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Non linear effects of urban freight transport policies: a retailer's perspective.

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NON LINEAR EFFECTS OF URBAN FREIGHT TRANSPORT POLICIES: A RETAILER'S PERSPECTIVE

By Edoardo Marcucci[1] and Valerio Gatta[2]

ABSTRACT

Decision makers in urban freight transport (UFT) typically need to assess the impact new policy interventions might have on freight distribution. They need to assess the impacts of changes in freight distribution policies might have on a set of elements among which one can safely include: infrastructure needs and use, logistic performance, emissions and energy use. All these elements can be grouped and summarized in two macro-objectives; in fact, policy intervention objectives usually include the minimization of negative economic effects and the reduction of the environmental impact freight distribution provokes. The effects of policy changes are inextricably related with the extant regulatory framework that also influence the relationships among the various actors interacting along the supply chain.

The operators commonly considered important, given the crucial role they play in UFT, are: retailers, transport providers, and own-account. Notwithstanding the admittedly important role that a detailed knowledge of these three agent categories have for a correct policy implementation there is a limited knowledge concerning the specific preferences and behavior of each agent-type. It is *de facto* assumed that retailers, own-account and transport providers have homogenous preferences and can be seamlessly treated. The upsurge of behavioral models and the acquisition of data necessary to predict goods and vehicle flows both under the current and, more importantly, under altered policy/regulatory conditions explains the progressive importance that is attributed to an agent-based perspective.

This research reports the result of a stated ranking exercise (SRE) conducted in the Limited Traffic Zone (LTZ) in 2009 in the city center of Rome focusing on retailers which demand freight transport services and play an important role in extended supply chains. The lack of knowledge under this respect is most notably due to the difficulty and cost implied in acquiring the necessary data for estimation purposes. This paper proposes a comparison between two different MNL specifications where non-linear effects for the variations of the levels of the attributes considered are studied and detected. A meaningful comparison between willingness to pay (WTP) measures derived by the two model specifications is proposed so to avoid known scale problems. The results obtained are very interesting and meaningful from a policy perspective since they show potentially differentiated effects of the policy implemented in deep contrast with the, often assumed, homogenous effect hypothesis.

Keywords: freight operators, retailers, non-linear effects, preference heterogeneity, limited traffic zone.

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1. **Introduction**

Cities have historically, but more so for modern cities, manifested a strong dependence on freight transport systems to efficiently guarantee the net inflow of goods and ensure the availability of the necessary resources to fuel economic and urban growth. Local policy makers have intervened on the articulated contractual relationships among agents so to achieve the desired policy objectives. The most important agent-types in urban freight distribution are: retailers, transport providers and own-account. Few are the studies that have explicitly investigated the specific preferences and behavior of each of these agent-types (Stathopoulos et al., 2012; Stathopoulos et al., 2011) notwithstanding the *a priori* relevance that is ascribed to them (Ogden, 1992). At the base of this research gap in this field one can safely put the lack of appropriate data that is, in turn, linked to elicitation costs and the low interest agent-types usually show when asked to participate in applied research projects in this field. The capability policy interventions have in producing the desired results is inextricably intertwined with the detailed knowledge policy makers need to have concerning the most likely response the intervention will produce given the extant regulatory, contractual and consuetudinal relationships that characterize this sector in the given city where the policy is to be implemented. In other words, we believe that one-size-fit-all policies, implying policy transferability, are not easy to define nor to implement in accordance to what has already been underlined by recent research (Stathopoulos et al., 2012).

The results reported and discussed are based on a data set derived from a research conducted for a Volvo Research Foundation project (2009) that focused on ex-ante policy mix evaluation for freight transport policies. The study concentrated on the freight LTZ in the city center of Rome. The analysis takes advantage of the data set collected that explicitly differentiates among three agent-types. The data include a wide range of information including both specific respondent's and his/her company's characteristics as well as the results of a SRE where interviewees were asked to rank alternative policy scenarios. The paper reports the results of two MNL specifications aimed at investigating the non-linear effects of policy intervention on retailers' utility functions in a similar vein to Rotaris et al. (2012). A comparison is performed, via WTP/WTA, between the potentially distorted scenario evaluations deriving from the assumption of linear policy effects. Our results allow us to comment on the distorted policy forecasts that would be produced by simpler and rougher treatment of the information acquired. On the base of recent evidence (Stathopoulos et al., 2011) we assume that the relevant policy attributes for retailers are: 1) number of loading and unloading bays (LUB); 2) probability of finding loading and unloading bays free (PLUBF); 3) entrance fee (EF) charged to enter the LTZ.

The paper contributes to UFT literature by bridging a specific gap via in depth investigation of retailers' preferences. A recent paper has investigated the role of heterogeneity for own-account agents with respect to policy intervention (Marcucci and Stathopoulos, 2012) whereas this paper focuses the attention on the presence and magnitude of non-linear effects given the different levels of the attributes considered. Policy makers usually intervene and evaluate policies assuming that attribute variations have linear effects thus hypothesizing there is no dependence on the *status quo* (SQ) level of the policy variable and, furthermore, that both increases and decreases have symmetric effects on agent's utilities. The results reported show that one cannot assume linear effects and consequently both the direction of the variation as well as its magnitude should explicitly be considered when assessing a given policy change. Having estimated the coefficients for the various attributes and levels we calculate, via WTP/WTA measures, the biases that a linear assumption concerning the effects implies.

The paper is structured as follows. Section 2 reports a short literature review concerning agent-type analysis for UFT. Section 3 describes the survey instrument developed and the data acquired

while section 4 reports and discusses the econometric results and policy implications. Section 5 concludes and illustrates future research endeavors.

2. **Literature review**

Freight modeling is usually performed via aggregate models thus limiting the attention dedicated to agent-level considerations that represent the appropriate level of analysis to investigate if a behavioral approach to the phenomenon is adopted. This section succinctly summarizes recent literature that testifies the increasing attention paid to behavioral issues in UFT.

Hensher and Figliozzi (2007) underline the weaknesses of the standard approaches to UFT modeling. In fact, the modified four-step approach (M4SA) when used to simulate UFT does not adequately consider the complexity characterizing freight movements at different geographical scales. This explanatory deficit is particularly relevant since the M4SA is structurally not capable of explaining potentially relevant preferences for current scenarios and, even more important, the possible reactions to policy changes. On the contrary, models adopting a behavioral approach (BA) to UFT modeling, representing only part of the larger disaggregate models set, explicitly consider stakeholders' utility maximization. BA to UFT presume the researcher is capable of univocally and correctly identifying key decision makers so to develop an agent-based micro-simulation approach modeling framework that both describes and forecasts the behavior of the actors considered (Liedtke and Schepperle, 2004). UFT is, according to a copious and qualified group of eminent researchers (Gray, 1982; Wisetjindawat et al., 2006; de Jong and Ben-Akiva, 2007; Hensher and Figliozzi, 2007; Samimi et al., 2009; Chow et al., 2010; Roorda et al., 2010) an appropriate field of research were the development of micro agent-based models is most likely going to produce policy relevant results.

Different UFT options are influenced, given the *derived* nature of freight transport demand, in their relative convenience for each agent-type considered, by changes in fuel prices, land use patterns and pricing strategies in the markets that demand freight transport services. It has been suggested (Puckett and Greaves, 2009) that in order to understand the impacts, measured in terms of the market outcomes that a policy might produce, one should conjointly consider all the instruments policy makers could use and the relevant attributes capable of affecting agents' freight choices.

Policy makers are intrinsically and structurally interested in knowing, before implementing a given policy, what the most likely reactions will be in terms of achievement of the desired objectives. As it will be apparent when discussing the econometric results (section 4) the research proposed can quantify the WTP/WTA for the possible policies implemented with respect to the reference scenario before the policy is actually put into action in a real-life context. This paper focuses on the role and preference of retailers that, in the context studied, play a relevant role (Quak and de Koster, 2009).

3. **Survey instrument and data description**

This paper is based on data acquired in Rome's LTZ between March and December 2009 thanks to a project carried out for Volvo Research Foundation (2009). The LTZ in the city center of Rome was first implemented in the late eighties over a $5km^2$ area originally banned to non-resident vehicles only. Only *Euro 1* and more fuel-efficient vehicles are allowed to enter the LTZ with free access granted to residents while others (e.g. retailers and freight carriers) pay an access

fee. Cameras and optical character recognition software are used to enforce the system which operates diurnally with a yearly entrance fee of 565€ per number plate.

Notwithstanding the extensive list of impediments applying generically to all agents a wide ranging of *ad hoc* exemptions applies to third party freight operators. The regulation, after a careful reading of all the exemptions conceded, seems mostly targeted to discouraging own-account operators.

As it is for the questionnaire development it is important to first define, select, develop and customize the attributes to be included in the questionnaire which, in our case, was a SRE since it was considered most appropriate to use a ranking exercise given the final aim was to unveil agents' preferences concerning UFT policies which are not *de facto* "chosen". The project involved different phases among which the most important are: 1) advancement from stakeholder consultation to final attribute selection criteria; 2) attribute definition; 3) levels and ranges selection; 4) progressive design differentiation by agent-type (Stathopoulos et al., 2011).

The SRE alternatives are characterized by a set of attributes, which can take several levels. The attributes considered were selected thanks to: 1) literature survey; 2) previous UFT studies performed in Rome; 3) focus groups with experts. An in depth review of the literature adopting an agent-based perspective allowed the identification of a set of eligible attributes that represented potentially conflicting policy instruments[3].

Previous UFT studies in Rome (STA, 2001; Filippi and Campagna, 2008) together with expert and stakeholder focus groups were very useful in guiding the attribute selection process[4] that were characterized by high and shared support of the stakeholders contacted (Stathopoulos et al., 2011). The attributes were also validated via a pilot test with real operators. The final list included: LUB, PLUBF, and EF. All attributes are considered as possible levers of intervention by local decision-makers and perceived as appropriate measures for possible policy mixes by stakeholders (Marcucci et al., forthcoming). Attributes, number of levels, and ranges are reported in Table 1. Attributes are all characterized by, at least, three levels thus allowing the test of non-linear effects that represent the core of this paper and play a special role in the evaluation of policy reactions to policy changes where different effects can be originated by varying specific levels.

Table 1 - *Attribute levels and ranges used in the SRE*

Attribute	**Number of levels**	**Level and range of attribute (*Status Quo* underscored)**
Loading/unloading bays:	3	400, 800, 1200
Probability of free l/u bays:	3	10%, 20%, 30%
Fees:	5	200€, 400€, 600€, 800€, 1000€

[3] Nighttime deliveries, for instance, were considered efficiency enhancing by carriers but considered a mere increase in costs by retailers and were consequently excluded.

[4] An important phase of the expert surveys focused on defining the policies considered most appropriate to mitigate the identified UFT problems (Stathopoulos et al., 2011). Volvo Report (2010) provides a detailed overview of the link between the stakeholder survey results and the attributes used in the SRE.

A SRE is adopted to test currently unavailable options. The alternatives presented to respondents, who had to rank them, include two policy options plus the SQ alternative. Table 2 reports an example of a SRE task.

Table 2 - *Example of a ranking task*

	Policy 1	**Policy 2**	**Status Quo**
Loading/Unloading bays	400	800	400
Probability to find L/U bays free	20%	10%	10%
Entrance fee	1000 €	200 €	600 €
Policy ranking	❑	❑	❑

In total, 252 interviews were finalized and 229 used after removing pilot interviews. The sample of retailers used for estimation consists of 90 units whose distribution is scattered in 9 main macro-freight sectors, namely: 1) *food* (fresh, canned, drinks, tobacco, bars, hotels and restaurants); 2) *personal and house hygiene* (detergents, pharmaceuticals, cosmetics, perfumes, watches, barbers, etc.); 3) *stationery* (e.g. paper, newspapers, toys, books, CDs etc.); 4) *house accessories* (e.g. dish washers, computers, telephones, metal products etc.); 5) *car accessories* (e.g. vehicle components, vehicles, gasoline, etc.); 6) *services* (e.g. laundry, flowers, live animals, accessories and animal food, etc.); 7) *clothing* (cloth, leather, etc.); 8) *construction* (e.g. cement, scaffold, chemical products, etc.); 9) *other* (all those not included in previous categories).

4. **Econometric results and policy implications**

This section reports the results of the models estimated for retailers based on the data obtained via the SRE described in section 3. The first model (M1), employing a MNL specification[5], utilizes all attributes as linear and normalized while the second (M2) adopts an effects coding for the variables in order to investigate potential non-linear effects of the different levels of the explanatory variables.

M1, reported in Table 3, employing just normalized variables, provides interesting results and also shows a good fit of the model (adj. $Rho^2 = 0.142$; 5 Coeff.).

All the coefficients are statistically significant and with the expected sign with the exception of the two alternative specific constants (ASCs) for which there was no strong *a priori* concerning the sign. In particular LUB and PLUBF have a positive coefficient since an increase in either the number of loading and unloading bays or in the probability of finding them free has a positive impact on retailers' utility. On the contrary, an increase in EF has a negative impact on retailers' utility. M1 also includes two ASCs for the unlabeled hypothetical cases (ASC_Alt1, ASC_Alt2) whose coefficients represent the overall alternative impact on retailers' utility when all the coefficients of the other attributes have a zero value. In our case, results show that, there is an *a priori* evaluation against the SQ (ASC_Alt3 has a negative sign) and, after conducting a Wald test

[5] We just recall that a MNL specification of the model implies an implicit assumption concerning the independence from irrelevant alternatives. In other words, it is assumed the un-observed effects homogeneously impact all the alternatives in the same way that is equivalent to hypothesizing that the error component is identically and independently distributed.

for ASC_Alt1 and ASC_Alt2, we cannot reject the null that the difference between the two coefficients is different from zero. In summary, one can affirm that ASC_Alt1 and ASC_Alt2 have a positive, but undistinguished between them, effect on utility. Furthermore, it is also interesting to note that the ASC inclusion in the model not only substantially increased the model fit but also provided more realistic interpretation of the parameters.

The normalization adopted for the explanatory variables allows us to compare the estimated coefficients of the attributes considered. One can notice that tariff plays the lion part in explaining retailers' preferences. In fact the EF's coefficient is more than double the sum of LUB and PUBF coefficients. This result is further reinforced by looking at the *t-stat* of each of the variables considered that testify EF's coefficient is, almost for sure (*t-stat* 16.44), different from zero even if LUB and PLUBF coefficients are highly significant too (respectively *t-stat* 5.24 and 6.51).

Table 3 – *Econometric results based on M1*

Variable	Coefficient	St.Err.	T-Stat	Expected Sign
LUB	0.253	0.048	5.24	+
PLUBF	0.347	0.053	6.51	+
EF	-0.699	0.042	-16.44	-
ASC_Alt1	0.824	0.154	5.32	*
ASC_Alt2	0.657	0.136	4.82	*

M2, reported in Table 4, differs from M1 in the treatment of the variables which, in this case, are effects coded[6]. The different coding aims at detecting possible non-linearities in the explanatory variables' effects. In fact, the estimation of a single parameter for a given attribute will give rise to a linear estimate (i.e. slope) and we generically refer to these estimates as linear estimates (M1). An attribute's impact can be estimated with two dummy (or effects) parameters, which are usually referred to as a quadratic estimate or higher degree dummy (or effects) parameters which are also referred to as polynomial of degree L-1 estimates (with L denoting the number of dummy or effects parameters). In more detail, one can affirm that the more complex the part-worth utility function, the more advisable is to move to more articulated coding structures capable of recovering the necessary data to estimate the more complex non-linear relationships.

M2, thanks to the effects coding of the variables, provides more detailed information and is characterized by a statistically significant better fit[7] with respect to M1 (adj. Rho^2 = 0.154; 9 Coeff.). All reported coefficients are statistically significant. In fact, the LUB2 (e.g. the second level of the variable LUB, -- i.e. 800) coefficient, not reported in the table, was not statistically significant thus suggesting agents' utility is not influenced by a variation of only 400 LUB from the SQ situation (i.e. 400)[8].

As it is for the PLUBF one can notice that there is an evidently non-linear effect of the variable. In fact, going from a 10 Probability Base Points (PBP) for PLUBF (*i.e.* SQ level) to 20 PBP we have a much greater impact on retailers' utility [$Beta_{PLUBF2-1}$ = $Beta_{PLUBF2}$ (0.246) - $Beta_{PLUBF1}$ (-

[6] For a clear description of effects coding the explanatory variable please refer to Hensher et al., (2005), pp. 119-121.
[7] We checked this by performing a log-likelihood ratio test.
[8] Therefore, we recoded this variable so that LUB3 = 1 when LUB = 1,200 and -1 otherwise (according to the effects coding of the variables).

0.509) = 0.756] than going from 20 PBP to 30 PBP [$Beta_{PLUBF3-2}$ = $Beta_{PLUBF3}$ (0.262) - $Beta_{PLUBF2}$ (0.246) = 0.016]. EF is the variable that benefited the most from the adoption of effects coding in detecting non-linearities. This is both due to the presence of 5 levels compared to the 3 levels for the other variables as well as to their symmetricity with respect to the SQ (i.e. 600€). The analysis of ASCs leads us to the same conclusions reported for M1.

Table 4 – *Econometric results based on M2*

Variable	Coefficient	St.Err.	T-Stat
LUB3	0.215	0.046	4.68
PLUBF2	0.246	0.059	4.15
PLUBF3	0.262	0.068	3.86
EF1	1.113	0.104	10.65
EF2	0.937	0.087	10.67
EF4	-0.761	0.099	-7.68
EF5	-1.589	0.126	-12.54
ASC_Alt1	1.085	0.166	6.51
ASC_Alt2	0.814	0.143	5.66

With reference to Figure 1, and in line with prospect theory (Kahneman and Tversky, 1979), one can observe that reductions in EF produce positive effects on utility compared to negative effects induced by opposite variations of similar amount. Initial variations, in both directions, from the SQ (EF3 = 600€) have bigger effects [$Beta_{EF3-4}$ = $Beta_{EF3}$ (0.300) - $Beta_{EF4}$ (-0.762) = 1.062 and $Beta_{EF2-3}$ = $Beta_{EF2}$ (0.937) - $Beta_{EF3}$ (0.300) = 0.637] with respect to subsequent ones [$Beta_{EF4-5}$ = $Beta_{EF4}$ (-0.762) - $Beta_{EF5}$ (-1.589) = 0.828 and $Beta_{EF1-2}$ = $Beta_{EF1}$ (1.114) - $Beta_{EF2}$ (0.937) = 0.176]. In fact, for positive variations (EF increases; EF4 = 800€ and EF5 = 1.000€) we have $Beta_{EF3-4}$ = 1.062 > $Beta_{EF4-5}$ = 0.828 and for negative variations (EF reductions, EF2 = 400€ and EF1 = 200€) we have $Beta_{EF2-3}$ = 0.637 > $Beta_{EF1-2}$ = 0.176. Furthermore, still in line with prospect theory we find that positive variations of equal amount are valued less than negative variations and, in our case, this is testified by both inner variations [$Beta_{EF3-2}$ (0.637) < $Beta_{EF3-4}$ (1.062)] as well as by outer variations [$Beta_{EF1-2}$ (0.176) < $Beta_{EF4-5}$ (0.828)]. Similar considerations also apply to PLUBF (see Figure 2).

Figure 1 – *Part-worth utilities for EF*

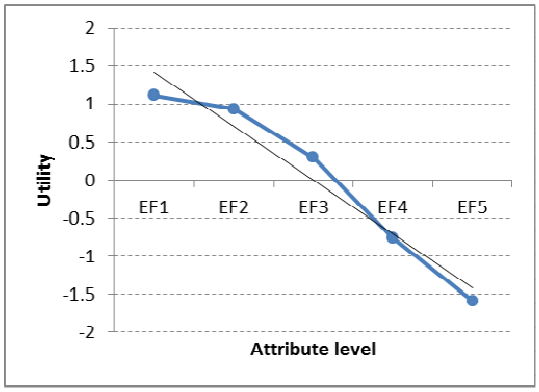
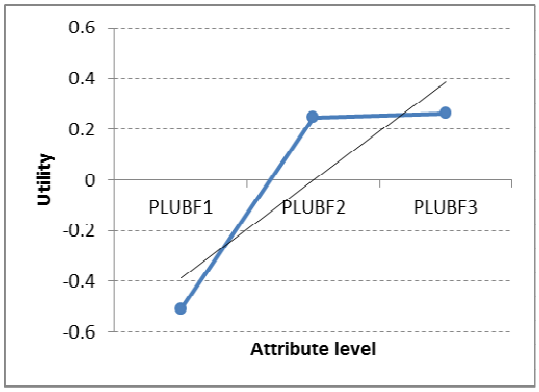


Figure 2 – *Part-worth utilities for PLUBF*



In order to analyze the impact of different estimation methods, define and measure the potential biases for policy implementation one can use WTP/WTA to avoid scale problems that would, otherwise, fraud the comparison.

As it is well documented in the literature (Daly et al., 2010) there are different methods that can be used to test the statistical significance of the ratio of coefficients between the desired attribute and the monetary one representing the base of any WTP/WTA measures.

Testing the statistical significance of the ratios is not only important *per se*, since it allows the researcher to infer reliability of the results obtained especially when using them for simulation purposes, but also because it is reasonable to assume some heterogeneity in the sample selected. Especially in connection with this last point and for policy evaluation purposes it is interesting to estimate monetary confidence intervals rather than using single point estimates.

In fact, among the methods that one can use to construct confidence intervals for these ratios the most popular are: 1) Krinsky and Robb (Krinsky and Robb, 1986; 1990); 2) Bootstrap (Efron, 1979; Mooney and Duval, 1993; Efron and Tibshirani, 1993); 3) Delta Method (see e.g. Greene, 2003). In our case we opted for this last method. WTP are assumed normally distributed and, thus, symmetrical around the mean. Delta Method's estimates of the variance of a non-linear function of two random variables is obtained by taking a first-order Taylor expansion around the mean value of the variables and calculating the variance for this expression (Hole, 2007). Our choice is motivated by two main considerations: 1) Delta Method is an exact method compared to both Krinsky-Robb and Bootstrap where a simulated distribution for the variable of interest is generated; 2) Shanmugalingham (1982) has empirically shown that the normality assumption underlying the Delta Method is, in general, less tenable when the standard deviation of the denominator variable is large relative to its mean and this is not the case for our results given that the cost coefficient is strongly significant and no skewness risks are incurred[9].

Table 5 and 6 report the WTP estimates respectively for M1 and M2. In both cases all the reported estimates are statistically significant and, with reference to M2, non-linear effects are clearly evident.

[9] Notwithstanding the above made considerations we think it would be interesting to test under which conditions each of the three methods provides the best results. We are presently working on a paper specifically addressing this issue using both simulated as well as real data.

Table 5 – *WTP estimates with Delta-Method (based on M1)*

Variable	Coefficient	St.Err.	T-Stat
LUB / EF	0.362	0.064	5.64
PLUBF / EF	0.496	0.066	7.47

To interpret the meaning of coefficients' estimates has to recall that for estimation purposes and in order to avoid measurement unit effects (e.g. LUB absolute numbers --400, 800, 1.200--; PLUBF PBP --10, 20, 30--; EF Euros --200€, 400€, 600€, 800€, 1,200€--), it is advisable to normalize all the variables so to sterilize the unit of measurement effect.

Notwithstanding the considerations above we deem useful to explain in detail how the monetary WTP were calculated so to facilitate interpretation. For instance (with reference to M1), as it is for LUB, departing from a normalized WTP of 0.362 and wanting to know the amount of money the interviewees are willing to pay for an additional LUB one has to perform the following calculations: 0.362 x (200€/400LUB) = 0.18€/LUB whereas for PLUBF we have 0.496 x (200€/10PBP) = 9.93€/PBP. At this point from a policy perspective it is interesting to compare two different policies that guarantee, in alternative ways, equal results. In more detail, one can compare how much people are willing to pay to have an extra LUB free either via additional LUB construction or via increased probability of finding a LUB free. In order to perform the comparison one has to recall that, taking the SQ as a reference, we need to construct 10 extra LUB to ensure 1 additional free LUB. On the other hand one could obtain the same result by an increase of 0.25 PBPs. One extra free LUB is evaluated 1.80€ if obtained by construction of additional LUBs whereas the same result would be evaluated 2.48€ if achieved by increasing PBPs of finding a LUB free. The *apparently* contradictory result could be interpreted, on one side, as a lack of trust the interviewees have in the announced extra LUBs construction policy which has for long been on the local administration agenda and never materialized and, on the other, as an explicit preference for a short-term, no-financial-outlay policy that can be simply pursued by an increased surveillance and repression of illegal parking. The policy implications derivable from this interpretation are clear and suggest the adoption of light intervention policy based more on regulation rather than LUB construction with a limited impact on the public purse.

Table 6 – *WTP estimates with Delta-Method (based on M2)*

Variable	Coefficient	St.Err.	T-Stat
LUB3 / EF1	-0.1938	0.0377	-5.13
LUB3 / EF2	-0.2302	0.0511	-4.49
LUB3 / EF4	0.2834	0.0621	4.56
LUB3 / EF5	0.1358	0.0279	4.86
PLUBF2 / EF1	-0.2213	0.0597	-3.7
PLUBF2 / EF2	-0.2629	0.0679	-3.86
PLUBF2 / EF4	0.3236	0.0911	3.55
PLUBF2 / EF5	0.1550	0.0400	3.87
PLUBF3 / EF1	-0.2358	0.0569	-4.13
PLUBF3 / EF2	-0.2802	0.0716	-3.91
PLUBF3 / EF4	0.3448	0.0828	4.16
PLUBF3 / EF5	0.1652	0.0408	4.04

Similar considerations apply to M2 (see Table 6) where we also calculate different WTP measures since we test and discover non-linear effects for the EF. It is important to clarify that since we have only ameliorative variations, with respect to the SQ level, for both LUB and PLUBF in the case of reductions of EF levels, in order to interpret the meaning of the coefficients one has to imagine that the values derived represent (in order to have a trade off of some sort) the amount of money the agent would be willing to receive for not having potentially gained from the increase in the level of the beneficial attribute under consideration.

Notwithstanding the interesting analysis just discussed one has to scrutinize the policy implications derived by using either M1 or M2. An informative comparison between the WTP estimates (and their respective confidence intervals) of the two models is reported in Table 7.

We underline that all the results reported use EF4 as a base since this represents the variation form the SQ (600€) to the next step up (800€). Moreover, for M2, having effects coded the variables, one has to be careful in interpreting results especially when it comes to WTP measures. In fact, one should recall that the WTP to move from the basic level of an attribute to a different one represents the difference in the corresponding valuations (Collins et al., 2012). In our case, for LUB3 we have 113€ representing the amount of money interviewees are willing to pay to obtain 800 additional LUB.

Table 7 – *WTP comparison between M1 and M2*

Variable	**M1**	**M2**
	WTP (discrete variation)	
LUB	+800	
	145€ (95€ - 195€)	113€ (65€ - 162€)
PLUBF	+10	
	99€ (73€ - 125€)	198€ (127€ - 270€)
	+20	
	198€ (147€ - 251€)	203€ (138€ - 268€)

The results reported in Table 7 show the strong policy impacts that adopting either a linear or non-linear assumption might have. In fact, one observes comparing the results of M1 and M2 that the greatest differences are related to the evaluation of an increase of 10 PBP for PLUBF when going from 10 to 20. In this case, using M1, one would estimate a 99€ WTP for such a variation whereas assuming non-linear effects (i.e. M2) the evaluation would double (198€). Moreover, looking at the monetary confidence intervals, it is important to underline that the two estimated values are statistically different and also in M1 there is a little dispersion around the mean value while the distribution in M2 is much flatter (see Figure 3).

A smaller effect is found with reference to LUB3. In fact, when using M1 we obtain a 145€ WTP for an increase of 800 extra LUB and, for an equal increase, just 113€ when using M2. In this case the two WTP distributions are similar in terms of dispersion around the mean value (see Figure 4).

Figure 3 – *WTP distribution for PLUBF2. A comparison between M1 and M2*

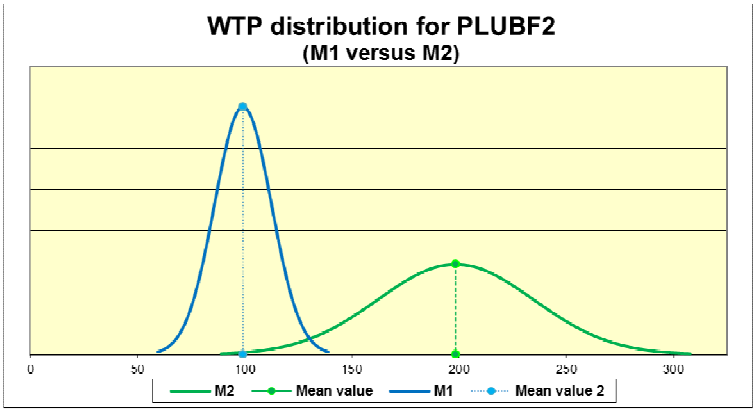
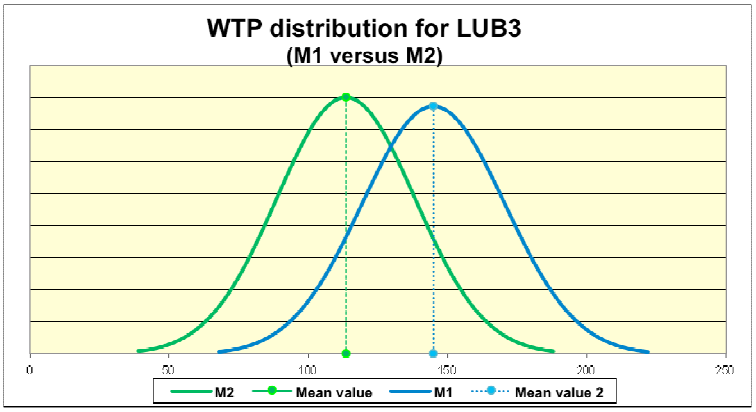


Figure 4 – *WTP distribution for LUB3. A comparison between M1 and M2*



From a purely statistical point one should suggest policy maker to have more faith in M2 results giving its higher explanatory power given its capability to fit the data.

5. **Concluding remarks**

This paper reports the results from an empirical research on UFT policy intervention in the Roman freight LTZ. The research specifically focuses on retailers' preference analysis for hypothetical policy scenarios. The paper innovates in terms of questionnaire development and in terms of ex-ante policy-mix evaluation. The results obtained are relevant both from a theoretical point of view as well as from a more practical and policy-oriented perspective. It is noticeable that notwithstanding the often called for agent-level analysis, the literature on UFT policies has rarely investigated this issue at this specific level. Therefore, the paper represents a first attempt at bridging the gap between theory, applied research and data needs.
In more detail, from a methodological stance the results reported show that not only it is important and interesting to adopt an agent-based point of view but also to consider potentially non-linear effects of the policy instruments adopted. Data reveals, in fact, that both with respect to all attributes considered the policy potentially implemented might have a different effect depending on the attribute level the policy is trying to influence. The results have been analyzed

in terms of WTP so to facilitate interpretation and, under this respect, the robust estimation conducted on the coefficients' ratios allowed us to produce monetary confidence intervals for each of the policy attribute considered. The comparison between M1 (linear effects) and M2 (non-linear effects) shows that potentially relevant biases could characterize the results obtained if non-linearities in the effects are duly accounted for. The limited amount of observations available do not suggest extrapolating the results to a real-life context, however we trust the reader will appreciate the methodology exposed as useful in providing local policy-makers with relevant information. Future research will pursue two different but concurrent objectives. On one side we will perform similar investigations on two other relevant UFT agent-types, namely transport providers and own account, while, on the other, from a methodological perspective, we will also investigate other potentially relevant issues such as for instance: 1) various forms of heterogeneity in preferences (e.g. investigating deterministic, stochastic, as well as both deterministic and stochastic, see Marcucci and Gatta, 2012); 2) develop interactive choice models along the methodological lines proposed by Hensher and colleagues at ITSL Sydney (Hensher and Puckett, 2007; Puckett et al., 2007); 3) adopt Bayesian estimation methods since they are particularly useful when researchers are faced with a limited number of observations.

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6. **Bibliographical references**

CHOW J.Y.J., YANG C.H.Y., REGAN A.C., (2010), "State-of-the art of freight forecast modeling: lessons learned and the road ahead", Transportation, 37(6), pp. 1011-1030.

COLLINS A.T., ROSE J.M., HESS S., (2012), "Interactive stated choice surveys: a study of air travel behavior", Transportation, 39(1), pp. 55-79.

DALY S., HESS S., de JONG G., (2010), "Calculating errors for measures derived from choice modelling estimates", ITS working paper, Institute for Transport Studies, University of Leeds.

DE JONG G., BEN-AKIVA M., (2007), "A micro-simulation model of shipment size and transport chain choice", Transportation Research Part B, 41, pp. 950-965.

EFRON B., (1979), "Bootstrap methods: Another look at the Jackknife", Annals of Statistics, 7, pp. 1-26.

EFRON B., TIBSHIRANI R., (1993), "An Introduction to the Bootstrap", Chapman and Hall: New York.

FILIPPI F., CAMPAGNA A., (2008), "Indagine sulla distribuzione delle merci a Roma, nell'ambito dello Studio di settore della mobilità delle merci a Roma", CTL: Centre for studies on Transport and Logistics and ATAC: Agency of mobility of Rome's municipality.

GRAY R., (1982), "Behavioural Approaches to Freight Transport Modal Choice", Transport Reviews, 2(2), pp. 161-184.

GREENE W.H., (2003), "Econometric Analysis", 5th ed. Prentice Hall: Englewood Cliffs.

HENSHER D.A., FIGLIOZZI M.A., (2007), "Behavioural insights into the modelling in freight transportation and distribution system", Transportation Research Part B, 41, pp. 921–923.

HENSHER D.A., PUCKETT S.M., (2007), "Theoretical and conceptual frameworks for studying agent interaction and choice revelation in transportation studies", International Journal of Transport Economics, 34(1), pp.17-47.

HENSHER D.A., ROSE J.M., GREENE W.H., (2005), "Applied Choice Analysis: A Primer", Cambridge University Press, Cambridge.

HOLE A. R., (2007), "A comparison of approaches to estimating confidence intervals for willingness to pay measures", Health Economics, 16(8), pp. 827-840.

KAHNEMAN D., TVERSKY A., (1979), “Prospect theory: An analysis of decision under risk”, Econometrica, 47, pp. 263-291.
KRINSKY I., ROBB A.L., (1986), "On Approximating the Statistical Properties of Elasticities", The Review of Economics and Statistics, 68(4), pp. 715-719.
KRINSKY I., ROBB A.L., (1990), "On Approximating the Statistical Properties of Elasticities: A Correction", The Review of Economics and Statistics, 72(1), pp. 189-190.
LIEDTKE G., SCHEPPERLE H., (2004), “Segmentation of the Transportation Market with Regard to Activity–based Freight Transport Modelling”, International Journal of Logistics: Research and Applications, 7(3), pp. 199-218.
MARCUCCI E., GATTA V., (2012), "Dissecting Preference Heterogeneity in Consumer Stated Choices”, Transport Research Part E, 48(1), pp. 331-339.
MARCUCCI E., STATHOPOULOS A., GATTA V., VALERI E., (2012), “A Stated Ranking Experiment to Study Policy Acceptance: The Case of Freight Operators in Rome’s LTZ”, Italian Journal of Regional Science, 11(3), pp. 11-30.
MARCUCCI E., STATHOPOULOS A., (2012), “Heterogeneity in urban freight policy impact: own-account agents in Rome's TLZ”, in Campagna M. et al. (eds.), Planning Support Tools: Policy Analysis, Implementation and Evaluation. Proceedings of the Seventh International Conference on Informatics and Urban and Regional Planning INPUT2012, Franco Angeli, pp. 1722-1737.
MOONEY C.Z., DUVAL R.D., (1993), “Bootstrapping: A Nonparametric Approach to Statistical Inference”, Sage University Paper Series on Quantitative Applications in the Social Sciences, series no. 07-095, Sage: Newbury Park.
OGDEN K.W., (1992), “Urban goods movement: a guide to policy and planning”, Ashgate, Aldershot, UK.
PUCKETT S. M., GREAVES S., (2009), "Estimating Policy-Induced Changes in Freight Vehicle Emissions in Sydney", Institute of Transport and Logistics Studies Working Paper, The University of Sydney.
PUCKETT S.M., HENSHER D.A., COLLINS A., ROSE J., (2007), “Design and development of a stated choice experiment in a two-agent setting: interactions between buyers and sellers of urban freight distribution services”, Transportation, 34(4), pp. 429-451.
QUAK H.J., DE KOSTER R., (2009), “Delivering goods in urban areas: how to deal with urban policy restrictions and the environment”, Transportation Science, 43, pp. 211–227.
ROONDA M.J., CAVALCANTE R., MCCABE S., KWAN H., (2010), “A conceptual framework for agent-based modelling of logistics services”, Transportation Research Part E: Logistics and Transportation Review, 46, pp. 18-31.
ROTARIS L., MARCUCCI E., SARMAN I., (2012), “Testing for nonlinearity in the choice of a freight transport service”, in Marcucci E., Puckett S., (Guest Editors), Special issue on: “Freight transport analysis: new trends and methodologies”, European Transport/Trasporti Europei, 50, pp. 1-22.
SAMIMI A., MOHAMMADIAN A., KAWAMURA K., (2009), “Integrating supply chain management concept in a goods movement microsimulation”, IEEE International Conference on Service Operations, Logistics and Informatics, Chicago.
SHANMUGALINGHAM S., (1982), “On the analysis of the ratio of two correlated normal variables”, Statistician, 31, pp. 251-258.
STA, (2001), "Quadro conoscitivo del problema della distribuzione delle merci nel Centro Storico di Roma", STA, Rome.
STATHOPOULOS A., MARCUCCI E., VALERI E., GATTA V., NUZZOLO A., COMI A., (2011), “Urban Freight Policy Innovation for Rome’s LTZ: A Stakeholder Prospective”, in City Distribution And Urban Freight Transport: Multiple Perspectives, Macharis C., Melo S., (eds.), Edward Elgar Publishing Limited, Cheltenham, pp. 75-100.
STATHOPOULOS A., VALERI E., MARCUCCI E., (2012), "Stakeholder reactions to urban freight policy innovation", Journal of Transport Geography, 22, pp. 34-45.
VOLVO REPORT, (2010), “Innovative solutions to freight distribution in the complex large urban area of Rome”, Final report, project SP-2007-50, Mimeo.
VOLVO RESEARCH FOUNDATION, (2009), “Innovative solutions to freight distribution in the complex large urban area of Rome”, Volvo Research and Educational Foundations and The Italian Centre of Excellence CTL – Centre for Transport and Logistics, 2008-2009.

WISETJINDAWAT W., SANO K., MATSUMOTO S., (2006), “Commodity Distribution Model Incorporating Spatial Interactions for Urban Freight Movement”, Transportation Research Record: Journal of the Transportation Research Board 1966, pp. 41-50.