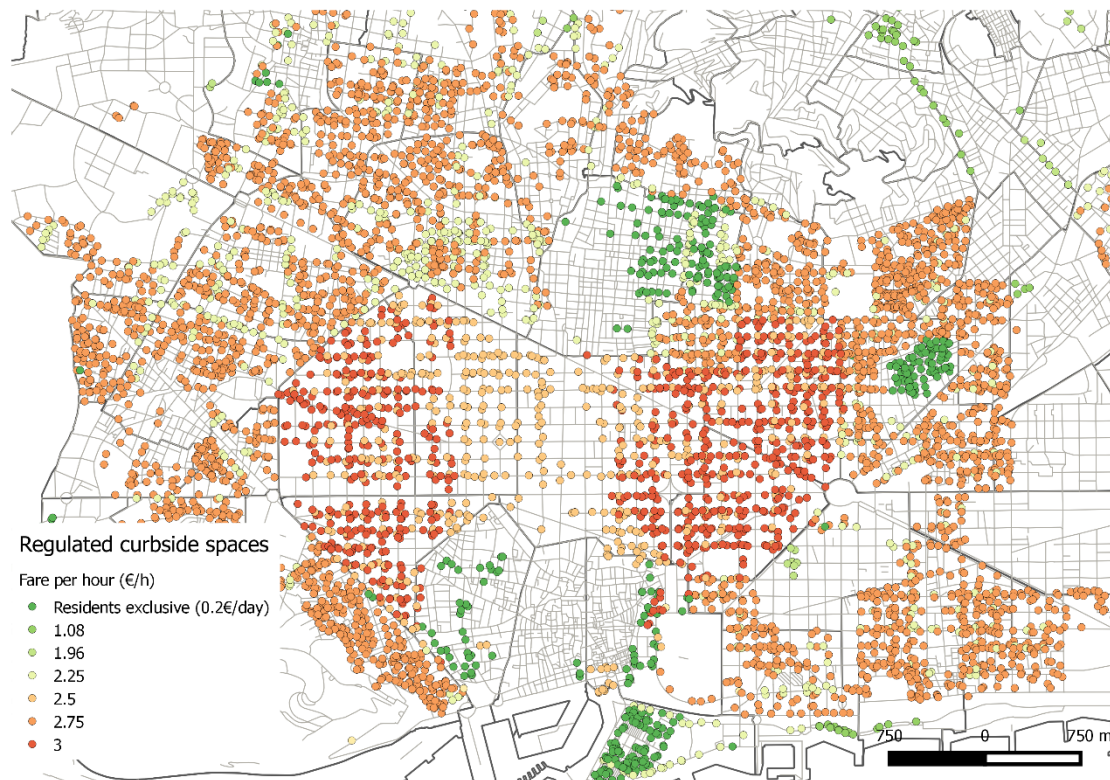

Figure 2. Curbside regulated parking space fees per hour (Source: BSM)

Note that Barcelona applies a city-wide parking regulation policy, known as ÀREA, in which no free curbside spaces are available, except in the city's outskirts (see Figure 2). A specific branch of the public operator (BSM) is responsible for the 55,000 regulated curbside spaces with dedicated uses (i.e., commercial, residential, mixed uses, etc.). These spaces are split into 22 regulatory zones with four fee/hour bands for commercial spaces and two bands for mixed use spaces (see Table 1). Fee bands are set according to actual parking demand, although no occupancy level target is fixed. It should be stressed that the curbside pricing strategy presents no evident links with garage fees, not even in the case of the BSM-managed garages.

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[19] Note that 1 hectare is equivalent to a 10,000 square meters, equivalent in turn to a standard block in the *Eixample* district of Barcelona (CBD).

Band	Commercial spaces		Mixed use spaces	
	Fee	**Time limit**	**Fee**	**Time limit**
A	2.50 €/h	1-2 h	3.00 €/h	1-2 h
B	2.25 €/h	2 h	2.75 €/h	1-2 h
C	1.96 €/h	3 h		
D	1.08 €/h	4 h		

Table 1. Curbside regulated space fee scheme for commercial (blue) and mixed use (green) spaces

Additionally, we include a measure of the garage's position of dominance over the curb to account for relative scarcity, measured as the ratio of home garage parking spaces to curbside spaces for commercial and mixed uses (GCratio).

To capture additional options to garage parking, we also include a measure of the availability of high capacity transit services, based on the number of access points to train, subway or tramway stations within the relevant market buffer area (TRANSIT). This measure captures both the availability and intensity of these services, as the number of station access points is correlated with the number of lines serving the area and, to a certain extent, with the volume of passengers. Alternative specifications are tested by means of a robustness check (dummy variable for the availability of a station).

Variable	Obs	Mean	Std. Dev.	Min	Max
FEE1stH	396	3.377449	0.5312005	1.5	6
CAPACITY	396	171.053	160.9266	9	1500
LANDVALUE	396	3527.959	724.9933	1517.27	4996.998
OPERHOURS	396	123.3283	45.17525	18	168
HHI	396	0.1240499	0.1636493	0.03125	1
SHOWN	396	0.0026863	0.0150682	0	0.1428571
SHCONCE	396	0.1224065	0.111487	0	1
TRANSIT	396	8.373737	5.80063	0	40
DENSCURB	396	11.20878	6.228112	0	25.75764
GCratio	392	52.51028	304.9318	0.4384977	5609.987
CURBFEE	392	2.654956	0.2113508	1.08	2.919482

Table 2. Summary of descriptive statistics for the variables included in our model. Dummy variables are not included.

4   Results and discussion

In this section, we present and discuss the results of the estimation of the price equation for our data sample. The results for the various alternative specifications are reported in Table 3. We build up the model from (1) to (4) by successively incorporating additional groups of variables: thus, Model (1) includes garage characteristics that account for the cost and quality drivers; Model (2) adds market structure characteristics; Model (3) adds both curbside parking and transit options; and, Model (4) also includes area specific-effects. It is apparent that the parameter estimates differ

markedly with and without the area-specific effects and so Model (4) is our preferred specification. However, the only area-specific effect that is shown to be statistically significant is that of the district of St. Andreu (a residential district that concentrates low income levels and less added-value economic activities), where garages charge a first hour fee that is 22.5% lower than that charged in the reference area (Ciutat Vella – historic district).

VARIABLES	(1)	(2)	(3)	(4)
CAPACITY	-0.000124**	-0.000135***	-0.000142***	-0.000109**
	(4.79e-05)	(4.88e-05)	(4.99e-05)	(4.45e-05)
LANDVALUE	6.74e-05***	6.30e-05***	6.33e-05***	3.31e-05**
	(9.88e-06)	(1.09e-05)	(1.13e-05)	(1.31e-05)
OPERHOURS	0.000705***	0.000697***	0.000755***	0.000646***
	(0.000190)	(0.000196)	(0.000201)	(0.000201)
PAYautom.	-0.000485	-0.000117	-0.00267	-0.00576
	(0.0152)	(0.0154)	(0.0156)	(0.0157)
PAYteletac	0.0673*	0.0538	0.0504	0.0561*
	(0.0366)	(0.0348)	(0.0348)	(0.0339)
TYPEactivity	-0.109***	-0.0974***	-0.0965***	-0.0811***
	(0.0249)	(0.0258)	(0.0256)	(0.0270)
TYPEstand-alone	0.0128	0.0178	0.0112	0.0132
	(0.0261)	(0.0277)	(0.0282)	(0.0298)
SALIENCoutside	0.0249	0.0224	0.0180	0.0283
	(0.0358)	(0.0361)	(0.0364)	(0.0357)
SALIENCinside	0.0502	0.0487	0.0471	0.0488
	(0.0328)	(0.0327)	(0.0328)	(0.0313)
HHI		-0.0599	-0.0664	-0.0348
		(0.0620)	(0.0597)	(0.0610)
SHOWN		0.532***	0.557***	0.574***
		(0.197)	(0.204)	(0.218)
SHCONCE		0.108	0.112	0.0818
		(0.0743)	(0.0801)	(0.0944)
UNIONaffiliate		0.0119	0.0125	0.00708
		(0.0220)	(0.0228)	(0.0232)
TRANSIT			2.00e-05	-0.000425
			(0.00174)	(0.00182)
DENSPACES			0.000326	0.000700
			(0.00143)	(0.00171)
GCratio			-1.87e-05**	-1.90e-05*
			(8.20e-06)	(9.98e-06)
CURBFEE			-0.0133	-0.115**
			(0.0396)	(0.0557)
Constant	0.870***	0.871***	0.900***	1.274***
	(0.0512)	(0.0602)	(0.133)	(0.184)
Observations	395	395	391	391
R-squared	0.234	0.246	0.247	0.283

Table 3. Estimated alternative specifications of the price equation for a 500m-buffer around each garage facility. (1) incorporates only costs and garage characteristics, (2) adds market structure, (3) adds outside options; and (4) includes area-specific effects. Standard errors are reported in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. Area-specific dummies are not reported.

Table 3 shows that the result for CAPACITY (estimation 4) is negatively related to the garage fee, reflecting both the cost and scarcity dimensions. The sign obtained can be interpreted as evidence of horizontal scale economies in garage construction, as

suggested by Arnott (2006)[20], so that garages with higher capacity would be able to operate at lower marginal costs and, thus, charge lower fees. However, it also reflects the fact that in areas of excessive demand (when the garage becomes capacity constrained), the garage might well set a higher mark-up, implying that low capacity garages set higher fees. As Froeb et al. (2003) note, we can expect a garage with demand exceeding capacity to set prices in such a way that potential demand at the given price is equated to available capacity. Overall, we find that each additional garage parking space reduces the fee for the first hour by 0.01%.

LANDVALUE is found to be positively related to prices, reflecting both the cost and demand dimensions. High-value residential areas are also characterized in our data sample by high levels of economic activity which attract demand to the area. This correlation precludes our disentangling the land value from the zoning density effect, as is done in Lin & Wang (2015). Here, a 1,000€/m2 increase in the land value translates into a 3.31% increase in the garage fee. This reflects one of the main entry barriers to the market and explains why new entries have been largely undertaken by the public sector by means of publicly managed or contracted out facilities located underground in public spaces. This is the only way to alleviate land acquisition costs in a densely populated city.

The cost measure of OPERHOURS, which reflects the operational costs associated with the number of opening hours, is found to increase the fee for each additional hour by 0.06%. We also find that the type of payment tools employed, as a proxy of investment in technology, shows a positive relation with prices. Specifically, we find that garages deploying teletac payment systems (PAYteletac = 1) charge 5.61% more for the first hour of parking, ceteris paribus. In general, these facilities also employ parking space sensors and guidance systems that increase drivers' perceived quality. However, note that this variable might also capture a specific demand segment, which shows a greater willingness-to-pay (given that teletac is usually provided by firms to employees using company vehicles in order to facilitate the monitoring of expenses).

We also find a statistical difference in the pricing behavior of garages associated with a pre-defined activity (TYPEactivity = 1 for hotels, shopping centers, supermarkets and cinemas). In such cases, parking is seen as a commodity to attract customers and the excess capacity is made available to non-clients as a means of increasing revenue. We find that facilities of this type charge prices that are 8% lower than those of their standard counterparts, regardless of the potential discounts the latter may apply to their customers. Ersoy et al. (2016) argue that parking is a commodity bundled together with the commercial activity to attract customers, and cost recovery does not necessarily

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[20] The author suggests that scale economies arise from the fixed cost (and space) imposed by the need for a ramp that connects different parking floors. We tested for the linearity of scale economies but NUMPLACES^2 was not statistically significant.

dictate the price setting behavior. Indeed, parking is a loss-leader for shopping activities. Our result is very much in line with this argument in the sense that parking operators associated with commercial activities appear to see each driver as a potential customer, thus, further expanding the loss-leader concept. This implies that the lower than average garage fees in facilities tied to commercial activities may result in the imposition of a positive externality on other users. Thus, the public authorities may encourage other facilities to open up their available capacity to the general public so as to help close the price efficiency gap. In this regard, our data also show that garages tied to commercial activities do not generally price discriminate with respect to the length of stay, probably as this would create further incentives for long-term parkers to avoid high fees by simply becoming customers with the right to discounts.

No significant impact is found in relation to price salience, either for facilities advertising their prices outside the garage or those displaying them inside the parking lot. Based on the discussion of imperfect information as reported in Albalate et al. (2016), this suggests that actual price salience is not relevant as knowing the prices appears to impose an excessive cognitive burden on drivers and they fail to integrate this information properly in order to affect their decision.

In the case of the market structure variables, we find no statistically significant relationship between prices and market concentration (HHI), based on the fraction of garages owned by each company, unlike the findings reported in Lin & Wang (2015). But, in line with these authors, we find that the share of garages owned by the home garage company does have a positive impact on prices (SHOWN), where a 1% unitary increase in the share of owned competitors increases the price by 0.57%. In this case, a market dominant position gives garages the opportunity to further exploit their localized market power. This figure closely matches that reported by Lin & Wang (2015) for the case of New York City.

These results suggest that the general statement that competition drives down prices (as proposed by Lin & Wang, 2015) might not always directly transfer to all parking markets, as it appears to be highly dependent on specific market characteristics. Some differences may arise simply from disparities in parking regulation. The number of regulated curbside parking spaces in NYC is much lower than that in Barcelona; and many blocks have been designated as parking-free spots. This might explain the huge price differential between garages and the curb in NYC. In the case of Barcelona, competition with on-street parking is much more intense and fee differentials are much lower.

However, it might also be that this difference arises from the presence of imperfect information (see previous discussion in relation to the findings of Albalate et al., 2016), an argument that has long been recognized in the information economics literature (Stiglitz, 1989). In atomistic markets, such as the parking market in Barcelona, it is

difficult for drivers to keep abreast of price changes and the best available offers. This means garage operators have few incentives to instigate price cutting strategies that might even yield a negative relation between market concentration and prices. Garage markets with low price dispersion reduce the incentives for drivers to gain information, given that the expected gain from the search is lower than its cost. In this regard, a number of differences between NYC and Barcelona are striking. Lin & Wang (2015) report a 1h parking price of $12.67 with a standard deviation of $4.4 (34%); while we find a mean price of €3.38/h with a standard deviation of €0.53 (15%). Thus, we would expect the drivers of Barcelona to be less informed, which might translate into less true competition between garages (as confirmed by Albalate et al., 2016). This imperfect information hypothesis is further supported by the fact that when our sample is restricted to the CBD (*Eixample*), the most atomistic of the city's districts, this negative relation is clearly apparent. Thus, we can conclude that the specific impact of imperfect information and its interplay with competition needs to be examined in greater depth in the parking market.

Additionally, and somewhat unexpectedly, we found no evidence that public garage provision has any impact on private garage operators' price setting behavior (SHCONCES). Moreover, no alternative specification considering publicly managed, mixed use and contracted out facilities, separately or as a group, yields a statistically significant impact. However, this is perhaps unsurprising if we take into account the fact that the public operator's price setting behavior does not deviate greatly from that of the private operators. The City Council's price setting objective for both publicly managed (BSM) and contracted-out facilities resembles that of revenue maximization taken by the private sector. The City Council ensures cost recovery and return on investment, constrained by political agreements[21]. In the case of BSM, this imposes a city-wide homogeneous fee to promote equal spatial treatment; yet, contracted-out facilities only face a price cap to limit private operator revenues and ensure the attractiveness of the area. We should stress that this approach is generally oriented to reinvest earnings in new facility developments and, moreover, that curbside and garage pricing strategies are not coordinated (as explained in Gragera & Albalate, 2016) and no possibility of cross-subsidy yet exists.

If we examine the alternatives to garage parking, we find that the level of supply of curbside spaces makes no statistical impact on prices (DENSPVISIT), but their scarcity does. We find that the ratio of garage spaces to curbside spaces (GCratio) has a positive impact on prices. That is, the dominance of the home garage with respect to the curb drives up prices, although the effect is almost negligible at an hourly fee level (0.002% for each additional curbside space). Yet, when added up its impact for all

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[21] See, for example, the City Council Agreement adopted by the Mobility and Security Commission on 12 July 2007.

parkers and the duration of their stay is undeniable. These results are closely in line with those reported by Gragera & Albalate (2016) in the sense that even the characteristics of curbside parking supply have an impact on garage demand, pricing being a much more efficient trigger for parking choice. This result is also relevant from a policy perspective, as Barcelona City Council is substituting parking spaces for dedicated bus or bicycle lanes, which, in the light of our results, will increase garage fees if the scarcity increase is not matched by a modification of the curbside fee.

In this regard, we find that the curbside fee is negatively related to garage prices, meaning that when these fees are lower, garages charge higher fees. In our case we find that a €1/hour increase drives up prices by 11.5%. We believe that the curbside fee captures just how inefficiently the curb is used, as lower fees are also associated with longer parking stay. Moreover, lower fees are associated with commercial spaces in the vicinity of the city's CBD, where demand is still high. We believe that this captures the fact that the cost of curbside parking is higher in this area due to higher cruising levels, which gives garages the opportunity to further exert their market power.

We hypothesize that regulated curbside parking reduces competition between garages. The fact that the curbside is generally preferred to garages (Gragera & Albalate, 2016; Kobus et al., 2013), and drivers might not know of the availability of alternative garages due to their imperfect information (Albalate et al., 2016), usually makes the curb the first option. These two factors increase the amount of time spent cruising for a curbside space, driving up total parking costs and giving private garage operators the opportunity to increase their mark-up simply by capturing excess curbside demand. In this scenario, the level of competition between garages is at most very mild and prices will be unaffected by concentration measures. Indeed, they will only be affected by the dominance of the home garage with respect to other garages and the curb.

Previous findings suggest that an integrated parking policy approach is not only mandatory for the public sector, as suggested by Gragera & Albalate (2016), but it should also integrate private garage reactions to curbside parking policy regulations so as not to further exacerbate market distortions. To our mind, parking policy needs to broaden the current approach being taken to parking regulation. In this regard, it might be advisable to create a specific regulatory body (in close coordination with existing transport authorities) that can coordinate public supply, pricing strategies and land use regulations and monitor the private sector so as to guarantee parking market efficiency within a broad integrated market focus.

5 Conclusions

Garage parking supplied by the private sector is a critical element in parking policy, especially as theoretical studies suggest that cruising can be eliminated if the right fee differential is set between garage and curbside parking. However, the reality in the vast

majority of US and EU cities is that of higher garage fees than those charged at the curbside, resulting in a significant pricing efficiency gap. In this paper, we have empirically explored the determinants of private garage operators' pricing behavior, by considering costs dimensions, market structure and curbside regulation instruments. In so doing, we have extended the empirical evidence presented in the existing literature by including both cost shifters and curbside characteristics. We estimated a price equation using a new, self-constructed, cross-sectional database for all public access garages in the city of Barcelona (508 facilities). We restricted the analysis to 391 garages, dropping all observations for publicly operated and contracted-out facilities with publicly regulated prices (as they respond to political decisions rather than to demand or changes in market structure).

Our results suggest that curbside regulation has an impact on private garage operators' price setting behavior, supporting evidence from previous spatial competition theoretical models. To achieve pricing efficiency, the public authorities need to focus their attention on the ratio between garage and curbside supply and more specifically on curbside fees. We found curbside fees to be negatively related to garage prices, capturing just how inefficiently the curb is used. Lower fees are associated with higher cruising levels in areas of high demand, with curbside parking generally being preferred to the garage option. This gives garage operators the opportunity to further exert market power, increasing their mark-up and aggravating the preexisting distortion. Therefore, the implication is that an increase in curbside fees should help reduce these distortive market outcomes.

If the public authorities seek to address the cruising issue simply by expanding public garage supply (which likewise adopts revenue maximization as a principle for setting prices), it would not, in the light of our results, be an effective strategy. Private operators do not seem to react to actual provision levels of public garages in Barcelona; they appear only to react to curbside regulation. The only effective way to impact private sector prices using public garage provision would be to target new facilities in order to reduce the dominance enjoyed by the private operators' dominance position, given that the share of garages owned by the home garage company in the relevant market is a major positive driver of prices. Public intervention by means of increased public garage supply should focus therefore on breaking the dominance of the private sector and on introducing true competition by exploiting potential cross-subsidies from the curb. This further stresses the need for an integrated parking market approach.

However, we report that most of the price variation in the market can be explained by provision costs and quality shifters (land value, capacity, number of opening hours and type of payment), which provide both the public and private sectors with further information about the heterogeneity of marginal costs and, consequently, how best to adapt public pricing strategies. In the case of pricing heterogeneity, we should also

highlight the empirical confirmation of parking bundling in garages associated with commercial-activities, which impose a positive externality. The public authorities may want to encourage more facilities to open up their available spaces to the general public as a way of narrowing the pricing efficiency gap.

We believe that neither direct price regulation nor the aforementioned public interventions are capable of providing full efficiency, since the data analyzed here points to the existence of imperfect information in the parking market. It seems highly likely that drivers are unaware of price distributions and/or the availability of alternative garages. This situation gives garages the opportunity to exert greater market power, allowing them to increase their mark-up and aggravate preexisting distortions. In this scenario, some cruising may continue, even with direct price differential regulation. In the case of Barcelona this point seems critical, and it might potentially represent a problem in many other cities, depending on search costs and garage price distributions. Public authorities need to invest in systems that make parking information more readily available to drivers (including details about set price quotation/salience standards; garage quality labeling; on-line platform/App); however, further research is needed on parker information and decision-making so that public interventions can achieve full efficiency.

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