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URBAN FREIGHT TRANSPORT POLICY CHANGES:
IMPROVING DECISION MAKERS’ AWARENESS VIA AN AGENT-SPECIFIC APPROACH

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Urban Freight Transport Policy Changes:
Improving Decision Makers’ Awareness Via an Agent-Specific Approach

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ABSTRACT:
This paper derives policy implications concerning a specifically developed questionnaire administration procedure aimed at eliciting agent-specific preferences for alternative policy variables with respect to the implementation of policy changes in the case of urban freight transport. In particular the research, based on the case of Rome’s Limited Traffic Zone, discusses alternative policy implementations whose impact can be tested ex-ante given the elicitation method adopted. After describing attribute definition and selection, questionnaire administration, data collection and treatment, willingness to pay estimates are calculated.

The paper tests, from a policy-maker’s perspective, the implications deriving from the presence of inter-agent heterogeneity and the specific composition of an improving and equally impacting policy on all agent-types’ utility. The paper shows how an agent-specific approach might increase decision makers’ awareness and help them taking better decisions.

Keywords: urban freight policy, agent-type heterogeneity, ex-ante reactions, stated preferences, discrete choice modelling, and willingness to pay

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1. Introduction

Local decision makers modify the extant urban freight transport (UFT) regulatory framework with the intent of ameliorating urban freight distribution. Policy changes aim to, among other objectives, reduce the amount of pollutants emitted, minimise the interference between passenger and freight transport during overlapping peak hours, guarantee high liveability standards for the urban environment, satisfy the structural import needs of goods and services characterising the normal city functioning and development. The success of UFT innovative measures is linked with local authority policy planners’ knowledge and awareness (Lindholm and Blinge, 2014). Decision makers often adopt coarse and undifferentiated policy changes without sound forecasts of possible direct and distributional effects among the various agent-types involved in UFT supply and demand.

The paper tests, from a policy-maker’s perspective, the implications deriving from the presence of inter-agent heterogeneity and the specific composition of an improving and equally impacting policy on all agent-types’ utility.

The paper is structured as follows. Section 2 reports a succinct literature review describing the limited number of papers adopting this specific research perspective while underlining their high informative potential. Section 3 describes questionnaire development and administration while section 4 presents econometric results and discusses their policy implications. Section 5 concludes.
2. Literature review

This section reports a succinct yet updated literature review. A recent systematic investigation conducted on articles focusing on UFT research and their relative citations detected a substantial increase in the attention devoted to these themes in specialised literature (Gatta and Marcucci, 2013). UFT research activities, as approximated by high quality publications indexed in the ISI Web of Knowledge database, particularly concentrate in the USA followed by UK, Spain and Italy. A relatively high number of articles, recently appeared, propose reviews (e.g. Cherret et al., 2012, Lindholm and Behrends, 2012; Nuzzolo et al., 2013; Woodburn, 2012) signalling the still enduring need of clarification, classification and, as suggested by Anand et al. (2012), clear ontological demarcation of what UFT research is. One, also, notices thematic clustering of articles. In fact, a qualitative analysis suggests a relatively high interest in freight movement vehicle routing and efficiency maximization (e.g. Hemmelmayr et al., 2012; Motraghi et al., 2012; Pillac et al, 2012), UFT regulation and environmental impact analysis (e.g. Arvidsson, 2013; Figliozzi, 2011; Lee et al., 2012; Sathaye et al., 2010a, 2010b), data acquisition concerns (e.g. Allen et al., 2012; McCabe et al., 2013; Roorda, 2011), disruption effect analysis (e.g. Friesz et al., 2011; Mamasi et al., 2013) and multi-agent modelling (e.g. Ballantyne et al., 2013, Teo et al., 2012).

Notwithstanding influential researchers have explicitly acknowledged the important role behaviourally consistent understanding and agent-specific approach play in modelling UFT policy impacts (e.g. de Jong and Ben-Akiva, 2007; Hensher and Figliozzi, 2007; Roorda et al., 2010), only a limited number of UFT related papers have adopted such a perspective both when acquiring data as well as when using them for model estimation purposes. (i.e. Gatta

Behavioural freight models constitute a sub-set of disaggregate ones that assume stakeholders strive to maximise utility. Freight movements can be rationalized by analysing the underlying motivations stemming from the relative convenience each stakeholder derives from the choice made. These reflexions are crucial for UFT from a policy-maker's perspective. In fact, they help clarifying and forecasting regulatory changes impacts on agents’ behaviour explicitly considering: inter-agent heterogeneity, optimised policy characteristic on revenue maximisation and equally impacting comprehensive effects on all agent-types’ utility.

3. Questionnaire development and administration

The results reported in this paper relate to a research project, funded by the Italian Ministry of Research, on methods for assessing the efficiency of freight distribution in Rome’s Limited Traffic Zone (LTZ). The research aimed at defining a knowledge base to optimise UFT policies. In fact, policy interventions so far implemented in Rome’s LTZ, in particular, and in Italian cities, in general, have often generated disappointing results. This is mainly due to the inadequate consideration paid to behavioural issues. The sequential interactions generated by policy changes are, usually, considered marginal if not completely negligible. On the contrary, we believe an in-depth analysis of specific agent-types’ characteristics and preferences should represent a key area of study when investigating overall system performance. The agent-
types examined are: transport providers, retailers and own-account operators\textsuperscript{1}. The project developed an appropriate stated preference (SP) exercise to acquire the necessary data to accurately estimate the most likely effects of the policies implemented.

The central component of the questionnaire refers to stated ranking exercises. This format was considered more appropriate since the choice set included policies rather goods or services. Moreover, it was assumed more logically consistent to ask for a ranking of policies rather than probe interviewees to choose them since this, \textit{de facto}, never happens in reality.

Selection of attributes and levels definition were based on: literature survey, previous quantitative studies performed in the city of Rome and focus group meetings with stakeholders. In particular, the attribute included had to satisfy the following criteria: 1) salient for the majority of respondents; 2) shared support among respondents; 3) credible from a respondents’ perspective; 4) reflect plausible changes to the current scenario.

A set of specific critical elements were identified: loading/unloading bays (too few, illegal occupation, lack of surveillance, inadequate structure), time windows (too many exceptions present in the current regulation making it inefficient) and entrance fee (too high or in need of a different articulation according to vehicle categories).

Based on relevance and acceptance, six attributes were preliminary selected and submitted to operators for evaluation. These were: 1) number of loading/unloading bays (LUB); 2) probability to find loading/unloading bays free (PLUBF); 3) time windows (TW); 4) entrance fees (EF); 5) exemption from time windows; 6) exemptions from entrance fees.

\textsuperscript{1} Three are the main facets characterising an own-account operator according to Italian legislation. In particular, freight transportation should not be the operators’ main activity, she should be the proprietor of the goods transported and the vehicles used should either be hers or leased.
The three agent-types consulted had different needs and suggestions. This induced the definition of an agent-specific questionnaire. TW attribute was included only for own-account operators since it did not provide plausible econometric estimates for both transport providers and retailers\(^2\). The two “exemption” attributes were eliminated due to the difficulty in individuating the correct interaction between them and the remaining attributes. Table 1 reports levels and ranges used to characterise the four attributes used.

The questionnaire, administered with a d-efficient design strategy in mind\(^3\), spanned four waves, each incorporating a change in the structure of the SRE that benefitted from previous findings (i.e. estimated coefficients available for each attribute and agent-type).

In particular, the criteria used in developing the design were: 1) agent-specific attributes; 2) priors based on estimates from previous waves; 3) effects coded priors; 4) uniformly or normally distributed priors; 5) d-efficiency to select design; 6) level balance and utility balance; 7) dominated task to control for ranking consistency.

### Table 1 - Attribute levels and ranges used in the SP experiments by agent-type

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Level and range of attribute</th>
<th>Own-account</th>
<th>Retailers</th>
<th>Transport providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of loading/unloading bays</td>
<td>400 800 1200</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Probability to find loading/unloading bays free</td>
<td>10% 20% 30%</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

\(^2\) In fact, transport providers and retailers, *de facto*, currently abide by any time window restrictions.

\(^3\) For more details please refer to Rose and Bliemer (2005).
Time windows

<table>
<thead>
<tr>
<th>Time windows</th>
<th>OPEN: (18:00-08:00) &amp; (14:00-16:00)</th>
<th>OPEN: (20:00-10:00) &amp; (14:00-16:00)</th>
<th>OPEN: (04:00-20:00)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Entrance Fees

<table>
<thead>
<tr>
<th>Entrance Fees</th>
<th>200€</th>
<th>400€</th>
<th>600€</th>
<th>800€</th>
<th>1000€</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: the underlined attribute-levels represent the status quo level.

Table 2 reports the evolution of the design and sample size by agent-type and wave.

Table 2 – Overview of the efficient design waves

<table>
<thead>
<tr>
<th>Waves</th>
<th>Type of design</th>
<th>N. of interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Own-account</td>
<td>Retailers</td>
</tr>
<tr>
<td>Pilot</td>
<td>Fractional factorial</td>
<td>3</td>
</tr>
<tr>
<td>First</td>
<td>Efficient</td>
<td>8</td>
</tr>
<tr>
<td>Second</td>
<td>Efficient</td>
<td>22</td>
</tr>
<tr>
<td>Third</td>
<td>Efficient</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>76</td>
</tr>
</tbody>
</table>

4. Econometric results, policy implications and discussion

This section reports, first, the econometric results obtained and, subsequently, discusses the ensuing policy implications.
a. Results

The results reported are for each agent-type. Multinomial Logit (MNL) models are estimated, linear attributes (i.e. LUB, PLUBF and EF) normalised and the qualitative attribute (i.e. TW) effects coded. Normalisation is achieved by dividing each level by its own minimum level of variation. This sterilizes the measurement-unit effect for coefficients estimates and facilitates direct comparison.

As it is for model sophistication one could suggest adopting a more articulated treatment of the error term rather than employing a simple MNL. This could, in fact, allow for an explicit treatment of non-systematic preference heterogeneity (e.g. Marcucci and Gatta, 2012). One example of this is, for instance, the latent class model where a discrete form of heterogeneity is considered appropriate for representing sample characteristics. However, it is important to underline that decision makers tend to differentiate UFT policy interventions on the base of well-determined and straightforwardly discernible characteristics such as belonging to a specific category (i.e. retailer, transport provider, own-account).

Results suggest agent-types evaluate policy attributes differently (Table 3). The overall model goodness-of-fit is acceptable for each agent-type. Both alternative specific constants (ASC1 and ASC2) for the unlabelled hypothetical cases reveal an a priori aversion to the status quo (SQ) alternative. EF has a negative and statistically significant impact on utility.

LUB and PLUBF are not significantly different from zero for own-account operators. This can possibly be explained by the common practice they have to double-park their vehicles in front of the shop until a loading/unloading bay becomes free. The small dimension of the vehicles

As an example, unnormalised LUB=400, 800 and 1200 while normalised LUB=1, 2 and 3 (e.g. 1200/400). For more details please refers to Marcucci et al., 2013.
owned by own-account operators represents an additional explanation of the phenomenon. In fact, while hindering circulation this practice is, unfortunately, accepted. The negative sign for the first level of the time window attribute (TW1) reflects its restrictive nature while the positive sign for the third level (TW3) is due to the improvement it represents with respect to the SQ.

Each attribute considered in the utility specification for retailers is characterised by statistically significant parameters. In particular, LUB and PLUBF, having a positive impact on utility, show a positive coefficient. EF plays the lion part in explaining retailers’ preferences.

The transport providers’ model shows the best fit to the data (Adj. Rho$^2 = 0.252$). Also in this case EF has the highest explanatory power. LUB and PLUBF have a similar impact on utility.

Table 3 – MNL results by agent-type

<table>
<thead>
<tr>
<th>Variable</th>
<th>Own-account</th>
<th></th>
<th>Retailers</th>
<th></th>
<th>Transport providers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>t-stat</td>
<td>Coefficient</td>
<td>t-stat</td>
<td>Coefficient</td>
<td>t-stat</td>
</tr>
<tr>
<td>LUB</td>
<td>-0.067</td>
<td>-1.18</td>
<td>0.253</td>
<td>5.24</td>
<td>0.558</td>
<td>9.16</td>
</tr>
<tr>
<td>PLUBF</td>
<td>-0.008</td>
<td>-0.16</td>
<td>0.347</td>
<td>6.51</td>
<td>0.435</td>
<td>6.31</td>
</tr>
<tr>
<td>EF</td>
<td>-0.768</td>
<td>-14.65</td>
<td>-0.699</td>
<td>-16.44</td>
<td>-1.170</td>
<td>-16.85</td>
</tr>
<tr>
<td>TW1</td>
<td>-0.875</td>
<td>-10.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW3</td>
<td>0.756</td>
<td>9.63</td>
<td>0.824</td>
<td>5.32</td>
<td>0.686</td>
<td>3.97</td>
</tr>
<tr>
<td>ASC1</td>
<td>0.936</td>
<td>6.20</td>
<td>0.824</td>
<td>5.32</td>
<td>0.686</td>
<td>3.97</td>
</tr>
<tr>
<td>ASC2</td>
<td>0.784</td>
<td>6.14</td>
<td>0.657</td>
<td>4.82</td>
<td>0.709</td>
<td>4.46</td>
</tr>
</tbody>
</table>
### b. Policy implications and discussions

This sub-section discusses the policy implications of the previously reported agent-specific results from a decision maker's point of view. Willingness to pay (WTP) measures for attribute variations provide valuable information to decision makers. This knowledge base would, in fact, put them in a better position to tailor UFT policy changes. WTP measures for a given attribute can, in a choice modelling framework, be estimated by dividing a given attribute coefficient by that of the cost variable (EF coefficient in our case). Due to attribute normalisation, the ratio between the two coefficients has to be multiplied by the minimum level of cost attribute (i.e. 200) and divided by the minimum level of the attribute at the numerator (i.e. 400 for LUB and 10 for PLUBF).

Having WTP measures in mind, all the considerations reported below rest on a simple and widely accepted pre-requisite that assumes, *de facto*, an undifferentiated implementation to all agent-types of a given policy change. Furthermore, given the deplorable present situation in the LTZ in Rome, the paper tests only ameliorations in LUB, PLUBF and TW. These changes are always assumed linked to an increase in the maximum acceptable EF, as estimated by the WTP measures, so to be able to either compensate for the costs incurred in the policy

| LL function: -959.9135 | LL function: -1126.935 | LL function: -690.6266 |
| LL (constants only): -1120.889 | LL (constants only): -1318.047 | LL (constants only): -926.3309 |
| Nº of observations: 1270 | Nº of observations: 1624 | Nº of observations: 1128 |
| Rho²: 0.144 | Rho²: 0.145 | Rho²: 0.254 |
| Adj. Rho²: 0.141 | Adj. Rho²: 0.143 | Adj. Rho²: 0.252 |
variations (increase LUB and PLUBF) or to maximise the revenues levied for a regulatory change (switch to TW3).

Table 4 reports WTP measures for policy changes by agent-type. We discuss below the two research questions the paper addresses by illustrating the increased awareness available to decision makers thanks to the agent-specific adopted.

In further detail, one notices that inter-agent heterogeneity is relevant. In fact, own-account operators are willing to pay 166€ for the desirable time windows while they would not willing to pay neither for LUB nor for PLUBF. On the contrary, transport providers and retailers are willing to pay for both LUB and PLUBF. Moreover, results show a detectable distinction in transport providers’ and retailers’ preferences. While the former are relatively more interested in PLUBF, the latter care more about LUB. In fact, transport providers are willing to pay nearly 200€ for 20 additional units of PLUBF and 145€ for 800 additional LUB whereas retailers are willing to pay, respectively, 150€ and 190€ for the equivalent policy changes.

<table>
<thead>
<tr>
<th>POLICY</th>
<th>Own-account</th>
<th>Retailers</th>
<th>Transport providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>+800 LUB</td>
<td>0 €</td>
<td>191 €</td>
<td>145 €</td>
</tr>
<tr>
<td>+20 PLUBF</td>
<td>0 €</td>
<td>149 €</td>
<td>199 €</td>
</tr>
<tr>
<td>TW3</td>
<td>166 €</td>
<td>0 €</td>
<td>0 €</td>
</tr>
</tbody>
</table>

*Table 4 – WTP for policy changes by agent-type*
An implication that can be derived from the information acquired is that no single policy would be acceptable to all agent-types. Supposing decision makers act under a re-election constraint, such as hypothesised in a citizen candidate game context (see Marcucci et al., 2005 for an example concerning road pricing policies), they would most likely have to adopt a policy package change. Suppose now the decision maker adopts a given policy, positively impacting on the utility of agent-type X and Y while irrelevant for Z and assume, as previously motivated, a consequent increase in EF. The policy maker would then need to compensate Z by increasing the level of another policy attribute positively impacting her utility.

Having set the scene, given the results obtained, we illustrate a possible use of the information acquired. Since own-account operators react to TW policy only, given that the only ameliorative policy possible is to switch from SQ to TW3, the corresponding maximum EF increase that could be imposed leaving these operators indifferent is 166€. Under these conditions, an overall acceptable policy package would have to include positive variations for transport providers and retailers who would also have to pay the additional EF. At this point, one has to define the optimal LUB and PLUBF combination, given the agent-specific WTP estimates, that makes both retailers and transport providers indifferent to a 166€ EF increase.

The solution the following system of equations represents the optimal combination the decision maker should adopt:

\[
\begin{align*}
\text{(retailers)} & \quad \frac{191}{800} LUB + \frac{149}{20} PLUBF = 166 \\
\text{(transport providers)} & \quad \frac{145}{800} LUB + \frac{199}{20} PLUBF = 166
\end{align*}
\]

\[\Rightarrow LUB = 395; PLUBF = 9.5\]
In conclusion the acceptable policy package would have to switch from SQ to TW3, create 395 additional LUB and increase PLUBF by 9.5%.

5. Concluding remarks

This paper discusses via an illustrative example the policy implications derivable from an agent-specific approach to UFT modelling. In particular it succinctly describes a specifically developed questionnaire administration procedure. This was aimed at eliciting agent-specific preferences for alternative policy variables via SP exercises. In particular the paper, based on the specific case of Rome’s LTZ, discusses relevant policy implications derivable from the elicitation method and data treatment adopted. More in detail, after describing attribute definition and selection, questionnaire administration, data collection and treatment, WTP calculations, it motivates the methodological choice made. It underlines the increased awareness decision makers gain from an agent-specific knowledge of the effects each policy component produces. The paper shows, through an example, the plausible use of the information acquired. Future research, especially in collaboration with interested decision makers, could address additional uses of the information available. Among those that can conceivably be considered one might include social welfare maximisation (e.g. optimise the policy mix given the WTP for given policy changes and compare them to the costs that have to be incurred in order to implement them) and definition of the revenue maximising policy mix (e.g. optimise, given the numerosity of every agent-type group and their respective WTP for policy attribute variations, the amount of EF levied).
In conclusion, the paper detected relevant agent-specific variations in policy attribute evaluation. In fact, modelling single operators uncovers different WTP patterns. TW is, in our case, what really matters to own-account operators while LUB and PLUBF are important only for retailers and transport providers. These agents, however, have divergent sensitivities. The latter are more interested in LUB while the former in PLUBF. No one-size-fits-all policy option emerges from the results. The methodology proposed clearly and substantially fosters decision makers’ awareness with respect to the implications deriving from possibly different compositions of alternative policy changes.

Acknowledgments

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Bibliographical references


