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Behavioural implications of non-linear effects on urban freight transport policies: The case of retailers and transport providers in Rome

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ABSTRACT

Cities import goods and freight transport is essential. However, it also generates social costs. Ensuring efficient urban freight transport is important although difficult. Policy makers intervene by defining and implementing policy measures that try to foster market efficiency in an environmentally sustainable way. General-purpose policies have often backfired when insufficient attention was paid to specific stakeholders' preferences. This paper investigates the impact the number of loading and unloading bays, the probability of finding them free and entrance fees have on retailers' and transport providers' utilities. Willingness to pay measures are used to test and quantify possible non-linear attribute variation effects. The main findings underline both the substantial difference in retailers' and transport providers' utility while evidencing the presence of non-negligible non-linear effects. Unfortunately the research results obtained are at odds with the recently introduced changes of the regulatory framework governing the Limited Traffic Zone in the city of Rome that is the case study considered in the paper.

1. Introduction

Cities import goods. Freight transport is essential but it also generates social costs. Ensuring efficient urban freight transport[1] is a fundamental and daunting task for local policy makers. In fact, while it is common to witness an articulated and pervasive deployment of detailed policies, these often engender undesired and unforeseen effects. This occurrence is prevalently linked to the: (1) complexity of the regulatory framework; (2) heterogeneity of contractual relationships and distribution of relative power among the agents involved; (3) contrasting stakeholders' interests; (4) absence of a well determined assignment of property rights that favours the insurgence of external costs (e.g. congestion, visual intrusion, noise, atmospheric pollution).

Freight modelling often adopts an aggregate stance with limited attention paid to agent-level considerations (e.g. Gruber et al., 2013; Liedtke and Schepperle, 2004; Roorda et al., 2010; Wisetjindawat et al., 2005). On the contrary, a micro level of analysis is necessary to investigate the behavioural implications these policies entail (Hensher and Figliozzi, 2007). Models adopting a behavioural approach explicitly consider stakeholders' utility maximization efforts thus providing richer model specifications capable of capturing important decision-maker's motivations and warranting a better understanding of policy effects. Freight demand is commonly considered, even with noticeable exceptions (Hesse and Rodrigue, 2004), derived rather than direct. In fact, there is always some agent's profit maximization intent, linked to an underlining market, at the base of freight demand. Analysing freight related choices within a well-defined theoretical framework helps understanding and forecasting.

The most important agent-types in urban freight are: retailers, transport providers and own-account. Only a limited number of papers have overtly considered their specific stated preferences and behaviour (e.g. De Oliveira et al., 2012; Domínguez et al., 2012; Gatta and Marcucci, 2013a, 2014; Hensher and Puckett, 2005; Holguín-Veras et al., 2007, 2008; Marcucci and Gatta, 2013; Marcucci et al., 2007, 2013b, 2015; Puckett et al., 2007) notwithstanding their *a priori* bearing (Ogden, 1992). The gap between the theoretical acknowledgment and the practical investigation of agent-specific characteristics can be explained via the lack of appropriate data due to the high cost of acquiring

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[1] According to Dablanc (2009) urban freight transport can be defined as: " . . . a segment of freight transport which takes place in an urban environment. Specifically, urban freight is the transport of goods by or for commercial entities (as opposed to households) taking place in an urban area and serving this area."

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them (Marcucci et al., 2013a). A complementary contribution of this paper is the definition and employment of an elicitation method representing a good compromise between cost minimization and data quality.

Effective policies capable of producing the desired results need reliable knowledge of the most likely response the intervention will produce. These will, in turn, depend on the: (1) regulatory regime; (2) contractual relationships; (3) commercial habits; (4) role played along the supply chain and, possibly, also other specific *status quo* elements. Agents' preference heterogeneity[2], role, characteristics, level of involvement are particularly pronounced in this sector. Urban freight transport policies are likely to have highly differentiated effects among stakeholders and this often implies a low level of result transferability (Stathopoulos et al., 2012). Furthermore, non-linear attribute effects are seldom investigated (Gatta and Marcucci, 2013b; Marcucci and Gatta, 2014; Nijkamp et al., 2004; Rich et al., 2009; Masiero and Hensher, 2009; Danielis and Marcucci, 2007; Rotaris et al., 2012). The linearity assumption implies a constant marginal contribution to the utility that should be tested rather than assumed. This represents the focus of this paper.

The results described are based on data acquired thanks to a project funded by Volvo Research Foundation (2009) focusing on *ex ante* policy evaluation for freight transport policies. The Limited Traffic Zone in the city centre of Rome is the case study investigated. The data collected explicitly differentiate among transport providers and retailers. Policy preferences were elicited through a Stated Ranking Exercise. Respondents were asked to rank alternative options including the *status quo* situation (Marcucci et al., 2012).

The paper reports the results of different Multinomial Logit (MNL) model specifications aimed at: (1) investigating the non-linear effects of policy intervention on both retailers' and transport providers' utility functions; (2) individuating potential biases when linearity is assumed; (3) comparing policy effects for the two agents considered.

Policy makers are keen to know, before a policy is implemented, the likely reactions so to gauge how much of the objectives set will be achieved. The reactions to a policy are strictly linked to the variation it provokes in each agent's profit function that can be approximated by willingness to pay (WTP) measures for its implementation given the articulated implications it might have. WTP is used to compare respondents' preferences under different assumptions with respect to the effects of given policies. Testing the commonly held assumption that attributes have linearly undifferentiated effects, the paper provides estimates of the possible biases this assumption might produce for the different agent types considered[3]. It consolidates and extends recent results (Marcucci and Gatta, 2014) that tested and measured non-linear effects in this research field for retailers alone adopting only a specific form of non-linear effects.

The paper is structured as follows. Section 2 illustrates the methodology adopted while section 3 describes the survey instrument developed and the data acquired. Section 4 reports and discusses the econometric results and policy implications. Section 5 concludes and illustrates future research endeavours.

[2] Heterogeneity can be investigated by using advanced modelling techniques (e.g. Marcucci and Gatta, 2012; Fabrizi et al., 2012; Felici and Gatta, 2008).

[3] It is also important to note that differences in attribute evaluation might depend on the specific type of good which can be characterised as specific versus generic where specific goods are made for a single customer while generic goods are produced irrespective of which final customer will buy them. These issues have been discussed in Massiani et al., 2009.

2. Methodology

Discrete choice models describe, explain and predict choices between two or more discrete alternatives[4]. In particular, MNL models are estimated using different specifications: (1) the deterministic part of utility is, first, specified as linear-in-the-attributes; (2) non-linearity is, then, tested by using, one at a time, three different mathematical transformations[5] (i.e. piecewise linear, logarithmic and power series) for all attributes[6]; (3) the best fitting model is obtained combining the most appropriate specification for each attribute.

Model 1 adopts a linear specification and attributes are normalised by dividing each level by its own minimum. The deterministic part of the utility, in the case of a single attribute, can be written as:

$$V_{i,q} = \beta_k x_{k,i,q} \tag{1}$$

where $x_{k,i,q}$ is the value of the attribute for alternative i faced by respondent q and β_k is its marginal contribution to the utility. In fact:

$$\frac{\partial V_{i,q}}{\partial x_{k,i,q}} = \beta_k \tag{2}$$

Model 2 refers to the piecewise linear specification. In this case, effects coding is used and the *status quo* level is taken as a reference. The deterministic part of the utility, in the case of a three-level attribute, can be written as follows:

$$V_{i,q} = \beta_{k_2} x_{k_2,i,q} + \beta_{k_3} x_{k_3,i,q} \tag{3}$$

where $x_{k2,i,q}$ and $x_{k3,i,q}$ are two auxiliary variables taking the values 1, 0 or -1. Assuming the first level as reference, $x_{k2,i,q}$ is equal to: 1 when the respondent faces level 2; -1 in the case of level 1; 0 otherwise. Similar considerations apply for $x_{k3,i,q}$. The marginal contribution to utility is thus:

$$\frac{\partial V_{i,q}}{\partial x_{k,i,q}} = \begin{cases} -\beta_{k_2} - \beta_{k_3}, \text{if } x_{k,i,q} = x_{k_1,i,q} \\ \beta_{k_2} \text{ if } x_{k,i,q} = x_{k_2,i,q} \\ \beta_{k_3}, \text{if } x_{k,i,q} = x_{k_3,i,q} \end{cases} \tag{4}$$

Model 3 is based on the logarithmic transformation of the variables. The deterministic part of the utility is expressed as:

$$V_{i,q} = \beta_k \log(x_{k,i,q}) \tag{5}$$

This hypothesis is consistent with standard microeconomic theory assuming a decreasing marginal contribution to utility which is calculated as follows:

$$\frac{\partial V_{i,q}}{\partial x_{k,i,q}} = \beta_k \frac{1}{x_{k,i,q}} \tag{6}$$

Model 4 adopts a power series transformation. In particular, a second degree transformation for the attributes is specified as follows:

$$V_{i,q} = \beta_{k_1} x_{k,i,q} + \beta_{k_2} x_{k,i,q}^2 \tag{7}$$

[4] For a detailed discussion of the methodological framework and possible applications of discrete choice models see, for example, Ben-Akiva and Lerman, (1985); Hensher et al., (2005); Train, (2005); Marcucci (2005); Gatta (2006); Marcucci and Gatta (2012).

[5] Non-linear effects on utility function can be also tested via self-stated attribute cut-off. Please refers to Marcucci and Gatta (2011) for a detailed description and application.

[6] Only the best fitting models are reported and commented.