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Urban freight, parking and pricing policies: An evaluation from a transport providers' perspective

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ABSTRACT

This paper investigates transport providers' preferences for alternative loading bays and pricing policies. It estimates the importance of loading bays, the probability of finding them free and offers strategically relevant information to policy makers. The results underline the relevance of both preference heterogeneity and non-linear attribute effects. Three classes of agents are detected with substantially different preferences also characterized by non-linear sensitivity to attribute level variations. The specific freight sector, frequency of accesses and number of employees are all relevant covariates explaining different preferences for alternative transport providers' categories. The implications of the results obtained are illustrated by simulating alternative policy scenarios. In conclusion, the paper underlines the need for rigorous policy analysis if the correct policy outcomes are to be estimated with an adequate level of accuracy.

"When we delay the harvest, the fruits rot. When we delay resolving problems, they continue to grow."

– Paulo Cohelo

1. Introduction and motivation

City centers are major destinations for goods pick-up and delivery where parking spaces are scarce. Although trucks represent a relatively small proportion of all vehicle traffic, the combination of high demand for parking and limited supply provokes an increase in both private and social costs. In fact, transport providers have either to cruise for a free parking space[1] or double-park illegally[2] (Jaller et al., 2013). Both options imply, from a private perspective, an increase in expenditures due to delays in deliveries, additional fuel consumption, rising driving stress and parking fines aggravating the cost of last mile distribution representing one of the largest shares of total distribution costs (O'Laughin et al., 2007). From a social perspective, instead, they contribute to congestion, infrastructure damage, vehicle emissions, greenhouse gases, and noise (Giuliano and Dablanc, 2013). These negative externalities are relevant given the high density of city dwellers.

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[1] While a vehicle in New York spends approximately nine minutes to find a parking space in Manhattan's Central Business District, according to Shoup (2005), it is reasonable to assume a longer time for truck delivery since they will search for a parking place close to the delivery location.

[2] In European cities, and mainly in France, Patier et al. (2014, p.100) report a 70–80% of double parked deliveries.

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An efficient and effective urban freight distribution system is fundamental for cities whose performance is crucial for national economies. Local policy makers are faced with contrasting policy objectives since they have both to foster economic vitality while minimizing the negative impact of urban freight (Lindholm, 2013; Wygonik et al., 2014). Literature surveys have underlined the sub-optimality conditions of freight transport in urban areas, the need for policy intervention and discussed the pros and cons of the numerous options available (e.g. Ambrosini and Routhier, 2004; Muñuzuri et al., 2005; Dablanc, 2007; Allen et al., 2008; Russo and Comi, 2011; Arvidsson, 2013; Marcucci and Puckett, 2013).

The difficulties encountered by policy makers in dealing with such a complex environment are magnified by the natural proximity and interaction among stakeholders characterized by contrasting objectives. An emblematic example is represented by off-hour deliveries (Holguín-Veras et al., 2007, 2008; Holguín-Veras, 2011; Jaller and Holguín-Veras, 2013). In fact, in this case transport providers favor this option since it facilitates loading and unloading operations and the use of uncongested roads. Retailers would, on the contrary, prefer to have the goods consigned during regular opening hours, while citizens are interested in having both a quite environment during night-time and fully re-stocked shelves when shopping. Policy interventions usually aim at re-balancing social costs and benefits.

Among all the relevant actors, transport providers play a key role in making urban freight distribution more sustainable (Quak, 2012), and are becoming progressively more important since just-in-time concepts have been adopted in complex supply chains (Massiani et al., 2009; Ehmke, 2012). They are confronted with daunting challenges in their daily activities and focus their efforts on technology and logistics to increase operational efficiency. At the same time, they have limited influence on the conditions under which urban freight transport takes place. These, in fact, are often determined by policy makers having environmental sustainability objectives in mind (e.g. emission zones, charging entrance fees, time-windows restrictions, etc.) that might be in contrast with transport providers' pursuit of efficiency.

This paper offers useful insights into transport providers' preferences for alternative loading bays and pricing policies in a large urban area. The development of sustainable management policies for urban logistics should be based on site-specific data given the heterogeneity and complexity of urban freight systems (Comi et al., 2008; Nuzzolo and Comi, 2014). The paper focuses on Rome where freight data are publicly available given the local public administration has carried out various dedicated surveys in the last ten years.

In particular, the paper investigates the limited traffic zone in the city center where freight distributors have to pay for access. The research motivation originates from the qualitative results obtained in two previous studies underlining the important role loading bays play for environmental sustainability and urban freight distribution effectiveness (STA, 1999; Filippi et al., 2008). The paper estimates the relative importance of the number of loading bays and the probability of finding them free. In fact, these two elements are at the core of a deep-routed problem in Rome and, possibly, in other cities. Already back in 1998 the majority of the 779 transport providers sampled in a research performed by the Mobility Agency of Rome indicated that the two most relevant elements hindering an efficient urban freight distribution system were the insufficient number of loading bays and the lack of appropriate surveillance with respect to their correct use (STA, 1999).

This paper extends and complements previous research based on data derived from a Volvo Research and Educational Foundation project (VREF, 2009) that can be summarized as follows: (1) Marcucci et al. (2012) report on the survey instrument development process to study freight agents' behavior, describe the stated preference experiment used and discuss the multi-stage efficient experimental design implemented incorporating agent-specific priors; (2) Marcucci and Gatta (2013a) focus on retailers concentrating on the role of the status quo and test for non-linear attribute effects; (3) Marcucci and Gatta (2013b) study own-account operators to investigate the impact time windows restrictions have on their behavior also considering preference heterogeneity; (4) Gatta and Marcucci (2014) test, from a policy-maker's perspective, the implications heterogeneity between own-account, retailers and transport providers has on specific policies equally impacting all agents' utility.

The present paper reports an in-depth analysis on transport providers, specifically addresses the role played by parking and pricing policies, while jointly tests for non-linear attribute effects and discrete mixture heterogeneity. The results obtained entrust local authorities with quantitative and strategically relevant results useful for policy making.

The main contribution of the paper, within the freight vehicle parking policy literature, is the specific focus, at a strategic level, on the overall number of loading bays and the probability of finding them free which, to the best of our knowledge, have never been investigated.

The paper is structured as follows: Section 2 reports a brief literature review on freight vehicle parking policies in urban areas clarifying the contribution of the paper and positioning it with respect to previous research; Section 3 describes methodology and data; econometric results are illustrated in Section 4, while simulations of different policies are reported in Section 5; Section 6 concludes and discusses future research.

2. Literature review

This section reports on the freight vehicle parking policies literature. It illustrates recent contributions and positions the present paper.

Urban freight transport research underlines, among the different policy options available, the importance of parking/loading related policies (CoE-SUFS, 2014). Less attention has been paid to commercial vehicles with respect to the investigation of passenger car parking in urban areas (e.g. Thompson and Richardson, 1998; Ommeren et al., 2012; Ibeas et al., 2014; Millard-Ball et al., 2014).

Muñuzuri et al. (2005) discuss, within the wider set of solutions related to land use management, the role parking space planning plays in improving general traffic conditions. The paper underlines the correlation between congestion levels and freight delivery conditions (p. 19). In addition, it points to the lack of specific infrastructure aimed at facilitating access, parking, loading, unloading and delivery of goods as one of the main problems city logistics faces (p. 19–20). On the same line, Jaller et al. (2013) discuss policy makers' development strategies for freight parking demand management. The paper highlights that parking represents a major challenge for drivers attempting to pick up or deliver goods within cities. The problem is usually augmented in older cities characterized by smaller streets originally constructed for a non-motorized society.

The main freight vehicle parking policies can be partitioned in the following categories: (1) time restrictions; (2) pricing strategies; (3) land use and space management; (4) parking enforcement (Nourinejad et al., 2014).

Time restrictions separate parking competition between commercial and passenger vehicles in time rather than in space. Many US cities apply time of day loading zone restrictions (Zalewski et al., 2011). In fact, time of day parking requirements are usually highly concentrated. As it is for New York, Jaller et al. (2013) show that the 2-h peak morning period accounts for about 13% of total traffic. This is also true for Europe where older cities are characterized by pedestrian zones in central areas (Better Market Street, 2011).

Pricing strategies try to foster a quicker turnover of vehicles so to increase parking chances. This objective can be enhanced by either imposing a maximum parking limit or by adopting an escalating parking rate structure (NYCDOT, 2012). Successful implementations have guaranteed considerable dwell times reductions (Zalewski et al., 2011), while dynamic adjustment of on-street and off-street parking prices balanced demand and supply in different blocks within San Francisco (Pierce and Shoup, 2013).

Land use and space management policies refer to the size, position and usage of curbside space for commercial vehicles operations. As it is for size and position, the city of Washington, DC, for example, has extended loading zones from 40 to 100 feet and moved them, wherever possible, to the end of the block (Jones et al., 2009). Shared spaces approaches provide an alternative and more flexible option with respect to strict separation between users' types. The intent is to optimize the use of loading bays (San Francisco County Transportation Authority, 2010). In addition, intelligent transportation systems can be used to optimize parking spot allocation. Truckers could, during a pilot study, book remotely monitored parking spaces by cell phone in Toyota City (PIARC, 2012).

Parking enforcement, while relevant in itself, becomes more important with articulated parking regulations especially during peak-hours when violations are likely to concentrate. Enforcement requires monitoring. This can be performed either by city staff or using technology (e.g. cctv cameras, license plate recognition software, etc.). City authorities, in addition to fining illegal parking, have, in certain cases, developed dedicated squads to tow away illegally parked vehicles and successfully enforced curbside management programs (NYCDOT, 2004). Physical barriers can also be used to enforce delivery regulation. Physical restrictions, including roadway design, gates and permanent/removable bollards, can selectively be used to either impede truck access or loading/unloading activities (Ramon, 2001).

All the interventions previously described, while different in nature, share the common objective of finding a viable solution to the delivery problems transport providers face when confronted with an insufficient supply of available parking spaces. Recognizing this overarching characteristic, independently of the specific method used to make available additional parking spaces, the present paper investigates the preferences transport providers have for the number of loading bays and the probability of finding them free. This feature distinguishes this paper from those dealing with parking simulation models (e.g. Delaître, 2009; Gallo et al., 2011) and parking choice models (Thompson and Richardson, 1998; Waraich and Axhausen, 2012) while contributing, from a strategic point of view, to the freight parking policy literature. In fact, the results obtained in the paper allow decision makers to gauge stakeholders' plausible reactions to specific policy interventions characterized by different entrance fees, number of loading bays and probability of finding them free. This represents a substantial improvement in modeling specific parking policies components' effects.

Table 1 reports a synoptic table summarizing the freight-related papers reviewed and pointing out the contributions proposed.

3. Methodology and data description

This section describes the methodology employed and the data utilized. Discrete choice analysis is used to model transport providers' preferences for alternative parking policy combinations. The reference model is a multinomial logit (MNL) with linear attribute effects. In particular, the utility function for a generic agent (i) and a generic alternative (j) is reported below:

$$U_i(j) = \boldsymbol{\beta}'\mathbf{x}_{ij} + \varepsilon_{ij}$$

where :

$$\boldsymbol{\beta}'\mathbf{x}_{ij} = \beta_0 + \beta_1 x_{ij1} + \beta_2 x_{ij2} + \beta_3 x_{ij3}$$

x_{ij1} = number of loading bays;

x_{ij2} = probability of finding loading bays free;

x_{ij3} = entrance fee.

Table 1
Freight-related papers reviewed and contributions proposed.

Papers	Categories				Proposed contribution
	Time restrictions	Pricing strategies	Land use & space management	Parking enforcement	
Ramon (2001)				X	Automated enforcement guarantees services. Curbside management and integration with zone access control in Barcelona
NYCDOT (2004)				X	The THRU Streets program provides beneficial effects on traffic conditions in Midtown Manhattan. The program required a strong parking enforcement
Muñuzuri et al. (2005)	X	X	X	X	Classification of generic solutions from a policy-maker's point of view. Lack of specific parking-related infrastructure
Jones et al. (2009)			X	X	A practical and acceptable solution to the use of downtown curbsides for freight delivery in Washington, DC
San Francisco County Transportation Authority (2010)			X		A proposal for pedestrian space that can be shared with delivery vehicles on Columbus Avenue in San Francisco
Better Market Street (2011)	X	X	X	X	Best practices for managing freight delivery on multimodal urban streets lacking off-street loading facilities
Zalewski et al. (2011)	X	X			Three curbside management models in large American cities provide policymakers with a strategic way of thinking about how they take curbside management decisions
NYCDOT (2012)		X			Park Smart project provides an escalating parking rate structure to make parking easier while reducing congestion and improving safety
PIARC (2012)			X		Key factors of success, possible barriers and ways to overcome the problems from a set of seventeen case studies. In particular, the optimization of parking spaces through a booking system in Toyota City
Jaller et al. (2013)	X				Variability in parking demand at different times of the day. Off-hour delivery programs can help mitigating parking problems
Pierce and Shoup (2013)		X			Evaluation of pricing that varies by time of day and location to manage curb parking. Estimation of the elasticity of demand for on-street parking using measured occupancy
CoE-SUFS (2014)	X	X	X	X	A comprehensive classification system of public sector initiatives, with a critical examination of the evidence concerning their performances
Nourinejad et al. (2014)	X	X	X	X	Classification of specific parking-related solutions. A micro-simulated parking choice model for policy evaluation

The model specification is:

$$\text{Prob}(y_i = j) = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{ij})}{\sum_{q=1}^{J} \exp(\boldsymbol{\beta}'\mathbf{x}_{iq})}$$

Potential non-linearities are investigated by effects coding the level of variation for each attribute.[3] This was possible since each attribute has, at least, three levels. In this case, the systematic component of the utility function is modified as follows:

$$\boldsymbol{\beta}'\mathbf{x}_{ij} = \beta_0 + \beta_1 x_{ij1a} + \beta_2 x_{ij1b} + \beta_3 x_{ij2a} + \beta_4 x_{ij2b} + \beta_5 x_{ij3a} + \beta_6 x_{ij3b} + \beta_7 x_{ij3c} + \beta_8 x_{ij3d}$$
$$x_{ij1a} \text{ and } x_{ij1b} = \text{effects coding of number of loading bays;}$$
$$x_{ij2a} \text{ and } x_{ij2b} = \text{effects coding of probability of finding loading bays free;}$$
$$x_{ij3a}, x_{ij3b}, x_{ij3c} \text{ and } x_{ij3d} = \text{effects coding of entrance fee.}$$

Moreover, one should test for preference heterogeneity given the well-known restrictions that characterize MNL and limit its ability to detect random variations of agents' preferences. The typical way of allowing for variations in behavior across respondents is to incorporate taste heterogeneity via the systematic component of utility assuming either continuous or discrete mixture structure (e.g. Greene and Hensher, 2003; Hess et al., 2005). Both approaches are characterized by their respective pros/cons and none can be considered unambiguously preferable. The present study adopts a latent class model (LC) since it allows for differences in sensitivities across population groups while producing results that can be easily used by policy makers. In fact, they are usually much more interested in discovering the "classes of users" that are influenced by the policy implemented rather than the specific effects on each single citizen. LC assumes that preference parameters can be

[3] Non-linear effects on utility function can be also tested via self-stated attribute cutoffs (Marcucci and Gatta, 2011).

adequately approximated by a discrete mixing distribution. A small number of mass points can be interpreted as different groups/segments of agents with distinct preferences. More in detail, for N classes, the model is specified as follows:

$$\text{Prob}(y_i = j) = P(j|n)P(n) = \sum\nolimits_{n=1}^{N} \frac{\exp(\boldsymbol{\beta}'_n \mathbf{x}_{ji})}{\sum_{q=1}^{J} \exp(\boldsymbol{\beta}'_n \mathbf{x}_{qi})} \left(\frac{\exp(\boldsymbol{\varphi}'_n \mathbf{k}_i)}{\sum_{n=1}^{N} \exp(\boldsymbol{\varphi}'_n \mathbf{k}_i)} \right),$$

where the last multiplicand represents the probability that agent (i) belongs to class n, modelled as a function of the agent socio-economic variables (k).

A crucial issue in LC specification relates to the number of classes to be estimated since the conventional specification tests cannot be employed. The most frequently used principles for determining the optimal number of classes are: (1) information criteria statistics; (2) significance of the estimated parameters; (3) plausibility of model results (e.g. signs and magnitudes of the parameters) and (4) *a priori* information concerning existing groups.

The data used in this paper were acquired in Rome's limited traffic zone, a 5 km^2 wide area in the city center (Marcucci et al., 2013). The regulatory framework, when the questionnaire was administered, foresaw the entrance of Euro1 and more fuel-efficient vehicles only. Residents could freely enter while other stakeholders (e.g. retailers and transport providers) were charged. Entrants paid a yearly fee of approximately 600€ per number plate. On May 2014 a major change in the regulatory framework took place since, *ceteris paribus*, the average yearly entrance fee was raised to around 2000€.

The stated preference survey acquired the necessary data to evaluate transport providers' sensitivities to loading bays availability and entrance fees (see Table 2). More in detail, this was performed considering both loading bays number and the probability of finding them free. This allows the evaluation of a joint policy change.

The relevance of the issues considered emerging from the literature review reported in Section 2 was confirmed by preliminary stakeholder meetings aimed at investigating the most relevant problems pertaining to the limited traffic zone, the appropriate/feasible policy interventions, and the likely stakeholder reactions (Stathopoulos et al., 2011). More in particular, Filippi et al. (2008), with specific reference to the main critical issues in the inner area of Rome, underline the importance of freight loading and unloading operations which, according to operators' stated opinion, are hindered by insufficient parking spaces for freight vehicles.

To improve the realism of the experiment, the questionnaire was administered as a stated ranking exercise adopting an efficient experimental design (see Rose et al., 2008) developed using Ngene 1.1 software (Rose and Bliemer, 2012). In fact, consultations with transport providers clarified they felt more comfortable expressing their relative appreciation for alternative policies rather than choosing one among a predetermined set. Replies to the ranking exercises were exploded into choices for estimation purposes. An example of a ranking task is reported in Table 3.

The sample includes 98 transport providers for a total of 1662 observations, operating in eight macro-sectors, namely: (1) *food* (e.g. fresh, canned, drinks, tobacco, bars, hotels and restaurants, etc.); (2) *personal and house hygiene* (e.g. detergents, pharmaceuticals, cosmetics, perfumes, watches, barbers, etc.); (3) *stationery* (e.g. paper, newspapers, toys, books, CDs, etc.); (4) *house appliances* (e.g. dish washers, computers, telephones, metal products, etc.); (5) *services* (e.g. laundry, flowers, live animals, accessories and animal food, etc.); (6) *clothing* (e.g. clothes, leather, etc.); (7) *construction* (e.g. cement, scaffold, chemical products, etc.); (8) *cargo* (general cargo).

4. Econometric results

Table 4 reports the econometric results obtained using the software Latent Gold Choice (http://statisticalinnovations.com). Non-linearity and heterogeneity are tested via MNL and LC. Non-linearity is studied by effects coding attribute levels. Heterogeneity is explored by analyzing the deterministic part of utility and assuming a discrete mixture of the error component.

The MNL, linear-in-attribute model (M1), is characterized by a pseudo-R^2 of 0.27 which, according to Domencich and Mc Fadden (1975), testifies to a good model fit.

In discrete choice experiments, it is good practice to test a model's predictive validity on a part of the dataset that was not used for estimation. When comparing the performance of two models, out-of-sample validity is as important as model fit. Different are the methods one can use to test out-of-sample validity. Among them, the most popular compares the hit rate of the models considered (Chorus, 2012). With this objective in mind the analyst splits the data into an estimation-sample and a validation one by randomly selecting 80% of cases for estimation and leaving the remaining 20% for validation. For each case in the validation-sample hit rates are computed by first predicting choice probabilities for every alternative on the base of the models calibrated using the estimation-sample. One, successively, compares the alternative characterized by the highest predicted choice probability with the actually chosen one. A score of one is assigned when the predicted alternative coincides with the one actually chosen and zero otherwise. Higher hit rates are preferred, indicating better predictive capabilities. Out-of-sample tests confirm the satisfactory predictive validity. In fact, for M1 the hit rate is 63.8% while for the constant-only model is 58.6%.

Variables' signs and their relative importance in M1 are in line with expectations. In fact, one supposes that a price \attribute has a negative effects on utility (i.e. entrance fee has a negative sign), while both the number of loading bays and the probability of finding them free are expected to have a positive sign since both represent desirable characteristics of the policy implemented from a transport provider's point of view.

Table 2
Attribute levels and ranges.

Attribute	Number of levels	Level and range of attribute – (*Status Quo* underscored)
Number of loading bays	3	400, 800, 1200
Probability of free loading bays	3	10%, 20%, 30%
Entrance Fee	5	200€, 400€, 600€, 800€, 1000€

Table 3
Example of a ranking task.

	Policy 1	Policy 2	Status Quo
Number of loading bays	400	800	400
Probability of free loading bays	20%	10%	10%
Entrance fee	1000€	200€	600€
Policy ranking	❸	❶	❷

Table 4
Econometric results.

Variable	MNL linear (M1)		MNL non-linear (M2)		LC non-linear (M3)					
	Coeff	*t-stat*	*Coeff*	*t-stat*	*Coeff*	*t-stat*	*Coeff*	*t-stat*	*Coeff*	*t-stat*
					Class 1		Class 2		Class3	
Number of loading bays	0.0014	11.45								
Number = 400			−0.7342	−11.92	−0.9157	−5.39	−0.4821	−2.89	−3.8616	−7.06
Number = 800			0.2362	3.70	0.3545	1.96	0.2304	2.59	1.1724	3.92
Number = 1200			0.4980	7.83	0.5612	3.29	0.2517	1.78	2.6892	8.04
Probability of free loading bays	0.0465	8.23								
Prob. = 10%			−0.6487	−8.95	−0.5938	−2.83	−1.1225	−6.51	−2.7453	−7.21
Prob. = 20%			0.0199	0.32	−0.0812	−0.51	0.4264	3.43	−0.5066	−2.74
Prob. = 30%			0.6288	9.28	0.6749	4.18	0.6961	3.67	3.2518	7.00
Entrance fee	−0.0058	−20.39								
Fee = 200			2.2022	18.22	5.0326	8.00	1.8851	7.31	2.2800	4.65
Fee = 400			1.5898	16.61	3.4168	10.65	1.5621	6.85	1.4408	3.89
Fee = 600			0.5663	6.15	1.1643	3.48	0.4911	2.75	0.6744	2.31
Fee = 800			−1.1430	−12.71	−2.8834	−8.96	−0.8041	−5.88	−0.2490	−0.87
Fee = 1000			−3.2152	−17.67	−6.7303	−9.22	−3.1343	−7.11	−4.1462	−6.49
Alt1 constant	0.1995	3.26	0.3452	4.62	0.2620	1.47	0.5979	3.53	−0.3675	−1.39
Alt2 constant	0.2512	4.83	0.3042	5.45	0.3388	2.66	0.4119	2.70	−0.0914	−0.26
Status Quo constant	−0.4507	−5.10	−0.6494	−6.07	−0.6008	−2.96	−1.0099	−3.47	0.4589	0.77
Sector: Food					−0.7634	−1.73	0.9216	2.45	−0.1582	−0.34
Sector: Hygiene					3.8925	7.74	−2.0145	−3.21	−1.878	−3.01
Sector: Stationery					−0.4906	−0.71	0.3841	0.64	0.1064	0.18
Sector: House appl.					1.5705	4.50	−3.453	−8.43	1.8825	4.69
Sector: Services					−3.2328	−3.82	1.7352	2.26	1.4976	1.94
Sector: Clothing					−3.3138	−6.52	1.0069	1.73	2.3069	4.23
Sector: Construction					1.7572	5.08	1.2541	3.61	−3.0113	−7.98
Sector: Cargo					0.5803	1.79	0.1655	0.45	−0.7458	−1.88
Employees					0.003	2.13	−0.0021	−1.24	−0.0009	−0.65
Access frequency					−1.1234	−3.76	−1.4489	−4.21	2.5723	5.40
Intercept					−1.184	−2.80	−1.5349	−3.24	2.7189	4.81
Class probabilities					46%		33%		21%	
Pseudo-R^2	0.27		0.30		0.59					
Pseudo-$R^2(0)$	0.35		0.38		0.64					
Loglikelihood	−1017.32		−975.06		−692.12					
NOBS	1662		1662		1662					

Elasticities, calculated via probability weighted sample enumeration, are used to rank attributes' importance. Entrance fee, with a statistically significant negative coefficient, has the highest elasticity indicating that a 1% increase of the entrance fee will, all else being equal, reduce choice probability by 2.6%. The number of loading bays and the probability of finding free loading bays have, respectively, an elasticity of 0.43% and 0.35%. In addition, it is important to note the aversion towards the status quo situation with respect to the two unlabeled hypothetical alternatives as suggested by the negative and statistically significant coefficient of the former.

The second model (M2), tests for potential non-linearities by effects-coding the explanatory variables. It is important to recall for a correct interpretation of the econometric results reported in Table 4 that effects coding a variable imposes a constraint on parameters' estimates since they have to sum up to zero. This allows calculating a specific parameter for each of the levels and avoids, as with dummy coding, confounding the parameter of the reference level with that of the grand mean. Three complementary indicators suggest the presence of non-linear effects. In fact, M2 is characterized by a higher pseudo-R^2 (0.30), passes a log-likelihood ratio test and outperforms M1's percentage of correctly predicted choice outcomes (64.7%). The results of M2 confirm M1's main conclusions.

Non-linear effects are relevant for the number of loading bays, less so for entrance fees. The shift from 400 to 800 loading bays has the highest impact on transport providers' utility. In fact, since the coefficients for 400 loading bays is −0.7342 and 0.2362 for 800, moving from the former to the latter has a positive impact on utility equal to 0.9704, while moving from 800 to 1200 produces only an impact of 0.2618. In line with Kahneman and Tversky (1979), departing from the status quo, equally scaled entrance fee increases (+200€) produce greater effects on transport providers' utility with respect to decreases (−200€). Moreover, it is noticeable that the shift from 600€ to 800€ has a smaller effect with respect to that from 800€ to 1000€.

The third model (M3), using M2's structure, investigates the presence of heterogeneity in preferences via a LC model relaxing the restrictive MNL assumptions.[4]

The final model specification reported is characterized by a good fit to the data (0.59 pseudo-R^2) and predictive validity (68.3%). The number of classes was determined accounting for information criteria statistics, parameter significance and plausibility of results. All these criteria, jointly considered, suggest the presence of three separate classes of transport providers each characterized by a different behavioral profile. Class 1, the most numerous (46%), comprises price-sensitive transport providers, members of class 3 (21%), on the other hand, are particularly interested in bay-based policies, while class 2 members (33%) have an intermediate position. In more detail, class 1 is characterized by the smallest willingness to pay for all attribute variations. In fact, for an increase of 400 loading bays class 1 members are willing to pay 63€ while class 2 and 3 have, respectively, a willingness to pay of 110€ and 411€. Similar considerations apply to an increase of 10% in the probability of finding a loading bay free (class 1 = 25€; class 2 = 222€; class 3 = 267€). One notices that while the number of loading bays is, in general, considered more important than the probability of finding them free, this is reversed for class 2.

Looking at non-linearity, one notices, with respect to M2, that this is also relevant for the probability of finding loading bays free. This phenomenon is particularly pronounced for class 2. Similar considerations apply to the number of loading bays. The non-linear effects of the entrance fee attribute are more evident for class 3. In fact, its members, while mainly focused on bay-based policies, are also sensitive to an entrance fee increase from 800€ to 1000€.

Conditional class probabilities are estimated using socio-economic covariates. These characterize the transport providers belonging to each class. The covariates explaining class membership are: (1) main sector of activity served; (2) access frequency; (3) number of employees. Class 1 is characterized by the presence of transport providers with a high number of employees serving construction/personal-house hygiene sectors. Class 2 is populated by operators with infrequent access and few employees working for food/services sectors. The operators in class 3, characterized by a high level of access frequency, serve the clothing/house appliances sectors.

A discussion of class membership has to jointly consider both the specific characteristics of the transport providers belonging to each class as well as their respective sensitivity to given policy changes. More in detail, the transport providers prevalently serving construction/personal-house hygiene sectors (class 1) are more sensitive to entrance fees. Considering their intermediate access frequency, this can be explained by the number of deliveries performed once entering the restricted area. These two sectors, in fact, have the lowest average number of consignments per trip (Filippi et al., 2008). Class 3, distinguished by high access frequency and transport providers serving clothing/house appliance sectors, is particularly sensitive to the number of loading bays and less so to entrance fees. The high number of accesses to the limited traffic zone implies a low average cost per entrance explaining the reduced sensitivity to entrance fees. At the same time, the strong attention paid to the number of loading bays could also depend on the concentration of clothing shops in the *Campo Marzio* borough (Unindustria-CTL, 2014) which is characterized both by a limited number of loading bays and a high demand for them (STA, 1999 full table illustration n° 28). The intermediate position of class 2 can be explained by two conflicting elements. In fact, on one side, the relatively low access frequency of the transport providers belonging to this class suggests a higher sensitivity to entrance fees with respect to class 3, while the high number of consignments per trip for food/services sectors (Filippi et al., 2008) justifies their specific interest for the number of loading bays. In particular, this last circumstance could explain why there is a relatively higher interest in the probability of finding loading bays free.

[4] Heterogeneity in preferences is important in itself. One should, however, recall that the hypotheses and procedures used to search for it have also an impact on the final results. See Marcucci and Gatta (2012) on this point.

5. Policy implications

Scenario analyses are performed to clarify the policy implications derivable from the results obtained while providing useful information to decision makers. The logic adopted in comparing alternative policy effects assumes that any variation introduced should leave transport providers indifferent to the change. The effects of non-linearity (M2) and preference heterogeneity (M3) of a given policy change are measured comparing, with respect to M1, the differences in the compensating variations needed to keep the choice probabilities unaltered.

It is important to note that the analysis proposed allows for a policy mix evaluation. In fact, free loading bays are the product of both the number and the probability of finding them free.[5]

Two types of policy simulations are reported. The first illustrates how a given increase in the number of free loading bays possibly implies adopting different, and equally accepted, entrance fee variations depending on the policy mix implemented. Conversely, a second policy simulation proposes alternative ways of compensating transport providers for a given entrance fee increase. As a special case, the paper simulates which should have been the changes in the loading bays policies needed to compensate the dramatic entrance fee increase recently passed in Rome.

Main results are reported in Table 5. Assuming policy makers provide 80 additional free loading bays (scenario 1, taking M1 as a reference) with the two polar cases being "+20% probability" and "+800 loading bays", the maximum increases in entrance fees that one can impose without stimulating a behavioral change and leaving transport providers indifferent, are, respectively, +160€ and +194€. This information could be exploited by a policy maker intending to maximize the revenues deriving from a given policy by focusing on an intervention aiming at loading bays increases rather than on the probability of finding them free. This practical implication would, however, be reversed accounting for possible non-linear effect of attribute variations (M2). Additionally, in this case, simulations suggest that only a lower increase in entrance fees can be charged for the improvements proposed. Furthermore, considering also heterogeneous preferences (M3) reveals that the estimated parameters are just means of three different classes thus recommending the adoption of a differentiated pricing strategy. In fact, for "+800 loading bays", the entrance fee increase varies from +73€ to +488€ while using M2 it was estimated equal to +145€. Please note that the implementation of a differentiated pricing strategy also implies a financial advantage for local policy makers. In fact, considering the quota of the three classes, the additional resources deriving from the adoption of an articulated pricing policy would be 242,000€ a year for each 100 entrants.

A second scenario considered assumes a policy providing only 40 additional free loading bays (i.e. 50% of the increase tested in scenario 1). The analysis proposed indicates a substantial impact of non-linearity. In fact, the additional free loading bays, either obtained via an increase in their number or probability, does not provoke a 50% reduction of the previous compensating change in entrance fees. In particular, with reference to "+400 loading bays", the compensating entrance fee increase is equal to +115€ representing only a 20% reduction. This implies that a decision maker, aiming at maximizing the positive financial impact of the policy implemented, should probably choose this option.

Scenario 3 illustrates the case of "+200€ in entrance fee" from the status quo. The paper reports the two polar alternative policies that can be implemented to compensate for the entrance fee increase. As a preliminary consideration one should note that in both simulated policies one obtains results exceeding the range of variation for the attributes considered in the design.[6] More in detail, M1 indicates that an increase of either 820 loading bays or 25% of probability should be made available to transport providers, assuming linear effects outside attributes' range. These results are confirmed when using M2 and M3 and strengthened considering "+400€ in entrance fee" (scenario 4).

Based on the simulations performed one could envisage policies aiming at a temporally differentiated utilization of parking spaces throughout the day so to increase the number of loading bays during peak while guaranteeing flexibility. This option seems appropriate for Rome given freight-related traffic peak is slightly postponed with respect to passengers' peak (Filippi et al., 2008). At the same time, one has to underline the need for spatio-temporal recognition capabilities of various vehicle types implying surveillance and removal of illegally parked vehicles. This feature is complementary to the actions also needed to improve the probability of finding loading bays free. Additionally one could also conceive a geographical re-location of the number of loading bays presently available so to create an improved spatial matching of loading bays demand and supply. The *Campo Marzio* situation previously illustrated is emblematic under this respect.

Nevertheless, one has also to acknowledge the limits of the two components of the policies considered since there is a limit both to the increase in the number of loading bays that can be made available as well as to the probability of finding them free. This represents only a partially stringent limit to the optimization process of urban freight distribution since additional and complementary policies could be put into place to this end.

Scenario 5 reports the extraordinary high compensatory actions that should have been put into place according to the recently introduced policy variations establishing the yearly entrance fee at around 2000€. Ironically, the entrance fee

[5] For example, 40 additional free loading bays can be made available either by: (1) increasing their number by 400 (i.e. 40 free loading bays = 400 loading bays ∗ 10% probability), (2) increasing the probability of finding them free by 10% (i.e. 40 free loading bays = 400 loading bays ∗ 20% probability), or (3) adopting any appropriate linear combination of (1) and (2).

[6] The simulations proposed can be also used to define a linear combination of the two policy components whose variations fall within the attributes' range tested. With respect to scenario 3, a solution can only be found when using M1 and M2. As it is for M3, in fact, no linear combination can be found satisfying the above mentioned constraints for class 1 which is the least sensitive to loading bays policies.

Table 5
Scenario analysis.

Scenario	Policy objective	Simulated action		Simulated compensation				
				M1	M2	M3		
						Class 1	Class 2	Class 3
1	Increase the availability of free loading bays: from actual 40 to 120	• Only variations in the number of loading bays: +800	Variations in entrance fee	+194€	+145€	+73€	+115€	+488€
		• …	…	…	…	…	…	…
		• Only variations in the probability of finding free loading bays: +20%	Variations in entrance fee	+160€	+150€	+62€	+245€	+461€
2	Increase the availability of free loading bays: from actual 40 to 80	• Only variations in the number of loading bays: +400	Variations in entrance fee	+97€	+115€	+63€	+110€	+410€
		• …	…	…	…	…	…	…
		• Only variations in the probability of finding free loading bays: +10%	Variations in entrance fee	+80€	+80€	+25€	+222€	+268€
3	Increase the revenues for implementing the measures needed	Variations in entrance fee: +200€	• Only variations in the number of loading bays	+820	+1500	+5750	+11,600	+72
			• …	…	…	…	…	…
			• Only variations in the probability of finding free loading bays	+25%	+27%	+57%	+8%	+4%
4	Increase the revenues for implementing the measures needed	Variations in entrance fee: +400€	• Only variations in the number of loading bays	+1650	+4700	+13,200	+55,100	+383
			• …	…	…	…	…	…
			• Only variations in the probability of finding free loading bays	+50%	+61%	n.a.	+87%	+17%
5	Policy actually implemented	Variations in entrance fee: +1400€	• Only variations in the number of loading bays	+5800	+20,500	+50,450	+273,600	+72
			• …	…	…	…	…	…
			• Only variations in the probability of finding free loading bays	n.a.	n.a.	n.a.	n.a.	+69%

n.a. = not applicable.

increase was accompanied by no other policy change and the negative reaction of practically all transport providers' organizations is no surprise.

6. Conclusion

The paper investigates transport providers' preferences for parking and pricing policies. This is addressed at a strategic level considering entrance fees, number of loading bays and probability of finding them free.

The paper complements and extends previous research. Taking a transport provider's perspective, assuming non-linear attribute effects and heterogeneous preferences, three different model specifications are estimated and compared. Several policy scenarios are tested and their practical implications described via simulations. The results obtained help defining the compensatory measures that alternative interventions request in order to make transport providers indifferent to the policy introduced. Policy simulations suggest, notwithstanding the effort put into determining realistic attribute ranges, the need, in specific cases, for compensatory actions implying changes in attribute levels outside the ranges used in the experimental design employed. This is a possible weakness of the paper whose utility however is prevalently ascribable to the method developed rather than to the robustness of the results obtained. Future research will focus on finding possible solutions to this problem also via the analysis of the effects induced by the recent pricing changes introduced. Most likely, the inclusion of alternative policy instruments (e.g. night-time deliveries, consolidation centers, etc.) would show that the substitution rate between the policy components considered is lower than those estimated in this paper. Future research could also investigate: (1) transferability of results (e.g. other areas of the city); (2) explicit consideration of the specific freight distribution channel used; (3) spatial optimization of the loading bays location with respect to demand and supply in a given sector.

To conclude, the results obtained indicate the need for a different and more collaborative approach between local policy makers and transport providers in line with consultative procedures adopted elsewhere (e.g. freight quality partnerships in the UK) while avoiding "decide and defend" strategies that often backfire. To this end, decision makers should favor initiatives through the implementation of stakeholders' policy co-creation procedures. Living laboratories represent an appropriate instrument to help city administrators devising amenable contexts for stimulating innovation processes for public and private measures capable of contributing to increased efficiency and sustainable urban logistics. The methods illustrated for acquiring relevant data and estimating alternative policy effects represent a well-grounded starting point for developing a reliable and long-standing collaborative relationship between all stakeholders involved. Urban freight distribution should be considered, studied and treated as a system rather than the sum of its parts.

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