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Empirical evidence on imperfect information in the parking market

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ABSTRACT:

Parking economics literature main attention has been paid to the cruising externality and garage market power issues, but all works assume that perfect information exists. But imperfect information may arise as (1) drivers may not know all available options in their choice set; and (2) they lack of information to evaluate them; further exacerbating already mentioned distortions. In this paper we provide compelling evidence on the existence and extent of information frictions in this market; based on the case study of Barcelona. We also test whether parkers' lack of knowledge translates into undesirable market outcomes.

1 Introduction

Parking policy has lately gained much attention as it is seen as a convenient and effective travel demand management tool to boost transport systems efficiency tackling car usage related problems. But parking market behavior is quite complex to asses and policy makers need further insights on how to design policies that drive the market towards efficiency. This has motivated a growing body of literature that vastly focused on the analysis of parking market distortions and how to fix them.

The general tendency to set curbside prices low (or free) translates into excessive parking demand forcing some drivers to cruise around for an empty spot, where each parker imposes an external cost on all other drivers (search cost). This phenomenon is pervasive (Shoup, 2005; and Van Ommeren et al. 2012) and its associated welfare loss is very relevant (Inci et al. 2015).[1] An additional distortion that contributes to the previous is the fact that garage parking (curbside parking main alternative) is characterized by construction scale economies for garages, that imposes its discrete spacing and confers them some degree of localized market power (Arnott, 2006). Theoretical works have suggested different policy interventions to achieve full efficiency (eliminate cruising) or at least induce welfare gains; which include regulating price differential between garages and the curb, hourly differentiated curbside parking

[1] Shoup (2005) shows that about 30% of trips are affected and they spend on average 8 minutes cruising. Van Ommeren et al. (2012) suggests that cruising is mainly a parking regulation issue as cities with curbside regulated parking spaces and proper fare differential with respect to garages show almost absent cruising levels. Inci et al. (2015) estimate that the external cost of cruising is about 15% of the average wage rate for the case of Istanbul (equivalent to $2.7/h for the US).

fees, time-varying and uniform curbside parking fees (see Inci, 2015 for an extensive review).

However, such conclusions relay on the assumption that parkers have perfect information. Spatial competition models (for example Arnott, 2006; Calthrop and Proost, 2006 or Inci and Lindsey, 2015) assume that drivers choose whether to search for a curbside empty spot or directly proceed to park in a garage. This implies that only curbside parking search is costly; the time required to locate a garage and park there is neglected. They are implicitly assuming that garage locations and attributes (like price) are known and perfectly observed by drivers. But a closer look to the parking market suggests that the validity of such assumption might be challenged.

It is rather plausible that imperfect information may arise from the fact that: (1) drivers may not know all the available options in their parking choice set; (2) they lack of information to evaluate them (prices and quality). Even if they want to earn this knowledge they will need to involve in some amount of search, which is also costly. The lack of such information does not allow them to maximize their utility and has consequences on the market outcomes that have not been considered in previous research.

The relevance of imperfect information as a market failure has for long been recognized by information economics literature in a wide variety of sectors (Stigler, 1961; Akerlof, 1970; Diamond, 1971; Stiglitz, 1989, 2000 and 2002); and parking market is not different. Information is costly, so it is rational for consumers not to be fully informed. Under this situation markets tend to be characterized by price dispersions not explained by product characteristics differences. Salop and Stiglitz (1977) suggest that when individuals have a different search cost, lower price firms will

sell both to the well informed consumers and the uninformed ones that have the chance to purchase there (random); while high price firms will only be able to sell to the uninformed consumers. In this case imperfect information will allow firms to imperfectly discriminate consumer depending on their information level.[2] Garages will take advantage of non-optimal choice decisions made by consumers, allowing them to charge higher prices even with a large number of firms in the market or relatively small search costs. Furthermore, garages can also act strategically increasing consumers' search cost through obfuscation by simply not disclosing all relevant purchase information or making it more complex to understand; which allows them to increase prices (Ellison and Wolitzky, 2012). All this suggests that already highlighted parking market distortions (cruising and localized market power) might be further exacerbated due to the interplay with imperfect information. In such scenario, full efficiency cannot be attained even theoretically suggested interventions are implemented, as some cruising may remain.

The presence of imperfect information in the parking market can be inferred from the fact that there is a growing demand for such good, as many specialized information gathering start-up firms are currently providing it as pre-trip or in-route information assistance.[3] Parking behavior literature has focused on measurement of parking search and the characterization the strategies followed by drivers (i.e: Polak and Axhausen, 1990; Bonsall and Palmer, 2004; Weinberger et al., 2017 or Karaliopoulos et

[2] They highlight that well informed consumers impose a positive externality on the uninformed ones by incentivizing the existence of low price firms. If there are enough well informed consumers market equilibrium prices will tend to the competitive ones.

[3] Examples of such firms are Parkopedia, ParkMe, SpotHero or Bestparking.

al., 2017). The relevance of the parking search issue and available technology has motivated a large body of literature devoted to the development of parking assistance systems (i.e: Caicedo, 2009, 2010 and Shin and Jun, 2014); that are information provision and guidance tools for parkers aimed at reducing search cost.

However, all previous literature seem to implicitly assume that parkers know the spatial/temporal availability and characteristics of garages stock as the main substitute to curbside parking. Yet we believe that imperfect information impact on market outcomes is still missing in the parking literature, as the lack of information of drivers on prices and "quality" has not been addressed.

In this paper we provide evidence on the existence and extent of information frictions in the garage market; based on the case study of Barcelona. Moreover, we also examine whether the level of information affects parkers' garage choice behavior that translates into market outcomes (prices). We find that information frictions are so extensive that active search during a given trip does not help parkers to end up paying lower fares. Only passive information acquisition through experience seems to increase parkers' knowledge of the available garage stock that helps them to achieve cheaper parking options. We also find evidence of price obfuscation that might allow garage operators to exploit consumers' ignorance.

As far as we know, this is the first paper to analyze the imperfect information distortion in the parking sector. Our findings are a relevant contribution to parking theoretical models that should also account for the exacerbating cruising externality and garage market power. But also for empirical works on parking competition and demand modeling. It also suggest the need to empirically test whether imperfect information is as relevant in other cities. Addressing existent information frictions is a relevant policy

issue if parking market efficiency is ought to be achieved; which we believe deserves more attention in future research.

The reminder of the paper is organized as follows. Section 2 describes the parking market in Barcelona and parkers' knowledge level; showing descriptive evidence on parkers' knowledge level and costly search. Section 3 describes our empirical test of information role on parkers' paid prices, where results are also discussed. Section 4 summarizes our main conclusions.

2 The parking market in Barcelona and garage parkers' knowledge level

Barcelona applies a comprehensive curbside parking regulation covering almost the entire area of the city called ÀREA; which establishes dedicated spaces for commercial activities, mixed use (parking permit to residents but charge visitors), resident-exclusive and hauling activities; introduced in 2005 and expanded in 2009. The total current global curbside parking supply is about 140.000 car spaces and 48.000 are regulated (DB Aj.BCN, 2015).[4] These spaces are split into regulatory zones with four fee/hour bands for commercial spaces (from 1.08€/hour to 2.50€/hour) and two bands for mixed use spaces (2.75€/hour – 3.00€/hour). On commercial spaces all parkers are considered as visitors; while mixed use spaces allow both visitors and residents to park (the later at a reduced fee of 0.20€/day). Free parking only remains available during operating hours in the outskirt of the city where parking demand is much lower.

[4] From the global city parking supply about 73.000 are free parking spaces; the remaining include hauling and other reserved spaces where regular car parkers are not allowed to park.

Off-street parking supply is extensive, with a global estimated figure of 650.000 parking spaces (DB Aj.BCN, 2015). However, following Albalate and Gragera (2017a) only about 114.000 spaces are provided by public-access garages. The public-access garage supply is mainly provided by the private sector (78 per cent of facilities); with an extremely atomized market structure with only NN and SABA managing a relatively large number of garages run under a same brand name and image, 5 per cent and 3 per cent respectively. The public sector has a leading role both by means of public operators (8 per cent) and price-regulated facilities in concession regime (14 per cent). Such role strives on the fact that public sector has been the only new entrant in the market due to the off-street supply expansion policy followed in the past to promote the shift of curbside demand to garages combined with the high land acquisition cost for private operators (that public sector can circumvent by placing garages on public land). The City Council integrated both curbside regulated spaces and publicly managed garages in a single parking operator (BSM), even each of them represents a different business unit within the same company.

Garages establish a fee per minute and many of them differentiate it depending on parking duration, even some convoluted schedules are reported that might hinder consumers' ability to calculate the price to be paid. The city mean overall garage fare for the first parking hours is 3.32€/hour (Std.Dev 0.50€/hour); that is reduced to 3.19€/hour for the second parking hour and 3.14€/h for the third. This shows a very mild price discrimination as the reduction for the second and third parking hour is just 4

to 5 per cent, respectively.[5] Generally discounts for long, overnight and subsequent days stays are reported in the garage price menu. Also discounts and special rates are offered purchasable in advance, but non-discount users represent the majority of parking transactions (following figures reported by BSM, see footnote 17 in Albalate and Gragera, 2017a). Prices charged by public garages are fixed by the public authority and respond solely to political decisions. Publicly managed garages apply a 3.05€/hour fare (non-progressive) in all their facilities. All concessions are subject to price-cap regulation that is usually binding, ensuring cost recovery and return on investment to the private investor. The concessions' mean first parking hour fare is 3.09€/hour (Std.Dev. 0.38€/hour).

Further detail on the specific characteristics of the parking market in Barcelona can be found in Gragera and Albalate (2016) and Albalate and Gragera (2017a).

In order to evaluate the level of knowledge that parkers have about the parking market, we conducted a survey to 576 respondents among garage parkers at 61 different facilities spread throughout Barcelona, mainly concentrated at the Central Business District and its surroundings.[6] Specific survey locations are depicted in Figure 1. We

[5] It is especially striking to compare those figures with the ones reported by Lin and Wang for the case of New York City (Manhattan); where mean first parking hour $12.67/hour (Std.Dev. $4.4/hour) and the additional second hours adds up just $3.38/hour, a reduction of up to 73 per cent.

[6] All empirical approach undertaken are based on a sample that discarded the responses from parking subscribers, parkers that report having some type of discounted fare and all-day parkers. Additionally, each model uses the amount of observations that have the complete information for all variables used; dropping all observations where respondents were unable/unwilling to report specific information.

designed the questionnaire to gather information on garage parkers' trip and demographic characteristics, search activity and their knowledge on prices and available alternatives. The information was gathered in a single wave during two consecutive weeks on February 2016, during business hours. The survey was conducted by interviewers to parkers that were about to leave the garage facility after parking their car or when they return to pick it up (before payment). Garage prices and characteristics are extracted from a parking inventory conducted during the same period, as described in Albalate and Gragera (2017a). Curbside information has been provided by BSM and the neighborhood data is made publicly available by the Barcelona City Council Statistics Department.

[Insert Figure 1 here]

2.1 Descriptive evidence of imperfect information

2.1.1 Involvement in search activity

Our survey data suggests that garage might exert a significant degree of localized market power in line with previous evidence (Albalate and Gragera, 2017a), as 96.6 per cent of respondents reveal that their main reason to park in a given facility is proximity to their destination. The average walking time to final destination is restricted to just 5.8 min (st.dev. 5.5min); which assuming a walking speed of 0.5m/s translates into a 300m walk (more than 90 per cent of respondents do not walk more than 500m). Walking time distribution in our sample is reported on Figure 2.

[Insert Figure 2 here]

Parkers in our sample conduct very low search activity of all types. Regarding active search for a garage, only 6.9 per cent of respondents report to have searched for

one. Choice of the garage facility seems to largely relay on previous experience, as 78 per cent report that they already knew the facility and the remaining report to have reached it either following traffic signs (5 per cent) or they saw the garage sign while cruising around the area (17%). Only 3.4% state that they conducted any sort of pre-trip search for garage information, as information platforms (start-up firms) have yet a very low market penetration. About 17.8 per cent of respondents report that they previously searched for a curbside spot; while only a marginal 1.2 per cent state they additionally searched for garage after looking after an empty curbside spot. Further analyzing our data shows that no demographic or trip characteristics stands out having a significant difference in the mean level of search for garages.

[insert summary table here]

2.1.2 Knowledge of available garage alternatives

This low level of search activity is particularly striking as or survey data suggests that parkers have a very relevant lack of knowledge of the available garage options they have at hand. Only 51 per cent of parkers report to specifically know the existence of at least an alternative garage in the area; but as far as 78 per cent of those report not to know the fare the alternative garage facility will charge them and 65 per cent report not to know its characteristics. Jointly with localized market power this might plausibly impose a huge burden to competition between garages, in line with the results of Albalate and Gragera (2017a).

In order to gain some insight on our data we test whether the differences in the mean level of knowledge about the availability of alternative garages between different groups in our sample are statistically significant, as reported in Table 1. The mean

knowledge of garage alternatives available is higher for those who have previously visited the specific garage facility compared to those who don't, supporting evidence on the acumulation of knowledge of available alternatives through experience. This does also happen for those who involve in active search for garages but the contrary for those who previously searched for a spot on the curb. Having searched for a curbside spot first might indicate that it is a preferred option for them and might less frecuently park in garages (having less previous experience); which is also confirmed by comparing means between both groups with a t-test.

[Insert Table 1 here]

2.1.3 Knowledge of prices

Not only the parkers do not seem to know much about available garage alternatives, their characteristics and prices, but they also lack of knowledge on how much they will be charged in the garage they have just parked. In particular, our survey data suggests that 75 per cent of respondents report not to know the fares. When asked about how much it will cost the first hour of parking their average guess is 2.92€/h (Std.Dev. 0.96€/h) when its true sample mean is 3.18€/h (Std.Dev. 0.33€/h); with no statistically different mean between those who report to know and not to know the price. We measure parkers' price misperception as the difference between their fare guess and the actual fare applied at the garage they parked their car; which gives an average of -0.27€/hour (Std.Dev. 1.04€/hour), and its distribution is reported in Figure 3.

[Insert Figure 3 here]

2.1.4 Obfuscation

Another relevant aspect is the fact that price menus are visible from the street (outside the facility) only in 15 per cent of the garages in Barcelona, about 78 per cent only show such information inside the facility and the remaining 7 per cent do not even show it forcing parkers to ask if they want to know how much they will be charged.[7] In our surveyed sample we have 70 per cent of respondents that purchase in garages that only show price information inside the facility; while the remaining 30 per cent purchase at garages that do show it outside.

All garages that report their price menus specify it in terms of fare per minute as it is compulsory by law since 2006.[8] In order to describe the fare per minute they tend to display it as a fraction number reported using 2 to 6 decimal digits; which might make pretty difficult for customers to use in price computation. Many of them do not apply a flat fare but a differentiated fare per minute depending on parking duration, generally decreasing with the length of the stay. Garages also generally report in the price menus the available discounts for overnight stays and subsequent days.

All this further increases the complexity of the price menu and can potentially help garage operators to obfuscate prices, making it more difficult for parkers to

[7] Public Access garages information provision is regulated by law 40/2002, but it only requires that garage operators "make prices easily perceived prior formalizing the service contract" without any specification of the format, the means or where it is done (http://consum.gencat.cat/temes_de_consum/aparcaments/index.html). Note that reporting the price inside is imposing a high cost if parkers will reject to park in that facility ones they learn the price.

[8] Ley 44/2006, de 29 de diciembre, de Mejora de la Protección de los Consumidores y Usuarios

precisely realize the fare they will be charged (increasing parkers search cost). Thus, we include two different measures to account for potential obfuscation. On the one hand we measure price salience as a dummy variable, with the value of 1 if the price is not visible from outside the garage facility and 0 otherwise. On the other hand, we account for the complexity in how garages report the fare per minute, length of stay price differentiation and discounts taking advantage of the coded price menu string length, computed as the number of characters it contains. The average price complexity faced by the respondents to our survey is 38 characters (std.dev. 27 ch.). An example of some coded prices menus and their corresponding complexity is reported in Table 2.

[Insert Table 2 here]

[insert price complexity histogram]

2.2 The value of information: expected gains vs search cost

We have seen so far that parkers in Barcelona conduct very low levels of search, which based on previous evidence is plausibly explained by its potentially high associated cost.[9] It is rational to think that drivers may involve in search only if the marginal gain by search is higher or equal to its marginal cost. So we measure the expected gains of perfect information they might achieve as the difference between the first hour fare mean and the lowest garage fare within the relevant market reported by each respondent, as a buffer within walking distance to final destination. This gives us an intuition of what would be the difference in fares paid by a perfectly informed driver

[9] Unfortunately, the low number of parkers involving in search activity precludes us from taking a more sophisticated and reliable empirical approach to estimate search cost.

with respect to one paying the expected market price when purchasing simply at random, other things being equal.

In our sample this yields a 0.30€/hour differential (Std.Dev. 0.27€/hour) showing relatively mild incentives to search. Note that this potential cost saving is about the same magnitude of parkers' garage price misperception, suggesting that they might not even realize that such saving exists at all.

When analyzing the deviation from perfect information, computed as the first hour fare difference between the lowest price and the fare they actually pay; it yields a mean value of -0.17€/hour (Std.Dev. 0.27€/hour) that suggests that parkers are purchasing at higher prices than the lowest possible. When analyzing the deviation from purchasing at random, measured as the difference between the mean first hour fare within the relevant market and the price they actually pay; it yields a mean value of 0.13€/hour (Std.Dev. 0.31€/hour) suggesting that parkers do possess some amount of information that allow them to purchase better than at the expected market price.

To have a clearer picture we need to confront this expected gain of perfect information with its expected cost (search). We have no data on the search process followed by drivers, but we can give a fair enough approximation of the expected cost with a back of the envelope calculation by assuming that parkers follow a sequential search approach.[10] This is an equivalent problem to compute the probability of picking

[10] We believe this is a fair enough approximation to expected search cost, as a very low number of drivers involve in pre-trip search and the parking information systems/platforms do not have much market penetration yet. Note in addition that on our setting the only way to fully know garages prices in the vast majority of cases will be to visit each facility; without taking into account neither that fare is

the cheapest garage option from a sample without replacement (assuming all of them are equally distant from the drivers' final destination). In such scenario the probability of finding the cheapest facility is 1/n, where n is the number of garages in the relevant market. Using the mean values in our sample we can compute the mean expected cost of sequential search assuming there are 4 garages (Std.Dev. 2.9 garages) placed 200 meters apart (Std.Dev. 97 meters); where parkers drive from one to another at 10km/h and their time is valued at 9€/hour. The probability of picking up the cheapest in the first visit to a garage facility is 0.25, and so is on the 2nd, 3rd and 4th visit conditional on failures in the previous. Thus the expected search cost would be 1.87€, which well offsets the previous computed expected gains for the respondents in our sample.

To translate this result more generally to the whole city, the average value of perfect information in Barcelona is 0.67 €/hour (Std.Dev. 0.29€/hour) and its distribution is shown in Figure 4 (based on the data collected in Albalate and Gragera, 2017a). From that figure it is easy to see that in many areas it is too low to compensate assumed search cost. Precisely those sites with higher value of information are those with higher number of competing facilities. This implies that even expected gains might be higher, they might be well offset by also higher search costs if the main way to gain information by drivers is on-site search. The more garages are available the higher will be the expected number of visits to find the cheapest fare. Table 3 shows the detailed expected search cost per garage visited, suggesting it is very unlikely that drivers generally search for more than 2 garage facilities given the value perfect information yields.

quite usually not visible from the outside (imposing an additional cost if consumers want to learn the price) nor the cognitive burden price discrimination scheme might also impose.

[Insert Table 3 here]

[Insert Figure 4 here]

Additionally, we also find evidence that conducting active search for a garage does not actually help drivers find a cheaper parking option for the current specific trip. On the contrary, those that search end up with an average lower deviation from mean prices, meaning they are less able to purchase at lower than mean prices which does not differentiate from purchasing at random. This is a reflection of how poor is information in this market. Search might only be a pain to gather information by experience for future visits to the area. Table 4 reports the results of a t-test comparing the means of the subsamples of respondents that conduct active search and those who do not.

[Insert Table 4 here]

To overcome the lack of knowledge and potentially high search cost drivers might want to stick to already known options as 77 per cent select the garage facility based on previous experience (as long as they are satisfied with it); or otherwise relay on brand names as a signal to infer garage attributes, as long as 80 per cent of them report to know at least some of the main garage brand names. This argument is in line with the evidence from consumer behavior literature (Baels et al., 1981).

All in all, we believe that previous descriptive evidence shows that in order to choose a garage drivers conduct very little search (of any kind), they know very little about the stock of available garage alternatives and their prices, seem to largely rely on previous experience, face relatively low expected marginal gains with respect to the marginal search cost and potential obfuscation strategies by garages that might further increase it.

3 Empirical analysis of the role of information on paid prices

Previous section provides compelling evidence of informational frictions in the parking market. However, what is relevant to economists is not how much drivers ignore about parking options and prices or how many of them are not informed enough, but whether this ignorance implies that market outcomes deviate from the perfect competition scenario. Thus, we will test whether the level of information has an impact on the price paid by parkers; and whether garages obfuscation strategies might further increase them.

3.1 Models specifications

The intuition behind our approach is that perfectly informed drivers would be able to accurately identify available garage options and their characteristics (including prices) and consequently maximize the utility they get from garage choice. Other things being equal they should be able to choose a cheaper parking option. Those with inferior information levels might just be able to partially optimize their decision; while not informed parkers would be expected to simply purchase at random. Information level will depend on previous parking experience in the trip destination area or by conducting any type of search (pre-trip or on-site) in order to stablish at least a subset of available garage parking opportunities. We test this hypothesis by estimating three different type of models.

First, we simply estimate a regression model of the price paid for the first parking hour on parkers' information level and garages' information provision (Model 1). This will give us an idea of whether the conditional mean of prices for the whole sample is affected by parkers' knowledge and search activity. This is, whether

information dimensions make parkers pay higher or lower fares. In order to have comparable prices across respondents we use the first hour fare (list price), as we also stated in the questionnaire when asked parkers about their price perception. We estimate Model 1 with a log linear specification, so reported coefficients can be interpreted as semi-elasticities.

[Insert Model 1 equaiton]

Secondly, as it is plausible to assume that there are decreasing marginal returns on search that make not optimal for drivers to be fully informed (Ratchford, 1980); we estimate three binary outcome models regressing: (a) the probability of paying the lowest firs hour fare, (b) the probability of paying below the mean first hour fare and (c) the probability of paying above the mean first hour fare within the relevant market on the information dimensions (Models 2, 3 and 4, respectively).[11] In contrast to models 1a and 1b, those give us an idea of how well are drivers choosing among the available garages within their relevant market in terms of prices. These models estimate how much more or less likely is that a parker purchases in a specific price segment garage for a change in the information dimensions. Dichotomous response variables are simply computed by comparing parkers paid first hour parking fare and the mean fare applied within the relevant market for each respondent. This means that the dependent variable in Model 2 is 1 when F_i is equal to the minimum F_{min} within the relevant market for parker i; and 0 otherwise. The dependent variable in Model 3 is 1 when F_i is strictly

[11] We assume that the relevant market for each respondent is a buffer of the walking distance to his final destination around the garage facility where the survey was conducted. We estimate the walking distance based on reported walking time to final destination assuming 0.6 meters/second walking speed.

lower than the mean fare ($\bar{F}$) within the relevant market for parker i; and 0 otherwise. While Model 4 defines its dependent variable as 1 when F_i is strictly higher than $\bar{F}$ within the relevant market for parker i; and 0 otherwise. Note that models 3 and 4 are sort of reciprocal to each other. Models 2 to 4 reported estimates are the odds ratio for a logit regression model (exponentiated coefficients).

[Insert Model 2 to 4 equation]

And third, we estimate a regression model of the deviation from the mean fare within the relevant market area (Model 5), in order to be able to quantify how much each information dimensions contributes to the higher/lower deviation in prices with respect to purchasing at random (mean price). The dependent variable in Model 5 is defined as the difference ($\bar{F} - F_i$). This yields a positive deviation when the paid price is lower than mean fare, meaning that drivers are purchasing better than at random presumably by having a higher understanding of the available stock of garages and their characteristics. And the opposite when the deviation is negative. Model 5 reports the estimated coefficeints for a linear regression model.

[Insert Model 5 equation]

We include several information-related variables, as consumer behavior literature suggests that consumers (drivers) might acquire/search for information from very different sources, not only actively but passively from past experiences or when involved in other activities (Baels et al., 1981). It is clear that this information acquisition process and its consequences in terms of consumers' knowledge will depend

on the technology of information production and diffusion[12], the type and the level of complexity of its attributes, consumers' ability to use information, the amount purchased, experience with the product, preferences and beliefs (Salop, 1976 and Miller, 1993). Thus, we try to capture search activity by accounting for drivers actively looking for information including a dummy variable that is equal to 1 when the drivers has visited at least another garage facility (and 0 otherwise) and another also when they conducted some kind of pre-trip search (and 0 otherwise). We also try to capture passive information acquisition by including a dummy equal to 1 when the driver reports to have previously searched for a curbside spot (and 0 otherwise); whether the driver has previously visited the garage facility and the frequency of the trip to that destination, computed as the number of trips per month. In order to broadly capture the level of knowledge acquired from previous experience we introduce a dummy equal to 1 when the driver reports to know available garage alternatives in the area (and 0 otherwise).

Additionally, we do also include some variables to account for the potential impact of obfuscation strategies followed by garage operators that might increase parkers search cost, as already highlighted in previous section. We include a dummy variable that is equal to 1 when the garage does not show the price outside the facility (price not salient) and 0 otherwise. But also a continuous variable that tries to capture price complexity in how garages report the fare per minute, length of stay price differentiation and discounts (price menu). We measure that by coding the price menu and counting the number of characters it contain; in order to proxy the cognitive burden it might impose to drivers trying to figure out the price they will pay.

[12] It is clear that the cost associated to search information in the web or drive to visit different garage facilities would be pretty different.

It is relevant to stress that our test does not rely on any assumption on parkers' search behavior or the technology of information production and diffusion, as we solely focus on the impact of information levels on the price paid. However, it does rely on our ability to control for quality differences between garages. We control for garage characteristics by means of operator-specific effects, potential differences in garage attractiveness, the level of garage competition, but also competitive and locational advantages.

Operator-specific effects are included to account for quality differences as each operator tends to meet some set of standards regarding facility layout, parking spaces, signaling, etc; that are assumed to yield very similar parkers' experience. We control for differences in attractiveness of the area (that might allow parkers to achieve higher levels of utility by combining multiple activities for the same time of stay) by the density of economic activities measured as the ratio of the number of square meters associated to economic activities within the relevant market for each parker. The level of competing garage alternatives in the area is measured as the average distance between the garages located within the relevant market for each parker. To account for competitive advantage for each garage we introduce the share of owned competitors by the operator where each driver parked his car; as a measure of dominance position in the market. The location advantage of a garage is measured by the walking time to the parker's final destination.

We do also control for drivers' and trip characteristics heterogeneity. We include sex, age and vehicle price as drivers' traits. Vehicle price is intended to be used as an income proxy and it is computed as the actual selling price of the vehicle reported by

the respondent.[13] We also include trip purpose for which we stablish four different categories that include: work/study, business, shopping/leisure and personal (most of them medical appointments). And we also control for the length of parking stay, as even it might give parkers higher expected gains due to a higher total parking expenditure, it can also make it more difficult for them to make sense of the price menu when price discrimination is applied.

3.2 Results and discussion

Results for all models are reported in Table 5. Control variables are not reported in that table for sake of clarity. Operator-specific effects are found to be always statistically significant; but also the density of economic activities, level of competing garage alternatives, competitive and location advantage measures, trip purpose and length of parking stay show statistically significant coefficients in various models. We should also note that the number of observations vary across logit models (models 2 to 4) as controlling for operator-specific effects imposes that both success and failure observations are included for each of them. Some operators associated observations are dropped to avoid perfect collinearity.

[Insert Table 5 here]

Results reported in Table 5 suggest that active information acquisition (either by garage, curbside or pre-trip search) does not have a statistically significant impact on the

[13] Actual vehicle selling price has been gathered from an internet price information aggregator (coches.com). We also included a depreciated vehicle value taking into account the car purchase year reported by the respondent as a robustness check.

level of prices paid (Model 1). Models 3 to 5 suggest that when parkers conduct some search for alternative garages they end up paying higher than mean prices. Model 4 suggests that drivers that search for alternative garages are more than twice as likely to purchase above the mean price within their relevant market. In particular, Model 5 shows that they end up paying 0.13€/hour above the mean first hour fare. This implies that on-site search might be just a pain for not well enough informed consumers that are simply gaining experience that will only pay off in future visits to the area. This suggests that information frictions in the case of Barcelona might be somewhat extreme, if parkers are not able to achieve gains from active search.

Passive information acquisition seems to be a more determinant factor on the translation of parkers' knowledge into market outcomes. Models 3 to 5 suggest that having some amount of knowledge on the available garage parking stock does increase the likelihood that parkers are able to purchase better than at random. Model 3 suggests that they are twice as likely to purchase below mean first hour fare within the relevant market for each parker. In particular, Model 5 shows that they purchase 0.09€/hour below mean prices, which is half of the search cost assumed for a single garage visit in a sequential search scheme reported in Table 3.

Trip frequency shows a mild negative relation with the level of prices paid (Model 1); with the sign in line with Sorensen (2000). In this case our results seem to suggest that the familiarity with the area does slightly further facilitate the information gathering process. Models 2 to 4 suggest that trip frequency does slightly increase the probability of purchasing at the lowest available price and below the mean price, with odds ratios 1.098 and 1.115 respectively. However, Model 5 shows that the deviation in

price from the mean is not statistically significant. This suggests that trip frequency might just slightly add up to the broader knowledge measure of available garage stock.

One of our most relevant results is that we find compelling evidence that price obfuscation might be of extreme relevance in the case Barcelona. Model 1 suggest that drivers that park at garages where the price is not salient end up paying higher prices (12 per cent). The likelihood of purchasing at the lowest available price is cut by more than half (Model 2) and they are about 30 times more likely to purchase above mean prices (Model 4). Model 5 suggests that parkers facing non-salient prices purchase 0.17€/hour above the mean first parking hour fare, about the same magnitude of the search cost for a single garage visit. We also find a positive relation between price complexity of the price menu and the level of price paid by parkers (Model 1), even it does not seem to have a statistically significant impact on the probability of purchasing below the mean or at the lowest available price. In this regard, it only might raise awareness on the potential obfuscation implications of price discrimination with the length of stay; which might be relevant for the implementation of interventions

All this suggests that information frictions are so extensive in Barcelona that the only way parkers have currently to overcome them is by a good amount of consumer experience. It is plausible to assume that information frictions do also exist in other cities, even their relevance needs further investigation. This has implications for parking spatial competition models that have till date relied on perfect information assumption to draw policy recommendations, which might be hindered by the effects of information frictions. But it also has implications for empirical works that implicitly make the same assumption when parkers chose between curbside and garage parking. In this sense, previously found curbside premium (Kobus et al., 2013; Gragera & Albalate, 2016)

might be partially capturing garage information frictions rather than just a higher willingness to pay for curbside parking.

Public authorities should address the imperfect infomation issue as it might be causing substantial welfare losses and conferring additional market power to garage operators; and additionally this would also hinder any public intervention to eliminate cruising.

4 Conclusions

In this paper we have examined the existence of imperfect information in the parking market; based on the case study of Barcelona. We conducted a survey to garage parkers at different facilities spread throughout Barcelona, gathering information on parkers' trip and demographic characteristics, search activity and their knowledge on prices and available alternatives. From such data we provide compelling evidence on the extent of information frictions in this market; and we also test whether the level of information affects parkers' garage choice behavior that translates into market outcomes (prices).

On the one hand, we find that active information acquisition (either by garage, curbside or pre-trip search) does not help parkers to end up paying lower fares for a given trip. On the contrary, drivers that conduct search are more likely to end up paying more. On the other hand, passive information acquisition through experience (broad knowledge of available garage stock and trip frequency) seems to be a much relevant determinant for parkers to achieve cheaper parking options. Additionally, we also find compelling evidence that price obfuscation is a determinant of market outcomes in Barcelona; which may allow garage operator to take advantage of parkers' ignorance.

This implies that information frictions are so extensive in Barcelona that the only way parkers might have to overcome them is by consumer experience. Without a pervasive information platform penetration on-site search could just be the price to pay by less informed consumers to acquire information by experience; which will only pay off in future visits to the area.

Our findings suggest that addressing information frictions is a relevant policy issue if parking market efficiency is ought to be achieved. Previous literature suggested market interventions are missing a relevant issue that might hinder their potential welfare gains if implemented disregarding such frictions; as in presence of imperfect information garages will excise additional market power and even act strategically to increase drivers search cost through price obfuscation. This means that even so called optimal interventions will need to face the fact that some cruising might remain simply due to parkers' ignorance of available garage stock and its prices. So before implementing theoretically suggested interventions imperfect information needs to be addressed.

In order to correct such market distortion public intervention will be required. Information is a public good and private agents will unlikely have incentives to provide optimal information quantity and quality. Allowing parkers to be more informed in all set of parking transactions will require a huge amount of data and standardization procedures that might be costly. The fact that information gathering firms are blossoming in the parking market, the level of development of parking assistance systems, available technology and SmartCity prospects let us think that information availability will be ubiquitous and pervasive in urban systems in the near future. The implication of the public authority in the data gathering process (to reduce its cost) and

setting the right incentives to garage operators to disclose up-to-date relevant information might be desirable. A closer collaboration between public authorities, information gathering firms and markets stakeholders should be advisable. Additionally, it is also relevant to stress that there is evidence that price information provision can backlash in form of easier collusion (REFERENCES), so closer monitoring of the market would be advisable.

As far as we know, this is the first paper to analyze the imperfect information distortion in the parking sector. Our findings are a relevant contribution to both parking theoretical models and empirical works, as they point out to the need to take information frictions into account for their potential exacerbating effects on cruising externality and garage market power. We believe its relevant market implications deserve more attention in future research.

Tables and figures

Figure 1. Geographical distribution of garage facilities and the total raw number of surveys conducted at each of them.

Figure 2. Walking time to destinations density distribution reported by parkers in our sample

Table 1. One-tailed and two-tailed t-test results comparing levels of knowledge of available garage alternatives for different independent subsamples based on parkers' experience and search involvement.

Figure 3. Distribution of the first parking hour fare misperception by parkers, measured as the difference between their price guess and the actual garage fare.

Table 2. Example of different price menus faced by respondents in our sample

Table 3. Expected search cost assumed for a sequential search strategy at mean values in our sample for each visited facility

Figure 4. Value of perfect information (€/hour) at each garage catchment area, measured as the difference between minimum and mean first parking hour fare within a 500m buffer around each facility.

Table 4. One-tailed and two-tailed t-test results comparing the deviation with respect to mean prices for different independent subsamples based on parkers' active search involvement. Deviation from the mean prices is measured as the difference between the mean prices and the price actually paid for the first parking hour.

Table 5. Estimated results for models (1) to (5).