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Misinformation and misperception in the market for parking

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ABSTRACT

Parking regulations have been widely adopted by cities as a tool to tackle traffic-related externalities. Both researchers and practitioners have proposed parking policy interventions that tend to rely on the assumption that parkers have perfect information about the availability of parking options and their characteristics (prices and quality) when determining consumers' behavior. However, research shows that when information acquisition (search) is costly it is rational for consumers not to be fully informed at the expense of their taking non-optimal decisions, with negative welfare implications.

We conduct an empirical study of the level of knowledge and information held by drivers in the car parking market. We draw on a survey conducted with 576 garage customers in Barcelona to estimate different regression models to assess how drivers transform information into actual knowledge, identifying the factors that aggravate/mitigate misinformation and misperception (subjective information levels and its accuracy). We find that parkers know little about available parking alternatives and their prices, and the accuracy of their knowledge is poor and biased towards prioritizing curbside parking. Costly search does not help drivers increase their knowledge levels, with garage facilities' and surrounding areas' characteristics playing a relevant role. We also find that garages have effective obfuscation strategies to keep drivers uninformed and exploit their localized market power by reducing price saliency and increasing fee complexity. Our results suggest that information should be carefully considered in the design and implementation of parking policy interventions and transport information systems, in order to avoid undesired market distortions.

1. Introduction

Cities today face increasing traffic-related problems. Their mobility patterns are still heavily dependent on cars, which results in severe congestion, pollution, noise and greenhouse gas (GHG) emissions that generate severe economic and environmental problems (OECD, 2007; OECD, 2014). To tackle these issues many local authorities have adopted car parking regulations as a travel demand management (TDM) tool, but the intrinsic distortions of the parking market (i.e.: cruising-for-parking, garage localized market power, etc.), their true cost and the implications for land use demand, public space allocation, city economic vitality and the transmission of distortions to other (intermediate good) markets are not yet fully understood.

Cities have largely underrated the importance of parking and policy implementation in this area still lags behind the advances proposed by researchers to exploit the benefits of parking regulations to the full (Barter, 2015; Mingardo et al., 2015; Shoup, 2005). Many cities continue to apply regulations that consider parking as an infrastructure that needs to satisfy on-site demand and, thus, avoid spillovers. Others have adopted more intense curbside parking regulations and, additionally, have opted to promote off-street supply. Yet, curbside fees have generally been set too low and policymakers have neglected the fact that curbside parking and garages form a bundle of what are essentially substitute services that consumers choose from (Kobus et al., 2013; Gragera and Albalate, 2016).

Parking research has shown the relevance of the welfare loss associated with market distortions (Inci et al., 2017) and proposes various market-oriented policy interventions to eliminate cruising-for-parking. These include optimal uniform, time-varying (performance-based) and differentiated fees, and the regulation of the price differential between garages and the curb (Inci, 2015). However, such interventions rely on the assumption that parkers have perfect information about the spatial/temporal availability of parking options and their characteristics (prices and quality).

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The information economics literature shows that, as long as information acquisition (search) is costly, it is rational for consumers not to be fully informed at the expense of their taking non-optimal decisions, such as visiting stores that they might otherwise not choose if they had availed themselves of more accurate information or giving up a search rapidly owing to its high costs with respect to its expected benefits. Indeed, the impact of information frictions on market outcomes is well recognized in a wide variety of sectors (Stigler, 1961; Stiglitz, 2000; Stiglitz, 2002). Markets where imperfect information is present tend to show higher prices even with large numbers of competing firms, with price dispersion not being explained by differences in product characteristics. It does allow firms to imperfectly discriminate consumers depending on their information levels giving rise to high and low-price firms that target each specific group.

Information issues in the parking market have been of interest for different research communities: including psychologists, computer scientists, and transportation engineers. However, the topic has been elusive for transport economists and just recent evidence on information frictions in the parking market has been reported. Albalate and Gragera (2018) show that a lack of knowledge on the part of consumers results in their paying higher prices (even when there are many competitors in the market) and, furthermore, that garage operators take advantage of this by employing price obfuscation strategies.[1] They also suggest that active information acquisition (search) is no guarantee that drivers obtain better deals and that only experience seems to help them purchase at lower rates. The authors show that drivers do not have enough information to optimize their decisions and information frictions mean market outcomes deviate from a scenario of perfect competition.

Lee et al. (2017) report that errors in driver perceptions of parking costs are among the main factors encouraging drivers to cruise for on-street parking, revealing that even drivers who claim to be familiar with these costs are not in possession of complete or accurate information. This, combined with the information frictions described above, undermines any potential benefits from the implementation of suggested policy interventions.

The parking industry recognizes the importance of information as revealed by its gradual application of innovative technologies to promote real-time communication of pricing and availability, smartphone applications and new guidance systems to better serve its customers. Indeed, there has been a boom of new business models including transaction brokers and information-gathering platforms (Parkopedia, SpotHero, Yellowbrick, Bestparking) that provide parking information-related services. The parking research literature has analyzed drivers' search strategies and parking choices (Polak and Axhausen, 1990; Thompson and Richardson, 1998; Bonsall and Palmer, 2004; Karaliopoulos et al., 2017) and examined more broadly the theoretical or simulated advantages of different designs and applications of innovative technology to parking guidance systems (Caicedo, 2010; Wang and He, 2011; Kokolaki et al., 2012; Shin and Jun 2014). However, parking research to date has evolved separately from the consumer behavior literature and has tended to overlook the importance of just how consumers acquire information and transform it into useful knowledge (including its intrinsic biases) that determines their choices, that are crucial to design information provision and parking guidance systems.

Consumers' behavior literature suggests that information plays a relevant role on the decision formation process, which starts with information acquisition on market attributes, its processing into actual usable knowledge about them (affected by cognitive limitations) and is then used as input for decision rules or heuristics. Most consumers learn about market characteristics when shopping, be it consciously or unconsciously (Jensen and Grunert, 2014); yet, it is not unusual for them to have very little actual knowledge, being particularly unaware of producers' pricing strategies (Estelami and Lehmann, 2001). Here, the literature differentiates between subjective knowledge (in our context what parkers think they know) and objective knowledge (the accuracy of what they know), and suggests that the two have a different impact on consumers' ability to optimize their purchase decisions (Raju et al., 1995). Both dimensions are mildly to moderately correlated (Flynn and Goldsmith, 1999; Alba and Hutchinson, 2000) and indicate that consumers do not correctly calibrate what they really know, leaving room for intrinsic biases in how they store the actual information on market attributes that impose imperfect information resulting in market demand misallocation. Repeated exposure to prices due to purchase frequency is shown to increase the likelihood of the elaboration and rehearsal of price information (Estelami and Lehmann, 2001). This affects both consumers' objective and subjective knowledge but is reported as being more strongly correlated with the latter (Park et al., 1994). The intuition is that extensive exposure does not necessarily lead to more accurate knowledge of market characteristics but does increase the amount of information gathered leading to greater knowledge self-assessment (Mägi and Julander, 2005).

In this paper, we build upon previous literature strains and make a first step towards filling the gap between them by studying the level of subjective information – hereinafter, *misinformation* – and its accuracy – hereinafter, *misperception* – in the market for parking in Barcelona. By drawing on a survey conducted with 576 garage users, we are the first to assess how drivers transform information into actual knowledge (and its biases). Here we explore the contribution of several potential determinants of these two knowledge dimensions for the parking market, focusing our analysis on occasional parkers. This analysis is relevant both for local authorities and the parking industry, given that consumers' lack of (and biased) knowledge affects how they consider parking market attributes into their decision process, which affects consumers' choices and might cause demand misallocation, reduce the effectiveness of pricing strategies, impede effective price competition, aggravate current market distortions (cruising and garages' localized market power) and hinder the efficiency of any proposed policy intervention that does not first address parkers' information levels.

We find that parkers know little about available parking alternatives and their prices, and the accuracy of their knowledge is poor and biased towards prioritizing curbside parking. Costly search does not seem to help drivers increase their knowledge levels, with garage facilities' and surrounding areas' characteristics playing a relevant role. We also find that garages have effective obfuscation strategies to keep drivers uninformed and exploit their localized market power by reducing price saliency and increasing fee complexity.

We believe this stresses the need for further research on information issues in the transport literature. Our results offer valuable insights to researchers on how to introduce imperfect information on parking spatial competition models. Moreover, they can help on the design of future randomized-experiments to assess the impact of information provision on parkers' behavior completely lacking in current literature, and are crucial to the design and implementation of transport information systems (like MaaS platforms).

The rest of this paper is organized as follows. Section 2 describes the data and variables used and section 3 describes the methods employed. Results are presented in section 4. The paper ends with a brief summary and a policy discussion derived from our main results.

2. Data and variables

As described in Albalate and Gragera (2018), we use the data gathered in a survey conducted with 576 respondents among garage users at

[1] The term price obfuscation, used in industrial organization literature, refers to the strategic actions taken by producers of a good to make prices obscure, unclear, or unintelligible, aiming at increasing the consumers' search costs so as to raise prices and avoid competition. In Barcelona's garage market, obfuscation is achieved by failing to display prices outside the garage or by devising complex pricing schemes to impede understanding of real costs. See Albalate and Gragera (2018) for more information about these strategies.

61 different facilities located throughout Barcelona, but concentrated primarily in the city's central business district and surrounding areas.[2] The survey was conducted in a single wave over two consecutive weeks in February 2016, during business hours. The survey was conducted to parkers that were either about to leave the garage facility after parking their vehicle or when they returned to pick it up (but always before payment to avoid them to report the information just gathered in the bill). As users included both subscribers and occasional parkers, we opted to discard all observations from subscribers and all-day parkers (42 responses) and to focus our analysis on the market for occasional parking demand.[3] This gave us a final sample of 534 valid responses.

To assess the determinants of the parkers' misinformation, the survey included questions on the drivers' level of information about the parking options available to them (other garages) and the fees associated with each option, both regulated curb (commercial and mixed-use spots) and off-street (other garages) parking.[4] The survey also included questions about the active information acquisition activities (search) users undertook, and other items that might passively influence the parkers' ability to obtain this information, in addition to their trip and demographic characteristics.

As we seek to measure misperception (i.e. the accuracy of the information they hold), we need to measure the parkers' ability to recall the prices to which they have been exposed by comparing the prices they recall with the garages' real prices.[5] Curbside parking information was provided by *Barcelona Serveis Municipals* (BSM), and garage fees and characteristics were extracted from a parking inventory conducted during the same period, as described in Albalate and Gragera (2017; 2018). From the inventory we also obtained data about the garage market structure in the area in which the respondents parked. Finally, information about specific features of the area (district and neighborhood) was obtained from the Barcelona City Council Statistics Department.

2.1. Dependent variables

We consider three binary variables to study misinformation.[6] They specifically measure parkers' subjective knowledge about alternative garage parking options and about both curbside and garage prices:

- *Information on options* takes a value of 1 if the respondent declares having current knowledge of the existence of other parking options available in the area where he/she parked, and 0 otherwise. This variable is considered in order to study the determinants of the level of knowledge of the set of market alternatives in the area of parking.
- *Information on curbside fee* takes a value of 1 if the respondent declares having current knowledge of the fee charged at the curb (both commercial and mixed-use spots) in the area surrounding the garage where he/she parked, and 0 otherwise. This variable is included as a dependent variable to study the determinants of knowledge of curbside prices that compete with garages.
- *Information on garage fee* takes a value of 1 if the respondent declares having current knowledge of the garage's fee where he/she parked, and 0 otherwise. This variable is included as a dependent variable to study the determinants of knowledge of garage prices.

Additionally, we constructed two dependent variables to study misperception. These seek to measure the parkers' objective knowledge based on the accuracy with which they can recall the garage and curbside prices to which they have been exposed:

- *Garage fee misperception* is measured by the difference between the garage fees recalled by the respondents and real garage fees (absolute rates, cents of euro) for the first hour of parking, as described below.

$$Garage\ fee\ misperception = |Recall\ GF_i - Real\ GF_i|$$

where GF_i is the fee charged by the garage in which respondent *i* parked.

- *Curbside fee misperception* is measured by the difference between the curbside fees recalled by respondents and real fees (absolute rates, cents of euro) for the first hour of parking, as described below.

$$Curbside\ fee\ misperception = |Recall\ CF_i - Real\ CF_i|$$

where CF_i is the weighted curbside fee charged in the area around the garage in which respondent *i* parked.

2.2. Covariates

To explain the level of misinformation and the degree of misperception, we consider a variety of possible determinants that might influence both consumers' subjective and objective information dimensions by determining their ability to obtain and process parking market information which they can put to use. The categories of variables considered are the respondents' socioeconomic and demographic traits, covariates related to their actual parking behavior, trip characteristics, regressors associated with the garages' features and with certain characteristics of the area in which the garage is located. Table 1 summarizes them and offers a brief description.[7]

2.2.1. Sociodemographic characteristics

We include respondents' sociodemographic characteristics like age, gender and a proxy for income. Income is proxied by vehicle price,

[2] Our empirical strategy draws on a sample that discarded responses from car park subscribers and all-day parkers.

[3] We use the term occasional parkers to describe any parker that does not hold a monthly garage subscription or is going to park for multiple days in that single parking event. The word occasional does not mean that each parker does not visit more than once a given facility.

[4] Commercial parking spots are regulated (paid) spaces in rotation where any driver can park without price discrimination. Mixed-use parking spaces are regulated (paid) spots where residents enjoy much cheaper prices than the rest of parkers. Mixed-use spaces are implemented in cities such as Amsterdam, London, Paris, Munich, Copenhagen, Stockholm and Chicago, among others. In Barcelona, mixed-use spaces are more expensive for non-residents than are commercial spaces.

[5] We use the term 'price recall' as employed in the consumer behavior literature. Thus, we assume that parkers have been exposed to some price information that they have processed and stored (either consciously or unconsciously) for later use. It is specifically this stored knowledge that we are interested in here and which we ask them to recall.

[6] Please note that our misinformation measures implicitly include each respondent internal calculations on maximum walking distance and its tradeoff with 'expected' parking conditions. This is not relevant to us in our setting, as an aggregate measure of such biases is what we are actually aiming to measure. We are not aiming at analyzing how consumers transfer information into choices, but on how the transfer information into actual subjective knowledge. The former will need a controlled randomized experiment setting on which to draw reliable conclusions.

[7] Feature selection analysis using Lasso in Stata 17 was also considered and performed as robustness check. However, results of restricted models for misinformation were pretty similar to those considering all covariates. For misperception models, feature selection provided with restricted models that were unable to pass standard specification tests. Thus, we decided to only show results with our generalized models (considering all covariates). Results for restricted models after feature selection procedures are available as supplemental materials (Table S1).

Table 1
Summary of the covariates included in the model.

Sociodemographic characteristics	
Age	Respondent's age (or age group)
Gender	Male = 1; Female = 0
Vehicle Price	Actual selling price for the vehicle model (thousands of euros)
Parking behavior	
Previous visitor	Yes = 1; No = 0
Visit frequency/month	Number of visits to the area per month
Entitled to price discount	Yes = 1; No = 0
Uses electronic payment	Yes = 1 (teletac); No = 0
Length of parking stay	Parking stay in minutes
Trip purpose	Work/study, leisure, personal, administrative
Search activities	Looked for alternative garage, first curbside, pre-trip
Garage features	
Facility	Associated to shopping mall, cultural venue, hosp. facility
Franchise	Belongs to a branded garage network
Price complexity	Number of characters forming price schedule string
Price saliency	Price is displayed outside the facility (visible)
Area features	
# of visible garages signs	Parking signs of competing garages visible from the entrance
Economic activity	m^2 of economic activity within relevant area (in thousands)

computed as the actual selling price of the vehicle (in thousands of euro) reported as being driven by the respondent.[8] We specify age and vehicle price either as continuous variables or in age/price brackets, to improve models' goodness of fit.

2.2.2. Parking behavior

We do also include respondents' parking behavior characteristics that can affect their level of exposure to parking information (passive knowledge acquisition). We include if she is a previous visitor to the facility and the visit frequency to the area (time per month), capturing its familiarity with the facility and the characteristics of the parking market in the area, respectively. We also control for the fact that some parkers might be entitled to a price discount given to them by stores, restaurants or other business; presenting them with additional information on parking prices and the savings they offer. We also control for the use of electronic payment methods (teletac or Bip&Drive), to evaluate whether indirect involvement with the act of payment affects user information and perception of parking costs. We do also include the parking stay length (in minutes) reported by respondents, as higher expected parking cost might give parkers higher incentives to be more aware of available alternatives and prices.[9] In addition, to consider differences in perceptions of garages' attributes, we take into account respondents' trip purpose; defined as compulsory mobility (work or study), leisure (shopping, restaurants or theaters), personal (visiting relatives or doctor appointments) and administrative obligations.

We also take into account potential active engagement in knowledge acquisition through search. We include binary variables describing whether the respondent searched for an alternative garage before ending up in the one she was interviewed, whether she searched for a curbside spot before parking in that garage or if she conducted any pre-trip search. The way in which we framed the questionnaire rules out potential reverse causality issues with these variables, as respondents were asked about actual knowledge based on past behavior once the decision (to park) had already been made. The assumed parking knowledge acquisition process and its assessment is depicted in Fig. 1, consistent with the previously mentioned consumers' behavior literature.

It can also be argued that potential endogeneity might arise from the correlation of respondents' search activity with unobservable determinants of information levels. Even we included all controls we believe might be correlated with information levels and we cannot reject that our models have no omitted variables; our exploratory results on the impact of search activity make no causal claim and should be taken with caution.

2.2.3. Garage features

Regarding garage features, we include a binary variable to signal whether the garage belongs to a specific facility (shopping mall, hospital or cultural venue), as we expect that respondents looking to park in such a facility might face higher choice constraints and be myopic to potential alternatives and their characteristics. We also take into account whether the facility belong to a franchise or parking network, that makes easier for parkers to recognize and transfer the knowledge they already have acquired in other areas or occasions (affecting respondents' subjective and objective knowledge). Moreover, in order to account for potential strategic behavior of garage operators in affecting parkers' knowledge levels (obfuscation), we take into account price complexity and its saliency. We measure price complexity as the number of string characters used in the price schedule displayed and charged to garage customers, which can require them additional cognitive effort to transform information exposure into usable knowledge. We measure garages' price saliency as a binary variable takes a value of 1 if the garage in which the respondent parked displays its prices outside the facility and they are visible. This measure gives us an idea of the level of exposure to price information for their current parking option.

2.2.4. Area features

We include the number of other garage signs visible from the entrance to the garage where the respondent has parked their vehicle, in order to account for other nearby garage alternatives readily identifiable by in-situ inspection. Additionally, we do also account for the number of square meters (in thousands) of economic activities that lie within each respondent's relevant market area, as we believe that it is likely that areas with more economic vitality offers higher chances for drivers to be passively exposed to parking information when conducting their errands. We also include district fixed effects to account for certain unobservable area characteristics that might be correlated with the respondents' misinformation and misperception.

Table 2 shows the main descriptive statistics of the variables employed.

3. Methods

3.1. Misinformation models (logistic regression)

To analyze misinformation in the parking market, we explore three different subjective knowledge dimensions that take into consideration whether parkers report having knowledge of alternative garages available in the area (*Information on options*), garage prices (*Information on garage fee*) and curbside prices (*Information on curbside fee*). In this way we consider the binary nature of all the dependent variables and apply probabilistic models (logistic regression) that takes the form:

[8] As in Albalate and Gragera (2017), this is calculated using an internet price information aggregator (coches.com). As a robustness check, we also include a depreciated vehicle value taking into account the year of purchase as reported by the respondent.

[9] Unfortunately, we did not gathered information about the uncertainty of respondents' intended length of the parking stay, which might potentially affect parkers' ability to process price information, due to the need to keep the questionnaire as short as possible.

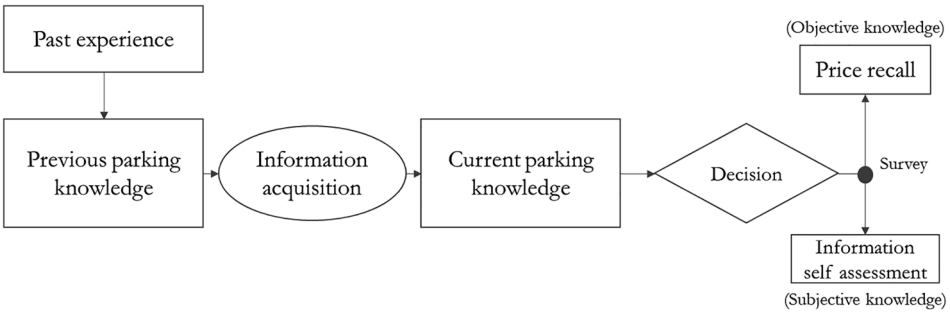

Fig. 1. Parking knowledge acquisition process and its assessment.

Table 2
Descriptive statistics of covariates employed in the empirical models.

Variable	Mean	Std.Err.	Min	Max
Sociodemographics				
Age	47.36	12.87	20	91
18 – 30 years old	0.08	0.26	0	1
+64 years old	0.20	0.40	0	1
Gender	0.64	0.48	0	1
Vehicle_Price	18.81	12.53	7.49	107.88
10.000 – 20.000€	0.39	0.49	0	1
+20.000€	0.43	0.49	0	1
Parking behavior				
Previous visitor	0.77	0.41	0	1
Visit frequency/month	2.71	5.53	0	30
Entitled to price discount	0.016	0.13	0	1
Use electronic payment method	0.41	0.49	0	1
Parking stay length	169.31	97.36	5	600
Search for alternative garage	0.07	0.26	0	1
Search for curbside space	0.17	0.38	0	1
Search pre-trip	0.04	0.19	0	1
Trip purpose				
Shopping/leisure	0.37	0.48	0	1
Personal	0.27	0.44	0	1
Administrative	0.16	0.36	0	1
Garage features				
Facility	0.21	0.41	0	1
Franchise	0.72	0.44	0	1
Price saliency	0.31	0.46	0	1
Price complexity	38.65	27.99	12	172
Area features				
# of visible garage signs	1.00	0.801	0	3
Economic activity	6.23	2.68	1.34	10.81

$$logit(p) = \beta_0 + \alpha \bullet S_i + \beta \bullet P_i + \gamma \bullet G_i + \delta \bullet A_i + \varepsilon_i \quad (1)$$

where $p = P(Y = 1)$, and as explanatory variables we use the vectors of sociodemographic characteristics (S), parking behavior (P), garage features (G) and area features (A).

3.2. Misperception models (OLS and GLM)

To analyze misperception in this market, we explore two different objective knowledge dimensions that take into consideration the accuracy with which parkers can recall garage (*Garage fee misperception*) and curb (*Curbside fee misperception*) prices, measured as the absolute difference between the prices they recall and the true prices. In this way we consider the continuous nature of most of the dependent variables. We implement linear regression models with the OLS estimator, which requires that the error distribution follows a normal distribution. An inspection of the error term indicates a fit that is closer to that of a negative binomial distribution. Hence, we applied a log-transformation of our dependent variable to obtain a distribution that was closer to the normal. This helps both in applying the OLS estimator and in obtaining an interpretation of coefficients that is more straightforward than that of models accounting for Poisson and Negative binomial distributions. To verify the OLS results, we also conducted GLMs that allow for different error distributions and different relationships between the response variable and the independent variables. However, as the results are largely similar, here we opt to report and discuss just OLS results of the following models.[10]

$$Log(Y_i) = \beta_0 + \alpha \bullet S_i + \beta \bullet P_i + \gamma \bullet G_i + \delta \bullet A_i + \varepsilon_i \quad (2)$$

Again, given the number of variables and possible specifications, our ultimate choice is based on the fit of the models.[11] Likewise, we take into account potential problems of multicollinearity from the inclusion of the covariates.

4. Results

4.1. Misinformation

Our descriptive statistics show that drivers have a significant lack of knowledge about their alternative parking options and about parking fees. Only 51% of parkers reported knowing of the existence of at least one other garage in the area and 65% of these reported not knowing their characteristics. The mean knowledge of available alternatives is higher among those that have previously used the specific garage facility than it is among first time users, providing preliminary evidence of the accumulation of knowledge of available alternatives through experience.

The respondents' lack of information about prices is even more striking: 74% reported not knowing the fees charged by the garage where they parked. This percentage is higher (and statistically different) for drivers unaware of alternative garages in the area (79%), but is not much better in the case of those with knowledge of alternatives (69%). In fact, 78% of the latter reported not knowing the fees charged by these other garages.

Similarly, the level of information on curbside fees was no better: 72% of respondents reported not knowing the hourly fee they would have to pay if parking in an on-street regulated space. This percentage fell to 64% – statistically lower – among those reporting have looked for a curbside space before entering the garage. Thus, drivers who search for on-street parking seem to be slightly better informed – or at least they believe themselves to be, as we shall argue below. It seems likely that this group look for curbside parking because they either know or think prices there are much cheaper than off-street parking, in addition, that

[10] GLMs applied in the verification of the OLS results do in fact account for the negative binomial distribution of the error term. Results available upon request.
[11] Each model uses only those observations for which complete information was available for all the variables used. This means we eliminated those items for which respondents were unable/unwilling to report specific information.

is, to what is the usually greater preference for on-street parking.

Although descriptive statistics are useful for demonstrating that drivers would appear to know very little about garage availability and parking fees, a multivariate analysis enables us to assess the factors that aggravate/mitigate problems of misinformation. Table 3 shows our main results for the multivariate analysis of the determinants of the customers' level of information. The '*Know other options*' columns illustrate the model which explains customers' knowledge of other garages (at least another one) in the vicinity of the one in which they parked, while the '*Know curbside fee*' and '*Know garage fee*' columns show our results for the models explaining customers' level of information about curbside and garage fees, respectively. As expected, because our survey specifically targeted garage users, the model for curbside fee knowledge performs worse than the other two. It is important, therefore, that we limit the results of this model to garage parkers and that we exercise caution when generalizing this result to all drivers. Yet, having said that, our descriptive statistics show that knowledge is not biased by the fact of our interviewing garage users, given that we find a similar percentage of users claiming to know the curbside fee (28%) and those claiming to know the garage fee (26%).

In the multivariate models, the sociodemographic variables seem to have little impact on respondents' subjective information levels. We find no effect for age and gender, and just the price of the vehicle, included as a proxy of income, has a positive impact on the knowledge of alternative parking options. Each 1.000€ in vehicle price is correlated with a 0.4% higher chances of being informed. This suggests that, although it might be assumed that higher income parkers have lower incentives to acquire information due to the higher search costs, they are likely to accumulate

Table 3
Logistic regression results on misinformation. Estimated odds ratios and marginal effects at sample means.

	Know other options		*Know curbside fee*		*Know garage fee*	
VARIABLES	Odds Ratio	Marginal effects	Odds Ratio	Marginal effects	Odds Ratio	Marginal effects
Sociodemographics						
Age	1.011	0.00282	1.001	0.000181	0.986	−0.00242
	(0.00854)	(0.00211)	(0.0124)	(0.00248)	(0.0110)	(0.00192)
Gender	1.009	0.00232	1.235	0.0423	0.992	−0.00141
	(0.220)	(0.0545)	(0.393)	(0.0637)	(0.264)	(0.0460)
Vehicle price	1.018*	0.00450*	0.997	−0.000598	0.988	−0.00211
	(0.00987)	(0.00242)	(0.0104)	(0.00208)	(0.00946)	(0.00165)
Parking behavior						
Previous visitor	3.827***	0.335***	1.488	0.0797	5.112***	0.282***
	(1.223)	(0.0800)	(0.594)	(0.0799)	(2.370)	(0.0750)
Entitled to price discount	0.955	−0.0115			18.75***	0.507***
	(0.691)	(0.181)			(16.47)	(0.155)
Use electronic payment (teletac)	0.419**	−0.217**	1.025	0.00497	0.272**	−0.225**
	(0.156)	(0.0928)	(0.666)	(0.130)	(0.146)	(0.0912)
Parking length of stay	1.000	−3.50e-05	1.000	−1.38e-05	1.001	0.000121
	(0.000284)	(7.10e-05)	(0.000347)	(6.94e-05)	(0.000506)	(8.78e-05)
Trip purpose						
Leisure	1.233	0.0520	0.705	−0.0684	0.804	−0.0383
	(0.346)	(0.0697)	(0.277)	(0.0765)	(0.290)	(0.0636)
Personal	0.931	−0.0180	1.045	0.00935	1.591	0.0959
	(0.371)	(0.0995)	(0.523)	(0.107)	(0.736)	(0.0999)
Administrative	0.783	−0.0609	0.987	−0.00280	0.592	−0.0843
	(0.267)	(0.0848)	(0.434)	(0.0928)	(0.238)	(0.0627)
Search for alternative garage	3.141**	0.286**			1.728	0.0946
	(1.443)	(0.115)			(0.874)	(0.0875)
Search pre-trip	1.321	0.0695	0.150***	−0.380***	1.993	0.119
	(0.703)	(0.133)	(0.104)	(0.139)	(1.473)	(0.129)
Search first for curbside space			1.658	0.101		
			(0.651)	(0.0789)		
Garage features						
Facility	0.409***	−0.223***	1.581	0.0917	1.512	0.0715
	(0.135)	(0.0822)	(0.965)	(0.121)	(0.613)	(0.0703)
Franchise	1.931*	0.164*	0.824	−0.0387	2.059*	0.125*
	(0.661)	(0.0854)	(0.515)	(0.125)	(0.885)	(0.0739)
Price saliency					1.449	0.0642
					(0.559)	(0.0664)
Price complexity					0.995	−0.000935
					(0.00717)	(0.00124)
Area features						
# of visible garage signs	0.850	−0.0405	0.907	−0.0197	0.688**	−0.0646**
	(0.133)	(0.0390)	(0.211)	(0.0466)	(0.130)	(0.0328)
Economic activity	1.144**	0.0335**	1.221**	0.0400**	0.965	−0.00618
	(0.0737)	(0.0161)	(0.110)	(0.0178)	(0.0748)	(0.0134)
Constant	0.0822***		0.0967***		0.324	
	(0.0559)		(0.0767)		(0.267)	
Area-specific effects	YES		YES		YES	
Observations	428		267		431	
Log-Likelihood Full Model	−266.8		−150.2		−204.9	
Chi-square test	43.24		29.05		77.84	
Pseudo R2	0.0997		0.0784		0.180	

higher knowledge levels due to more parking purchases (exposure) and higher education levels (ability to process information), as discussed in the consumer behavior literature (Mägi and Julander, 2005).

Parking behavior variables have a much larger impact on respondents' subjective knowledge. Previous experience, based on the fact of having visited the garage on an earlier occasion (at least once), seems to be an important contributor to the users' level of information about garages (both fees and alternatives availability). Being a previous visitor increases the probability of being informed about garage parking alternatives and fees by 33.5% and 28.2%, respectively. This is consistent with previous evidence of the accumulation of knowledge through experience. On the other hand, the likelihood of these drivers knowing curbside prices is no different from that of the rest of respondents.

We also find that being entitled to a price discount does increase the probability of knowing garage prices by 50.7%. This increase in subjective knowledge presumably reflects greater exposure to price information and the higher cognitive requirements needed to process it. In short, the implication is that such users are much more likely to have consciously transformed this information into actual knowledge. Additionally, the use of electronic payment methods (teletac) is correlated with a 22.5% lower probability of knowing garage prices, and a 21.7% lower probability of knowing a garage-parking alternative. This finding is consistent with Soami (2001), who suggests that payment methods affect consumer spending behavior to the extent that, in the case of routine purchases particularly, consumers tend to be less forward looking and to rely heavily on past experience. Teletac reduces consumer price awareness and, hence, their ability to evaluate past payments retrospectively. At the same time, it acts as a constraint on the parking alternatives of those using this payment system, since it is typically given by employers to employees for work-related trips and serves, in part, as payment in kind (company car). To the best of our knowledge, this is the first empirical confirmation of such a relation in the transport sector. Additionally, both the length of parking stay and trip purpose appear to have no effect on respondents' knowledge. Active information acquisition strategies, such as undertaking search activities, do offer interesting results. First, we find that drivers having searched for other garages in the area have a probability 28.6% higher to claim they know of the existence of other garages. As such, active search seems to provide better knowledge about supply, but no statistically significant difference is found in relation to knowledge about garage fees. In contrast, respondents that searched for on-street parking first are not better informed about curbside fees. Active pre-trip search only correlates with larger misinformation about curbside fees, with 38% lower probability of knowing curbside fee. This might be explained by the fact that such parkers are specifically interested in parking in their final destination and rule out the option of curbside parking (even the share of respondents that conducts such search is just 3% of our sample).

The characteristics of the garage also seem to influence the level of user information. When the garage is linked to a specific facility (a shopping mall, public building, theater or hospital), the probability of the respondents' level of information on garage-parking alternatives is significantly lower (22.3%). This suggests that drivers parking in garages linked to specific facilities tend to have a limited knowledge of the market outside that particular facility (i.e. their final destination constrains their information acquisition needs). Parking in garages that are franchises of garage networks is correlated with a 12.5% higher probability of knowing the garage fee than the rest of the respondents, and a 16.4% higher chances of reporting being aware of garage alternatives (even both just at 10% significance level). Knowledge of the brand can facilitate the recognition of shared attributes and make the knowledge gathered in the franchise's facilities highly transferable, including the fee. We do also find that garages' strategic behavior has no impact on drivers' subjective knowledge on garage prices, even we will show later that it does affect its accuracy.

Regarding area-specific features, just the level of economic activity of the area is significant – and positively related – to the knowledge of garage alternatives and the curbside fee reported by the respondents. In particular, each additional thousand square meters of economic activity increase the probability of knowing at least an alternative garage by 3.3% and curbside fees by 4%. We believe that areas that are more vibrant offer higher chances to cover various errands by walking, are more likely to be visited in the past and thus offer the opportunity to drivers to accumulate (even passively) more information on parking options and their characteristics. Additionally, the number of visible parking signs, as a proxy of competing alternatives, is correlated with a 6.5% lower subjective knowledge of parking fees. This is aligned with information economics literature that suggest that in markets with imperfect information (as reported for Barcelona in Albalate and Gragera, 2018) price dispersion will be higher, thus likely make it more complex for respondents' to be aware of prices once we control for previous experience.

4.2. Misperception

Declaring that one knows or does not know the price to leave one's vehicle in a garage is no guarantee that this information is accurate. According to our survey, the average garage fee recalled for the first hour of parking was 2.91 €/h (Std. Dev. 0.96 €/h) compared to a true sample mean of 3.18 €/h (Std. Dev. 0.33 €/h). We found no statistical difference between those that reported knowing (2.84€/h) and those that reported not knowing the fee (2.95€/h). Both groups recalled lower fees than those actually charged.

We can simply measure fee misperception as the difference between the price recalled and the actual fee charged at the garage, which gives an average of −0.27 €/h (Std. Dev. 1.04€/h). This misperception is the same for those who undertook an active search for a garage, while the opposite was the case for those who had previously looked for a curbside spot. As Albalate and Gragera (2018) argue, the fact that the latter tried to park on the curbside initially is probably an indication that on-street parking was their preferred option and that these users are less likely to park in a garage (having less prior experience). This is, in fact, confirmed by comparing means between both groups with a *t*-test.

When computing the average deviation of recalled fees from the real fee without taking into account whether they were higher or lower – in absolute values – we find that respondents deviate by an average of 0.78 €/h (Std. Dev. 0.70€/h) from the real price of the garage. Respect to the real garage fee, this represents an average deviation of 25%. The average difference between recalled and real curbside prices is lower than that found for garages, namely −0.12 €/h (Std. Dev. 0.64€/h). If we take the average deviation in absolute terms, we find that respondents deviate from the real curbside fee by 18%.

The descriptive statistics point to an important problem of misperception. Table 4 shows our main results for the multivariate analysis of the determinants of misperception, which enables us to identify the characteristics that aggravate/mitigate this problem. Estimates refer to the models assessing determinants of garage and curbside fee misperception, as described in Eq. (2).

Sociodemographic variables do not seem to explain the parking fee misperception. Only in the case of respondents older than 64 do we find a positive correlation with misperception about curbside fees at the 10% significance level, possibly reflecting a decreasing ability to process price information with age. This implies that being a + 65 years old parker is correlated with a 51% higher curbside fee misperception than the reference group. However, no differences are found for garage fees.

Other individual features, specifically the frequency of monthly parking episodes in the area and using an electronic payment method (teletac), do seem to affect misperception. Each additional visit per month is correlated with a 4% lower garage fee misperception; while using teletac increases it by 180%. In the first case, repeated parking episodes in the area seem to help the driver have better information about both curbside and garage fees, suggesting that higher exposure to price information reduces misperception. In the second case, the use of

Table 4
Least squares regression estimates on parking fee misperception.

	Garage fee misperception Log(|fee recall – real|)		Curbside fee misperception Log(|fee recall – real|)	
VARIABLES	Estimates	Marginal effect	Estimates	Marginal effect
Sociodemographics				
Age	0.00180	0.0018	0.00676	0.0068
	(0.00578)		(0.00883)	
Gender	0.0944	0.0990		
	(0.149)			
Vehicle price	0.000700	0.0007	−0.00472	−0.0047
	(0.00459)		(0.00502)	
Parking behavior				
Previous visitor			−0.645	−0.4753
			(0.398)	
Visit frequency/ month	−0.0404***	−0.0396***		
	(0.0140)			
Use electronic payment method (teletac)	1.034***	1.8123***	0.148	0.1595
	(0.246)		(0.271)	
Length of parking stay	−0.000250	−0.0002	2.16e-05	0.0000
	(0.000301)		(0.000406)	
Trip purpose				
Shopping/leisure	−0.161	−0.1487	0.794***	1.2122***
	(0.178)		(0.234)	
Personal	−0.337	−0.2861	0.691*	0.9957*
	(0.224)		(0.384)	
Administrative	−0.0636	−0.0616	0.625**	0.8682**
	(0.189)		(0.288)	
Search for alternative garage	0.167	0.1818		
	(0.248)			
Search pre-trip	0.271	0.3113		
	(0.352)			
Search first for curbside space	−0.0873	−0.0836	0.0362	0.0369
	(0.177)		(0.346)	
Garage features				
Facility	0.162	0.1759		
	(0.228)			
Franchise	−0.824***	−0.5613***		
	(0.249)			
Price saliency	−0.418**	−0.3416**		
	(0.202)			
Price complexity	0.00720**	0.0072**		
	(0.00336)			
Area features				
# visible garage signs	0.146	0.1572		
	(0.0945)			
Economic activity	−0.0825**	−0.0792**	0.142*	0.1526*
	(0.0417)		(0.0762)	
Constant	3.872***		2.881***	
	(0.403)		(0.571)	
Area-specific effects	YES		YES	
Observations	303		89	
Log-Likelihood Full Model	−455.4		−105.7	
R^2	0.155		0.350	

Note:Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Marginal effecs column provides the percentage change in the outcome variable y (|fee recall – real|) due to a unit increase in x, computed as $\Delta y = e^{\beta} - 1$ and reported in decimal format.

teletac seems to worsen users' information accuracy in the case of garage fees, since the payment method offers fewer incentives and consciously reduces their price information processing. These results are consistent with our previous findings related to experience and the use of electronic payment devices in determining the level of knowledge of parking fees.

Curbside fee misperception is also higher among users whose trip is undertaken for a purpose other than that of compulsory mobility (work and education), ranging from 87% (administrative duties) to 121% (shopping/leisure). We believe it seems to be the purpose that ensures parkers have a better knowledge of curbside fees due to higher information exposure (passive). However, this result is not maintained in the case of garage fees, which might require a more active information acquisition process compared to that associated with on-street parking.

Search activities do not seem to improve information accuracy. Yet, garage characteristics do appear to be particularly relevant. We find evidence that obfuscation may promote misperception. On the one hand, price saliency is negatively correlated with a 34% lower misperception with respect to their counterparts, indicating that it is a good instrument for promoting more accurate price recall by drivers. That is by providing greater exposure to price information. On the other hand, complexity hampers drivers' ability to process price information and appears to be positively correlated with parkers' misperception; implying a 0.7% increase for each additional character in the price schedule text string. Thus, fee simplification and promoting price visibility seem to constitute two clear options for limiting misperception. Interestingly, respondents also seem to have more accurate information about the fees charged when they park in garages belonging to franchises or networks. In particular, parkers using a franchised facility show 56% lower misperception than their counterparts. We believe this is due to pricing strategy similarities that increase the users' ability to recall prices more accurately, especially if they have parked on other occasions in garages belonging to that network.

Finally, the amount of economic/commercial activity in the immediate area is associated with greater accuracy in the case of garage fees, but with poorer accuracy in the case of curbside fees. Likewise, district fixed effects seem to matter for the level of information accuracy, as they capture unobservable area characteristics influencing consumers' ability to accurately recall prices through information exposure levels associated with the urban pattern, parking options and the distribution of economic activity.

This confirmation of the misperception of both curbside and garage fees is a matter of concern. However, the misperception regarding the relative price of garage parking and on-street parking is a matter that goes beyond a simple information problem, given that it would appear to be an essential determinant of cruising for parking if we follow the available parking spatial competition models, which leads to aggravated inefficiencies. Indeed, this misperception of relative pricing can be constructed as a difference between recalled and real fees. On average, respondents estimate a difference between garage and curbside fees of 1.04 €/h, while in reality the average difference between the two is 0.56 €/h (the garage fee being higher than that charged at the curb). Surprisingly, 82% of respondents believe the difference to be greater than it actually is. Differences per individual are even more substantial when we focus our attention on those searching for on-street parking (1.94 €/h) and contrast this with those not looking for curbside spots (0.44 €/h). These results are of particular relevance for parkers that prefer on-street parking and who are aggravating the existing pricing distortion in the market. The estimated misperception of drivers who head straight to a garage facility lies in the range of the curbside premium reported in the literature (Gragera and Albalate, 2016; Kobus et al., 2013), which suggests that the previously assumed curbside preference might not derive from walking costs and its more ubiquitous distribution but from a price misperception.

Moreover, individuals searching for curbside spots seem to be more prone to believe that the curb is comparatively cheaper than it really is. If we assume that the misperception of curbside parkers is the same as

that estimated for those that searched for curbside spots in our sample, this means that the pricing efficiency gap computed in this market does not lie between 0.45€ and 1.05€/h as it did for garage parkers (Gragera and Albalate, 2016), but between 1.84€ and 2.44€/h for curbside parkers with the true value lying somewhere in between. This is of considerable relevance as it implies the need for much greater increases in fees if cruising is to be eliminated without first addressing information issues. It indicates that misperception does not only affect consumer decisions, but that it can potentially further aggravate cruising-for-parking and associated externalities, and makes any policy intervention through prices much more difficult from a political economy perspective.

5. Concluding remarks

In this study, we combine both consumer behavior and transport economics literature to look into how little we know about how transport users translate information into knowledge; which then affect their choices. We have examined garage parkers' misinformation and misperception as measures of consumers' subjective and objective knowledge regarding available parking options and prices, respectively. This is the first paper to assess the contribution of several potential determinants of these two dimensions of information in the parking market.

Our findings suggest that parkers have low levels of knowledge about available parking alternatives and their prices. Moreover, the level of accuracy of this information is poor and biased towards prioritizing curbside parking. This can result in demand misallocation that further exacerbates cruising-for-parking and limits effective price competition in the market. Misinformation and misperception can hinder the beneficial effects of any parking policy interventions if they are not appropriately addressed.

The level of exposure to market information seems to be a crucial determinant of parkers' knowledge. Among our findings, we highlight that previous experience helps users increase both their subjective and objective knowledge dimensions, that income positively correlates with knowledge of garage options, and that users engaged on compulsory mobility-related trips show comparatively better knowledge of curbside prices. The conducting of search activity does not seem to be especially effective in increasing knowledge other than reducing misinformation regarding the availability of garage options, suggesting high search costs.

The specific characteristics of the selected garage and its surrounding area also play a role in determining the users' levels of information. Drivers using garages associated with a particular commercial activity are less well informed about available competing alternatives, which acts as a restriction on their choice set. Those who opt to park at a franchise facility have higher subjective knowledge on garage characteristics and more accurate information about prices, a characteristic associated with greater exposure levels and knowledge transferability. The level of economic activity in the immediate area increases users' subjective knowledge about garage alternatives and curbside prices, but is correlated with greater accuracy on their knowledge of garage prices and lower for curbside fees; which implies some knowledge bias. Finally, price saliency increases knowledge accuracy and fee complexity reduces it, suggesting that garages' obfuscation strategies are indeed keeping parkers uninformed.

As information is a public good it requires public intervention if it is to be provided in optimal quantity and quality. In this respect, we advocate a greater role for the public sector in the establishment of provision standards, incentivizing up-to-date, private-sector information disclosure and active cooperation, while curbing data gathering costs and data maintenance in a neutral platform. From the perspective of promoting competition, it would also be advisable to make parking price saliency mandatory in order to prevent the negative market effects induced by garages' obfuscation strategies. Indeed, our evidence suggests that the greater the exposure to this information, the better informed consumers are likely to be.

Our paper highlights the lack of evidence on the actual use of information by transport users using information from the city of Barcelona. Our results and its potential relevant policy implications suggest the need for further (and more sophisticated) research to fill in this gap. Future research should focus on overcoming present study limitations by:

i. moving from correlation evidence (our paper) towards causal inference. The causal impact of consumers' information exposure on market outcomes can be assessed using randomized control trials (large-scale experiments) with real or emulated conditions. In such experiments consumers can be randomly confronted to different information inputs under different decisions contexts to assess how those impact their decision making and study potential heterogeneities in knowledge formation (and biases). Alternatively, quasiexperimental approaches could be used taking advantage of external shocks to the parking market or unanticipated regulatory changes, yet those are proven to be difficult to find, especially when needing to control the information consumers get in an uncontrolled setting.
ii. exploring how case-study-specific results (our paper) transfer to other decision settings. How much information is distributed to consumers, what type of channels are used, how they treat such information and react on it, might well differ across settings. Cross-city or -country studies can be a good starting point to assess the differences across market conditions, instutitionals and cultural environments.
iii. extending the analysis done for parking (our paper) to other transport-related decisions and modes. It would be of relevance to analyze how imperfect information issues appear in other transport markets and might bias travel decisions, or its role in the success or failure of traffic demand management tools implemented in large urban agglomerations. This will help further expand the literature on travellers information systems effects on travel behaviour.
iv. Additionally, to give a broader picture of the information-knowledge-behaviour process, it should explore how knowledge levels trigger consumers to activate different sets of decision heuristics, accounting for the interactions between them. Moreover, the analysis of the policy relevance of information issues will require exploring how nudging and information provision strategies can be used to steer demand allocation to the socially optimal solution by considering consumers' knowledge biases.
v. Finally, we believe that the seminal insights provided in the paper also justify exploring the modification of actual spatial equilibrium models to account for imperfect information. Standard theoretical models usually work under the assumption of perfect information. This means that agents, producers and consumers, have all necessary and relevant information to take rational decisions about a transaction in the parking market. According to our evidence, this seems far to be true and should not be difficult to account for it in theoretical models.

Indeed, if we just focus on the parking sector, it is suffering a huge transformation due to fast paced digitalization. However, it is still quite old fashioned. If we compare the informational characteristics in parking markets across cities (and countries), we can see quite common patterns. On the one hand, curbside parking information is provided by public authorities using signals, paintings, parking meters, official webpages and quite often with their own payment Apps. On the other, off-street option is less publicized with just relatively big operators implementing web portals and investing into brand promotion. Parking locations are signalized by directional traffic signs, yet information on prices and garage characteristics is obscure in general (showed outside

each facility at best) across cities and countries. Therefore, although this analysis is based on the case study of the city of Barcelona, we believe our findings can be easily generalized. A simple exploration of Parkopedia database of garages shows that the information available on-site for parkers is equivalent across cities and countries. Thus, we see no great differences in the specifics of information provision between Barcelona and other cities. Additionally, we see no major differences regarding the type of information acquisition strategies they might activate.

Parking has a transient nature and there is certain agreement in the parking industry that consumers just think about parking once they are in their car. On-site search seems to be the go-to strategy, as current penetration rates of parking information and pre-booking tools are still low, only showing big numbers for "events" and airport parking. Indirect evidence of this is supported by a low proportion of downloads of such Apps compared with the total number of potential parkers. Such tools amount to below 10 M installs in Google Play for the Parkopedia, EasyPark, ParkMe, ParkCklick and JustPark combined in a more EU context (as we checked ourselves); and around 13 M in the US based on IPI (2016).

All this, makes us believe that the informational issues present in Barcelona can be transferrable to a similar extent in almost all cities. However, we acknowledge that the case study of Barcelona might be at the upper bound of information-distortion spectrum due to: (1) highly atomized garage market (relatively low concentration of big operators); and (2) a maybe lower penetration rate for such tool due to lower digitalization levels of the economy and lower tech-savviness of consumers. Additionally, it is clear to us that the evolution of the rate of adoption of such information tools can depend on the "technology readiness" of consumers in each area, with just anecdotal evidence pointing towards faster adoption in the US. Further research using data from other cities will allow exploring how representative is the case of Barcelona.

CRediT authorship contribution statement

Daniel Albalate: Conceptualization, Methodology, Formal analysis, Validation, Investigation, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Albert Gragera:** Conceptualization, Methodology, Formal analysis, Validation, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tbs.2022.03.005.

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