Explaining, modelling and measuring the heterogeneity in shipper's value of time

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Abstract

The intention of the present article is to shed light on the heterogeneity of value of time among shippers. In order to deal with this issue, we first look at the reasons for which different shippers may value a time saving differently. This analysis makes use of a distinction between generic goods and specific (tailor made) goods. Subsequently, we analyse how this heterogeneity could be represented in the framework of Mixed Logit which is increasingly popular among the Transport Science research community. We concentrate on the issue of the selection of an adequate distribution for the random coefficients of time and costs attributes. In the final part of this article, we make an estimate of the value of time heterogeneity using data collected from shippers in Italy.

Keywords

Value of time, freight transportation, Mixed Logit.

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1. Introduction

During recent years, the development of Random Parameter Logit models, within the well-established framework of Random Utility Maximisation, has offered transport modellers a set of powerful and flexible tools to represent and measure how transport behaviour is affected by the heterogeneity of the economic agents' preferences. This has resulted in a parallel development of many formal specifications for the kernel component of the random utility model and a number of empirical applications.

However this renewal has scarcely affected the understanding of firms' preferences for *freight* transportation. Indeed, similar to travellers, firms may value single attributes of a transport service differently from one another. Consequently, the understanding of heterogeneity among firms' preferences and the production of original quantitative results should be ranked high on the agenda of transport economists.

In this article, we propose to investigate the reasons for the differences among individual firms' valuations of transport attributes, and we propose a representation of this heterogeneity using some Random Parameter Logit specifications. We concentrate on one single transport service attribute: transport time. This choice is motivated by two reasons. First, in the field of public policy, this choice recognises the pre-eminent share that time savings usually represents in transport project benefits. Second, in the field of management science, the role of time competition has been underlined by different works (Cachon e Harker 2002, Li and Lee 1994, Stalk and Hout, 1990). Another peculiarity of our approach is that we concentrate on the demand side of the transport market, that is *shippers*, companies that produce material goods and consume transport services. We will not consider heterogeneity on the supply side: hauliers, that is, the *producers* of transport services. Regarding the latter, we will only mention at this stage the works by Wynter (1995) and Kawamura (1999) who investigated the heterogeneity of *hauliers'* valuation and we will return briefly in the body of the present article to the mechanisms that may link shippers' preferences and hauliers' preferences.

In short, we want to investigate the heterogeneity in shippers' value of time. Our presentation follows three steps: understanding where heterogeneity stems from, investigating the possibilities to model this heterogeneity; providing quantitative evidences of heterogeneity in freight values of time based on a shipper interview.

2. Understanding heterogeneity

In this section we investigate the causes of heterogeneity. The question is here why a certain company would be prepared to pay a certain amount of money to reduce transport time. We deal with this question introducing a distinction between two different types of goods that in turn relate to two distinct relations to time.

2.1 Definition and distinctions

The distinction we use is inspired by Salais and Storper (1993), and already commented in transport economics by Burmeister (2000). The first category of goods is referred to as "generic goods" and to the second type as "specific goods". *Generic* goods are undifferentiated between one unit and another. This means that they can be produced in advance, whenever a firm considers that it is reasonable to forecast that some units of these goods will be bought in the subsequent periods of time. On the contrary, the *specific* goods are tailor made for each client. In this situation it is not feasible for a firm to produce a unit of the good before the precise specifications of its features have been agreed with the client. These two types of goods create a different relation with time as is discussed below.

Dealing with **generic goods**, the question on how much time to spend in production and/or in transport relates to the choice of an optimal stock policy, coping with the extra costs occurring when stock increases and the extra costs due to stock-out when stock decreases. This type of trade-off has attracted the attention of economic and logistic science and has given rise to various models of optimal stock policy, such as the model of Baumol and Vinod (1970). In this framework the value of time for the shippers has two components: the reduction of inventory costs occurring during transportation and the reduction of the costs of holding inventories to respond to unexpected change in the demand. This last component appears because the level of the safety stock is larger when the transportation time is long. Using the formal model provided by Baumol and Vinod, one can write the willingness to pay of the hauliers for a marginal change in transportation time for each single shipment as (with authors' notations):

(1) $$wtp^g = s\left(uT + \frac{wkT}{2\left(\left(s+t\right)T\right)^{1/2}} \right)$$

where, wtp^g refers to the willingness to pay of shippers for a marginal reduction in transportation time, *s* is the frequency of the shipment (for instance 0, 01 if there are 100 shipments per year), *u* carrying cost per unit of time; *T* quantity of goods transported, *w* warehouse carrying costs per unit per year, *k* is the accepted probability of stock-out.

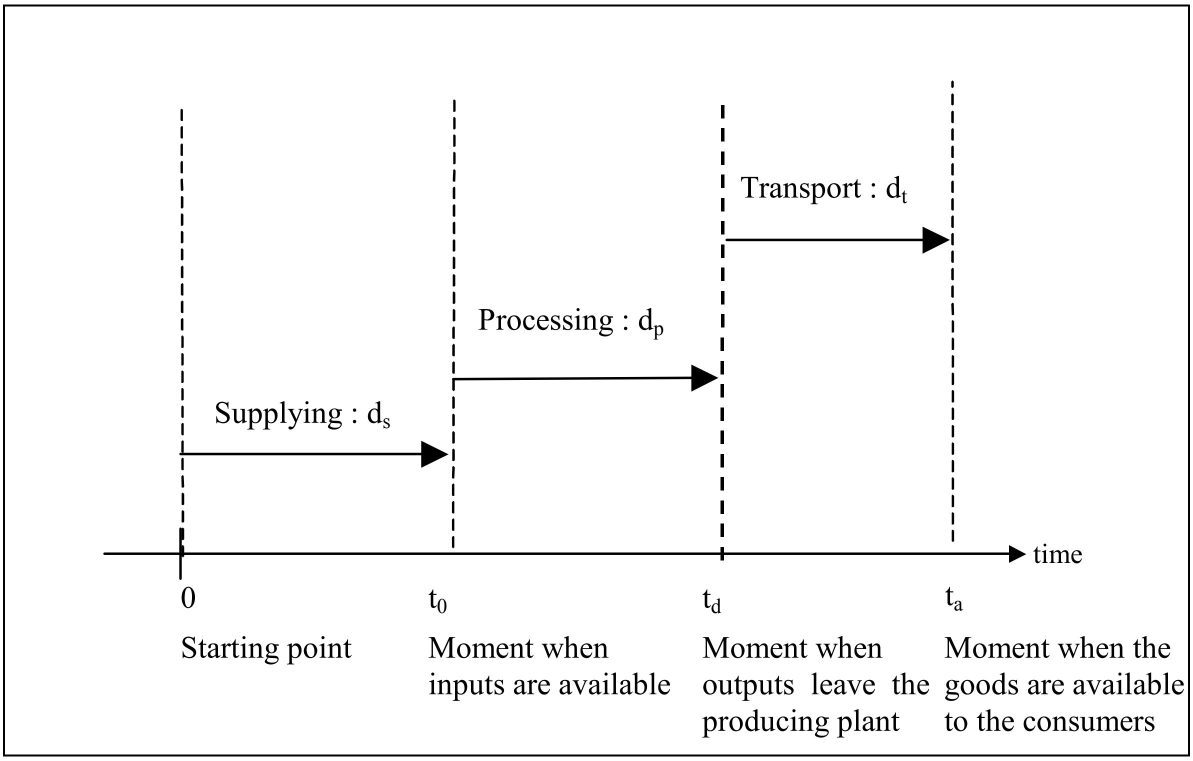
If we consider in turn, the situation of **specific goods**, the idea of optimal stock is barely satisfactory as it is useless for the firm to produce a unit until the firm has agreed on its features with a client. Thus the cost benefits trade-off made by the firm are based on something other than the optimal stock. A suggestion that we explore further in this paper, is that there is a trade-off between cost and time in the whole production process, including the transport operations. This trade-off is the source of the valuation of travel time savings.

2.2 The trade-off of specific goods producers

Massiani (2005) has developed a model representing the trade-offs made by a producer, for a given output, regarding the production cycle duration of a specific good, where the production cycle duration refers to the time that elapses between the order of a good and its delivery to the final consumer. We will concentrate here on a situation where the production is specific both for inputs and outputs. In this framework, the production cycle will consist of **three phases**: in a first phase the (specific) inputs are ordered and delivered to the producer; second the inputs are processed to produce the outputs; third, the output is transported outward to be delivered to the client.

Figure 1 illustrates the succession of the different phases, introducing the notations that will be used further in this paper, where d_s refers to the duration of the supplying phase, d_p is the duration of the processing phase, d_t is the duration for the phase of (outbound) transport. Note that the notation can also be expressed in terms of time, or moment, instead of duration as is indicated on the x axis of Figure 1, where t_0 refers to the moment when inputs are available for the production process, t_d refers to "departure time" when the good leaves the producer, and t_a is arrival time, that is the time at which the good is delivered to the consumer.

Figure 1: duration of the different phases involved in the specific good producer trade-off.



In this framework, we suppose that a given firm needs to select an optimal duration for each of these phases. We assume that the cost of each phase depends on the duration dedicated to each of them. We posit that this relationship can be represented through U shaped functions. This means for instance that there exists a cost minimising processing (/supplying/ transportation) duration, and that any deviation from this duration will increase the costs of the corresponding operation. This time dependent costs are represented by four functions.

Duration dependent costs and revenues:

$cs(d_s)$, supplying costs as a function of the supplying duration,

$cp(d_p)$, processing costs as a function of processing duration.

$ct(d_t)$, transportation costs as a function of the transport duration of the outputs. These costs correspond to the tariff paid by the producer to the haulier.

We will suppose that each of these functions is strictly positive and U shaped

Eventually, one should consider that the cost of transport time for the producer is not only consisting of the tariff paid to the hauliers but also of other components usually referred to as "immobilising costs". A more precise presentation of these costs that we propose consists of three components: the financial inventory costs of having the good in transit, the costs of damage as the shipper perceives them as proportional to the time spent in transit, the costs linked with the physical change of the good during the transportation (this particularly applies to perishable goods). We will refer to these 3 costs as "generalised immobilisation costs" and denote it with the following function:

$ci(d_t)$, generalised immobilisation costs as a function of the transport duration.

This function is supposed to be monotonic strictly increasing (no hypothesis is made on the sign of the second order derivative):

(2) $$ci'_{dt} > 0$$

Apart from costs, durations also impact revenues: clients may be willing to pay more in order to receive their goods sooner [1].This can be expressed by the function $r(d_s+d_p+d_t)$, that makes the revenue depend on the arrival time, we will suppose that $r(d_s+d_p+d_t)$ is differentiable and monotonously decreasing, that is:

(3) $$r'_{ds} = r'_{dp} = r'_{dt} < 0,$$

Profit maximising in a time framework

In this framework, the maximisation program of the firm becomes:

$$\underset{(d_s,d_p,d_t)}{Max}\left[r(d_s+d_p+d_t) - \left(cs(d_s) + cp(d_p)+ct(d_t)+ci(d_t)\right)\right]$$

Assuming that all functions involved in the trade-off are differentiable, one can write the first order conditions as:

(4) $$r'_{ds} = cs'_{ds}$$

(5) $$r'_{dp} = cp'_{dp}$$

(6) $$r'_{dt} = ct'_{dt}+ci'_{dt}$$

these conditions can be summarised in:

(7) $$r'_{ds} - ci'_{dt} = r'_{dp} - ci'_{dt} = r'_{dt} - ci'_{dt} = cs'_{ds} - ci'_{dt} = cp'_{dp} - ci'_{dt} = ct'_{dt}$$

Recalling that revenues are decreasing with duration: ($r'_{ds} = r'_{dt} = r'_{dp} <0$) and that generalized immobilisation costs are increasing with transport duration ($ci'_{dt}>0$), we can find: $cs'_{ds} < 0$, $cp'_{dp} <0$, $ct'_{dt} < 0$. These latest inequalities mean that the profit maximising durations chosen by the shipper will be located on the downard slope of the three different cost curves. In other words, when the shipper maximises profit, it is in a situation where costs would be reduced by an increase in duration. Also one can deduce from equation (1.7) that a profit maximising shipper will be prepared to pay for a faster transportation as much as the extra cost it would incur in reducing the duration dedicated to other operations (purchase and production), plus the reduction in generalised immobilisation costs due to transport duration.

The consequences of a reduction in transport time

These maximisation conditions provide insights about the marginal benefit of a reduction of **transport time**. When transport time is reduced the shippers benefit from a reduction in generalised immobilising costs, as well as one of the following three effects:

- the marginal increase in revenue due to a faster delivery,
- the marginal decrease of production costs allowed by an increased production duration,
- the marginal decrease of supplying costs allowed by an increased supplying time,

These three quantities being equal when the shipper maximises its profit.

Resulting from the conditions given in equations (4) to (7) to, is a formal expression of the willingness to pay of a specific good producer for a marginal time saving:

(8) $$wtps^s_s = -(r'_{dt} - ci'_{dt}), \text{ with:}$$

wtp^s_s, shippers willingness to pay for a decrease in transport time (specific goods),

[1] The less typical case where clients prefer to postpone the reception of the good can also be dealt with but we will concentrate here on the more typical situation.

r'_{dt} ,   marginal temporal revenues in function of the transport duration (r'_t is negative: the revenue decreases when the transport time increases).

ci'_{dt} ,   marginal generalised immobilisation costs (costs increase when transport time increases)

The understanding of heterogeneity

These maximisation conditions have implications for the understanding of heterogeneity. The different producers will face different time depending revenue functions and different time depending cost functions. This will result in equilibrium where the different firms locate at different points of the envelope of clients willingness to pay curves. Each of these equilibriums will be determined by a tangent to the revenue curve, while the three time depending cost functions of the producer will have the same differential. The distribution of the willingness to pay of producers for transport time savings will reflect the distribution of final consumers' willingness to pay for a reduction of delivery time.

Eventually if we recall that specific goods represent one among two types of goods, we can represent the density of the willingness to pay of shippers for a marginal reduction in transport time of a given shipment with the following formula.

(9) $P(wtp = v) = P(G)\times P(wtp^g = v|_{gén.}) + P(S)\times P(- r'_t + ci'_t = v|_{spéc.})$, with:

$P(wtp=v)$, probability that a shipper has a willingness to pay equal to v,

$P(G)$, probability that a shipper produces a generic good.

$P(wtp^g = v|_{gén.})$, probability that a generic good's producer faced with a transport time saving has a diminution of the costs (immobilisation + reduction in the optimal stock) equal to v,

$P(S)$, probability that a shipper produces a specific good.

$P(-r'_t + ci'_t = v|_{spéc.})$, probability that a specific good producer has a willingness to pay for a time saving equal to v.

In this section we have presented the mechanisms that make transport time savings valuable for shippers. We have found that when the goods are *generic*, the shippers' benefits are based on the reduction of inventory costs and the reduction of the costs of holding a safety stock. When, instead, the goods are *specific* the benefits rely on the reduction of generalised immobilisation costs and the economies (or extra revenues) allowed by the reuse of the time that is made available by the reduction in transport time. Thus, the variation in the valuation of the time savings among the population of shippers, will depend on the category of good, and of the parameters describing the situation of each shipper.

3. Modelling heterogeneity

In this section we make use of the well known Random Utility Maximisation model (Domencich and Mc Fadden, 1975), and examine how heterogeneity should be taken into account in the RUM framework.

First, one needs to recall, that several ways to represent heterogeneity exist. For instance, in the fixed parameter Random Utility Maximisation model, the additive random term of the utility function may represent differences in the utility function that characterises each individual. Other, more resourceful, possibilities are the use of interaction terms (for instance the product of transport time by the value of the good is introduced in the utility function in order to allow for different valuations of the time attribute based on the value of the good), a priori segmentation (based, for instance, on product category) or a posterior segmentation (such as Latent Class models).

In this section we will concentrate on the Random Parameter Logit and consider several issues. First, we recall the properties of RPL. Second, we concentrate on the crucial question of the selection of the density probability to be used for the kernel component of the RPL.

3.1 Presentation of the Random Parameter Logit

We present here the model such as it is reported in McFadden and Train (2000), and Train (2003). The utility of a shipper *n* that has to chose among *J* alternatives in *T* choice situations can be represented with:

(10) $$U_{nit} = \beta_n^{'} X_{nit} + \varepsilon_{nit} \text{ with}$$

X_{nit} , vector of the observed deterministic independent variables,

β_n , coefficients for individual n,

ε_{nit} , random additive terms for individual n, alternative i, and choice t.

terms β_n and ε_{nit} are not observed by the analyst, they are random. Maximising random utility, means that the shipper will choose alternative i iff

(11) $$U_{ni} > U_{nj}, \forall j \neq i$$

Coefficient β_n is supposed to have a distribution independent form ε and *X,* with a density $f(\beta / \theta)$, where θ represents the distribution parameters of β among the population (for instance the mean and variance). The notation *n* indicates that the parameters can vary among individuals but are fixed for the different choices of each individual. Such a specification can take into account interpersonal preferences.

The random term ε_{nit} is IID Gumbel (or "extreme value"). If the analyst could observe each individual coefficient β_n, the choice probabilities could be treated through a standard logit. The probability, conditional to β_n, would be:

(12) $$L_{ni}(\beta_n) = \frac{\exp(\beta_n^{'} X_{ni})}{\sum_{j=1}^{J} \exp(\beta_n^{'} X_{nj})} \text{ with:}$$

$L_{ni}(\beta_n)$, choice probability for alternative i, function of the coefficients.

But, as the observer does not know β_n, the choice probability can be expressed as the integral of $L_{ni}(\beta_n)$ weighted by the density $f(\beta / \theta)$ on all values of β_n.

(13) $$P_{ni} = \int L_{ni}(\beta_n) f(\beta \mid \theta) d\beta$$

for instance the density β is represented by a normal with mean b and covariance W, the choice probability is:

(14) $$P_{ni} = \int \frac{\exp(\beta_n^{'} X_{ni})}{\sum_{j=1}^{J} \exp(\beta_n^{'} X_{nj})} \Phi(\beta \mid b, W) d\beta \text{ with:}$$

Φ, density of the multivariate normal.

These probabilities can not be solved analytically but can be approached by simulation as presented in Train (2003, p. 148).

3.2 Selection of the density for the stochastic parameter

The core question that needs to be addressed in order to make use of a Random Parameter Logit is the selection of a distribution for the coefficients. The question can be considered in two ways. As the value of time is the ratio of the time coefficient on the cost coefficient of the indirect utility function, one may want to consider these two terms separately. The other alternative is to consider directly the distribution of the ratio of these two terms.

The first solution is appealing as it is similar to the way in which the Random Utility Maximisation is usually implemented, namely with one coefficient for cost and one coefficient for the time attribute. Although there are some difficulties with the derivation of a statistical density for the ratio of two densities[2], such difficulties may not be an hurdle because one can also, making use of Bayes formula, estimate individual values for each coefficient (as proposed in Hensher and Greene, 2003). In this case, the distribution of the values of time will be provided by the ratio of the individual estimates of the time and cost coefficients, without the need for the analytical derivation of a density function. A more serious difficulty is that the elements that would provide insight about the adequate density function for each single term of the ratio (time coefficient/cost coefficient) are much less that the one regarding the distribution of the value of time.

A review of the more frequent distributions available for the utilisation of RPL in the area of *passenger* transportation is proposed by Hensher et al. (2005). These are namely: normal, Log-normal, uniform and triangular. Recently, some other distributions have been proposed in the literature. The Raleygh distribution or the Johnson distribution (Train et Sonnier (2004)) offer a large flexibility. However the possibility to implement such distributions is still very limited in the estimation software available to date [3]. Among the different available distributions there is a sharp distinction between unbounded distributions, that provide non zero density for large absolute values of the coefficients, and bounded distributions that can be criticised based on the consideration that *natura non fecit saltum.* Second, it suggests that we find no definite choice criteria among the different distributions. If we come back to formula (8), one could say that the value of time for the producers of specific goods results of the addition of two phenomenon (the one represented by $-r'_t$ and the other by ci'_t). Moreover, the second of these phenomenon, generalised immobilising costs, results itself of several additive effects: inventory costs, costs of damages in as far as they are proportional to transport time, modification of the physical features of the goods (perishable goods). This additive feature is consistent with the normal distribution (sum of additive phenomenon). However, although they are additive, they are neither in a large number, nor independent, as a strict application of the central limit theorem would imply.

Given the impossibility of finding a definite statistical choice criterion regarding the selection of a density function, one may then search some selection criteria based on economic analysis rather than merely statistical considerations.

3.3 Evidence based on economic analysis

It has been proposed by Kawamura (1999) to use properties of household income distribution to select a distribution for the value of time of the hauliers. We will first investigate this proposal and, second, propose a retropolation procedure to retrieve an adequate distribution of the shippers' value of time based on hauliers' value of time.

Can we use information regarding travellers' value of time distribution ?

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[2] This problem is not absolute considering, for instance, the case of two lognormal distributions.
[3] The Limdep software that was implemented gives the possibility to use Uniform, Normal, Log-Normal and triangular distribution.

In travellers' transportation, the distribution of the coefficient associated with the value of time can be found considering both microeconomic and empirical elements. The cost coefficient in the indirect utility function, corresponds to (minus) the marginal utility of money. This marginal utility is inversely related to income. Considering that the distribution of income is empirically found to be represented by a log normal density, on can conjecture that the coefficient of cost in a linear utility is the inverse of a function of a variable that has a lognormal distribution. This provides thus indications, both theoretical and empirical, to select the distribution of the cost attribute and hence of the value of time. However, one should recognise that these indications provide evidence only on one term of the value of time ratio. More important, we see no elements that could be transferred to freight transportation. It seems then that the idea advocated by Kawamura should be rejected and that one should look for other elements to select a distribution.

Retropolating shippers' preferences from hauliers' preferences

An appealing possibility is to base the selection of the distribution function on a formal relationship between the willingness to pay of the shippers and of the hauliers for a time saving. This relationship permits us to use some information available about the distribution of *hauliers'* willingness to pay in order to derive information about the distribution of *shippers'* willingness to pay. We present hereafter this possibility of retropolation.

One needs first to introduce a distinction as to the different *objects* of willingness to pay of hauliers and shippers for time savings. Hauliers willingness to pay relates to *travel* time, while shippers willingness to pay relates to *transport* time, where *travel* refers to the time that is spent by the freight while moved in a vehicle, and *transport* refers to the bundle of operations that the good spends in all transport operations (stocking, cross docking, border crossing, etc.) The point here is that the trade-offs regarding *travel* time are usually an internal matter for the haulier, while the shipper usually only knows about the *transport* time. For this reason, it is usually possible to know the willingness to pay of hauliers for a *travel* time saving (but not for *transport* time savings), and of the shippers for a *transport* time saving (but not for *travel* time saving).

The willingness to pay of hauliers

Let's label μ (respectively $\bar{\mu}$)[4] the travel (resp. non travel) operation and $d\mu$ (resp. $d_{\bar{\mu}}$) the duration dedicated to travel (resp. non travel) operations, and $c_\mu(d_\mu)$ (resp ($c_{\bar{\mu}}(d_{\bar{\mu}})$) the cost of travel (resp. non travel) operations[5]. Finally, let's label d_μ^{min} the minimum duration of travel operations (due, for instance, to the conditions of infrastructure). Note $rt(d_\mu + d_{\bar{\mu}})$ the revenue of the haulier. The profit maximising program of the haulier will be:

$$\text{Max } rt(d_\mu + d_{\bar{\mu}}) - (c_\mu(d_\mu) + c_{\bar{\mu}}(d_{\bar{\mu}})),$$

$$\text{s.t. } d_\mu > d_\mu^{min}.$$

Positing that the constraint is binding, this will result in the conditions:

$$rt'(d_\mu^{min} + d_{\bar{\mu}}^*) = c_{\bar{\mu}}'(d_{\bar{\mu}}^*) \quad (15)$$

$$d_\mu = d_\mu^{min} \quad (16)$$

The Lagrangian multiplier associated to the constraint on the minimum travel duration is

$$\lambda = rt' - c_\mu' \quad (17)$$

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[4] The notations μ and $\bar{\mu}$ corresponds to the distinction between metakinesic and ametakinesic, from the Greek word metakinesis (travel).

[5] This suppose that the cost of non travel operations does not depend on the duration of travel operation, and conversely. The alternative, more complex situation is discussed in Massiani (2005, p. 313)

This multiplier indicates the benefits of a marginal reduction of the minimum *travel* time or, in other words, the willingness to pay of hauliers for a reduction in *travel* time.

Thus, we can use the notation:

(18) $$wtp_h = rt'(d_\mu^{min} + d_{\bar{\mu}}^*) - c_\mu'(d_\mu^{min})$$

d_μ^{min} is the minimum travel time on a given corridor, $c_\mu(d_\mu^{min})$ is the cost of producing a transportation service on this corridor, $rt(d_\mu^{min} + d_{\bar{\mu}}^*)$ are the revenues of the hauliers as a function of the minimum transport time that they can offer on a certain corridor. The willingness to pay of a haulier for a marginal change in transport duration is the sum of the marginal change in hauliers' costs and the marginal increase in hauliers' revenues. The second effect, marginal increase in hauliers' revenues, is only the counterpart of the willingness to pay of hauliers clients, that is shippers, for a time saving. This feature proves to be useful in the retropolation as illustrated below.

From hauliers' preferences to shippers' preferences

Using the fact that the revenues of hauliers for a faster transportation equates with the willingness to pay of the shippers for a time saving, it comes

(19) $$wtp_h = wtp_s - c\mu'_{d\mu} ,$$

where wtp_s is the willingness to pay of the shippers to reduce transport time, and $c\mu'_{d\mu}$. is the marginal cost of travel operations. The willingness to pay of the hauliers for a time saving reflects the willingness to pay of the shippers plus the changes in travel costs. This latest element will depend in turn on two elements: the property of the first derivative $c\mu'_{d\mu}$, and the point of this function where hauliers locate in current conditions.

Then, it is possible, based on equation (19) to isolate in the left end term wtp_s and to write:

(20) $$wtp_s = wtp_h - c\mu'_{d\mu,}$$

Equation (20) indicates that the willingness to pay of the shippers for a marginal time saving can be deducted from hauliers' willingness to pay, net of the travel cost reduction due to this time saving. In terms of distribution, the conclusion of this retropolation procedure is that the distribution of shippers value of time results from the addition of two distributions, the distribution of hauliers' willingness to pay for a time saving and the distribution of marginal *travel* costs.

It then becomes possible to use certain empirical evidence such as that collected by Wynter (1995), Kawamaru (1999) and Kawamaru (2000) that establish a log-normal distribution for hauliers' value of time. If we consider that $c\mu'_{d\mu}$ is fixed, it will then be possible to conclude that wtp_s is lognormally distributed, and we will only make an error as far as the hypothesis that is made about the constancy of ($c\mu'_{d\mu}$) among the hauliers being restrictive. This suggests that the *retropolation* technique provides a way to infer the distribution of shippers' willingness to pay based on the information that is available regarding the distribution of hauliers willingness to pay. This can be useful in situations where the researcher has empirical data that make it possible to derive conclusions on hauliers' value of time distribution, but has no empirical elements on the distribution of shippers' value of time distribution.

In this section, we have discussed the choice of a density function to represent the distribution of shippers' value of time in the Random Parameter Logit (RPL) framework. Statistical properties of the most common distribution functions provide no definite choice criteria, except a weak conjecture in favour of normal distribution, we have explored other indications based on economic analysis. We have found that the empirical evidences regarding the distribution of households' income provide no useful information regarding the distribution of *shippers'* value of time. We have also found that it is possible to retropolate *shippers'* value of time distribution based on *hauliers'* value of time distribution, although such a relation provides a satisfactory approximation only insofar as the marginal cost of *travel* time saving is relatively similar among the different hauliers considered. This creates a conjecture in favour of log-normal distribution. As a conclusion, we consider that normal distribution and log-normal distribution provide interesting candidates for the distribution of value of time.

4. Measuring heterogeneity: empirical application based on shippers' interviews

In the present section, we provide some empirical results regarding the distribution of hauliers' value of time based on an SP survey that was made among Italian shippers.

4.1 Data

The data were collected, for a joint project for the University of Trieste and the University of Urbino (Italy). It consisted of an SP survey in the Italian regions of Friul Venitia Giulia, Marches and Latium. The 99 surveyed companies are part of five sectors (mechanical equipment, steel products, furniture, chemicals, and electronics). Furthermore, they were selected considering that they were likely to send their shipments through intermodal transport[6]. Companies were first contacted by telephone to present the survey, to get information about logistic characteristics of the company and to propose an interview. In a second step, when the company was willing to participate in the survey and was a potential user of intermodale transport, a face to face interview was made with the logistics manager of the firm. Interestingly, these data contain information on the logistical framework in which companies operate. In particular, firms were to give information on their logistics policy. This provides information on whether the good produced is generic or specific.

Discrete choice exercise

The SP exercise was based on the selection of one from three alternatives. Table 1 hereafter provides an example of the choice proposed to the interviewees.

Table 1: alternatives proposed to the interviewed shippers, an example

Alternative A	**Alternative B**	**Alternative C**
Intermodale	Road	Current mode
Cost: 5% increase	Cost: 10% increase	Cost: current situation
Time: one day more	Time: one day less	Time: current situation
85% of the shipments on time	85% of the shipments on time	% shipments on time: current situation.
Probability of damage: 10%.	Probability of damage: 20%	Probability of damage and loss: current situation.
Frequency: low	Frequency: high	Frequency: current situation
Flexibility: high	Flexibility: high	Flexibility: current situation

Two of the chosen alternatives were generated based on an orthogonal design, the third corresponds to the typical shipment as it was reported by the respondent. This latter alternative will be labelled as status quo. The inclusion of the status quo reinforces the realism of the proposed alternatives. The value of the attributes used during the interview are presented in appendix table 4.

Descriptive results

[6] A more complete description of these data is provided in Danielis and Marcucci (in press) together with a data analysis relying on the use of cut-off for the different attributes.

Table 2 hereafter provides the main characteristics of the interviewed firms and of their shipments. This table exemplifies the large variability of most of these data whose coefficient of variation is larger than one. This is especially true regarding the value of the shipment.

Table 2: main features of the interviewed companies and of their shipments

	Mean	**Standard deviation**
Dimension (employees)	133	283
Shipment value (euro)	54.380	145.559
Shipment transport cost (euro)	1.055	1.888
Distance of the transport (km)	817	550
Duration of the shipment (days)	2, 8	3, 5
	%	
% of the shipment that are produced at request	51%	
% of the shipments that are outbound	86%	

Based on this sample of shippers we calibrate a series of models adhering to the RUM paradigm in order to measure the heterogeneity of shippers' preferences.

The model can be written as:

(21) $U = \beta_d.dur + \beta_c.cost + \beta_p\ punct + \beta_{fr}.freq + \beta_{fl}.flex. + \beta_a.asc\_sq + \beta_m.\ mode + \beta.dam + \varepsilon$

dur, duration (days),
cost, transportation cost (% change compared with current cost),
punct, punctuality (% of shipments that reach destination with less than one half day of delay),
asc_sq, alternative specific constant for the currently chosen alternative,
mode, 0 for road, 1 for intermodal,
dam, damage and losses (% of shipments that get damaged).
freq, frequency high (freq=0) or low (freq=1),
flex, flexibility high (flex=0) or low (flex=1),
ε, stochastic component.

The potential for heterogeneity has been analysed in preliminary estimates based on segmentation and interaction terms. Regarding **segmentation,** the results, presented in the appendix (Table 3 and Table 7), show that, for all segmentations based on firm size, shipment value, industrial sector and logistics management, the hypothesis of equality can be rejected with a risk lower than one percent. On the contrary, we cannot reject with 5% probability the hypothesis of equality of coefficients between inbound and outbound flows. Interestingly, these results give some insight about the effects of two different logistics and production policies. Although the information collected in the survey is not phrased in the same terms as the distinction we proposed between "generic" and "specific" goods, it provides a satisfactory approximation so that it can be used to investigate whether there is a difference between these two categories. The log likelihood ratio test clearly indicates that the behaviour of the two different firm types are significantly different based on their segments.

Models with **interaction terms**, are estimated introducing, in the MNL model, attributes that correspond to the cross effect of certain transport attributes and shippers' characteristics[7]. The results are presented in appendix Table 8. They indicate, for instance, that the value of the damage attribute is highly different for companies belonging to the mechanical industry compared with other industries. Based on these results it can be observed that a major source of heterogeneity is

[7] The selection process for the different variables was to introduce variables one by one (stepwise forward) based on the relative difference of the coefficient obtained in the segmented estimates (Table 5 and Table 6). During this procedure the significance of the coefficients, as well as the fitting statistics of the model are monitored.

constituted by the sector, and that the damage and punctuality attributes have effects that are highly different depending on the characteristics of the companies and of the shipments. Moreover it appears possible to introduce an important number of cross-variables before the adjunction deteriorates the adjusted R^2 . These results suggest that the introduction of interaction variables is a major source of amelioration for a RUM model. This still holds when taking care of the parsimony of the model.

These results raise the issue on whether other techniques, and in particular mixed logit, are adequate to represent the heterogeneity of shippers.

4.2 Estimates

RPL Estimates

In this section the main estimation results of RPL are presented. Intentionally, only a limited set of the numerous possible specifications are reported. These models have been estimated using three kinds of distribution: normal, log-normal and triangular. The distribution has been introduced either on one single coefficient, or on all but one coefficient, the variables being successively included or excluded based on the critical probability associated with the random component of each coefficient. The estimation of an RPL has, except in a few situations, proven incompatible with the presence of the "damage" variable in the utility function. The reason for this is probably the range chosen for this attribute: interviewer feedback indicated that much of this range was exceeding the range that shippers usually find acceptable.

The most significant results of this estimate are presented in Table 3. This table provides the coefficients and critical probabilities associated with them for four different specifications of the model. It also provides fitting criteria (adjusted ρ^2, log likelihood) for each of them and the number of observations used in the estimation. The two lines at the bottom provide information on the value of time for each estimation: first, the value of time based on the average transport cost in each segment, second the probability to obtain a counter intuitive positive coefficient for the time attribute[8].

[8] If β_d is normally distributed with parameters (μ,σ),the probability for a negative value of the coefficient is $[1 - \Phi(-\mu/\sigma)]$, where Φ is the cumulative distribution of the standardised centred Normal. When the utility function also contains some other terms with trip duration, their effect must be taken into account in the calculation of the probability of negative value.

Table 3: RPL estimates

	Models										
	1		2			3			4		
	Fixed Coefficient		NN			NN with interractions			Triangular (t,*) (mode : normal)		
	Coeff	proba (t)	Dist	Coeff	proba (t)	Dist	Coeff	proba (t)	Dist	Coeff	proba (t)
Fixed Coefficient											
Duration	-0,39	0,0%		-0,42	0,0%		-0,58	0,0%		1,12	0,0%
Cost (rel)	-10,93	0,0%		-11,84	0,0%		-24,56	0,0%		19,74	0,0%
Punct (half day)	2,65	0,0%		2,99	0,0%		3,02	0,0%		8,86	0,0%
Frequency	-0,17	29,1%		-0,34	3,5%		0,00	0,0%		0,76	1,1%
Flexibility	-0,41	1,1%		0,00	0,0%		-0,55	0,8%		1,22	0,0%
Constant Status Quo	0,57	0,0%		1,41	0,0%		0,78	0,0%		-0,09	59,6%
Mode	0,56	0,0%		0,43	0,1%		0,65	0,0%		1,34	0,0%
Dammages	-14,80	0,0%					-15,40	0,0%		54,90	0,0%
Random parameter (standard error of the coefficient)											
Duration			N	0,75	0,0%	N	1,07	0,0%	T	2,25	0,0%
Cost (rel)			N	6,59	0,0%	N	9,61	0,0%	T	39,49	0,0%
Punct (half day)									T	17,71	0,0%
Frequency									T	1,51	1,1%
Flexibility									T	2,44	0,0%
Constant Status Quo											
Mode									N	0,85	1,2%
Dammages									T	109,80	0,0%
Interraction terms											
damages*Sect 1							-43,97	0,0%			
punct*Sect4							6,08	0,2%			
damages*Sect 5							-18,60	6,2%			
damages*Sect 4							12,10	0,0%			
damages *Dimension1							-8,09	0,4%			
cost(rel)*Sect1							-8,65	1,0%			
cost(rel)*Sortants							9,46	0,9%			
duration*Sect4							-0,82	10,1%			
punct*Val2							1,37	0,2%			
costs*Sect2							5,70	5,6%			
Asc*Dim1							-0,49	1,2%			
adj. Rho²	0,43		0,35			0,55			0,59		
Loglikelihood	-891		-1018			-694			-646		
Number of choices	1425		1425			1425			1425		
Number of interviews	95		95			95			95		
average vot (% cost/day)	3,6%		3,5%			2,4%			5,7%		
p(βd) >0 :	0%		29%			28%			0%		

The first model (model 1) is a fixed coefficient logit model that is used as a comparison for other models. The other models are all with random coefficients. We label a model with NN where cost and time coefficients are normally distributed. This model cannot be compared to the previous one insofar as it is estimated without the attribute "damage"[9].

[9] The estimation of model NN including the damage variable has proved impossible. The estimation of a model with all coefficients normally distributed also failed. In both cases the estimation does not converge. This difficulty persists whichever optimisation algorithm is used: BHHH, BFGS, Newton, steepest descent. This issue is not solved even when the scale parameters of the variables (Limdep reference guide, p. R. 9-15) is taken into account. It is possible to force the convergence relaxing some convergence criteria (for instance the condition on gradient) but in all estimates that

The next model, NN with interaction (model 3) utilises both a distribution for the cost and time coefficient and the interaction terms. The non-significant variables (at 10 % probability) have been dropped during the estimate. One can observe:

- an important number of interaction terms is still significant even when we authorise a stochastic variation for the cost and duration coefficients.

- some interaction terms that were dependent of the cost and time attribute are not anymore significant once one allows for a stochastic variation of the coefficients of these attributes. This regards namely the cross-effect of time in the mechanical sector and the cross-effect of cost with directionality of the flow. Such a finding is not surprising as the variation in the cost and time coefficient can capture some of the cross effects.

- maintaining the interaction terms, extra to the distribution of the coefficients, increases the fitting of the model.

The last model (model 4) is based on a triangular distribution for the set of coefficients except the "mode" attribute (normally distributed) and the Status Quo constant (fixed). It is an extreme case where all coefficients, but one, are supposed stochastic. The adjusted ρ^2 and log likelihood are better than in the deterministic model with interactions.

The last lines of Table 3 also provide indications on the value of time that is obtained for each model and the probability of a counter intuitive sign for the travel time coefficient. One notes that the models that are based on a normal distribution of the time coefficient indicate 30 % probability for a (counter intuitive) positive value of the time coefficient. This figure indicates whether that one third of the shippers have a negative willingness to pay for a time saving, or that the model based on a normal distribution of the coefficient is not correctly specified.

Individual value of time estimates

In the subsequent part of this chapter we will concentrate on the model hypothesising a triangular distribution to examine the individual coefficients. This choice is based on the good fitting statistics of this model. Moreover it is consistent with the recommendations issued by practitioners: *"accrued experience however suggests that the triangular distribution is the best distribution to derive such individual level outputs*" (Hensher and al (2005), p. 693).

We propose here to implement the technique proposed by Train (2003, chapter 11 and 12). This technique makes use of the Baye's formula to obtain individual parameter estimates. The probability density of the coefficients is used as an a priori, the observed choices provide an extra piece of information, the a posterior is the density of probability of the coefficient vector for each individual.

The results of such estimation can be presented using a Kernel[10] function. Figure 2 shows the density of probability for model 4, where the cost and time coefficients are supposed to have a triangular distribution.

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were made the change of the coefficient from between the latest and the penultimate iteration was larger than 10% of the coefficient value. For this reason such estimates have been discarded.
An in-depth examination of the data suggested that the value of the "damage" attribute was the cause of the difficulty in estimation.

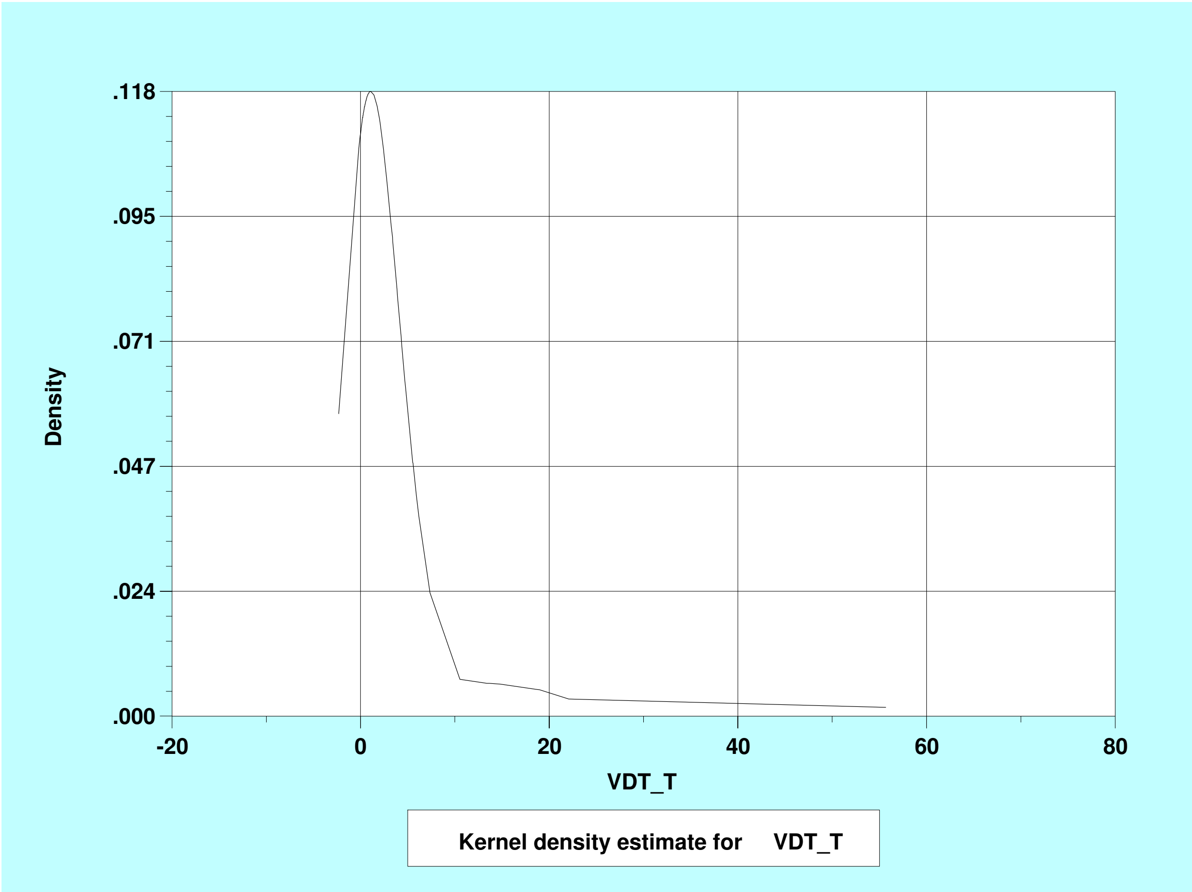
[10] Kernel density estimators have a role similar to that of histograms. They however have an extra advantage in that they do not need the definition of intervals.
The density of an x variable, with n different possible values, can be represented by a function $f(z_j)$, giving the density in M points z_j. This function is defined as:

$$f(z_j)=\frac{1}{n}\sum_{i=1}^{n}\frac{K\left[\left(z_j-x_i\right)/h\right]}{h},\ j=1,...,M\text{ , with}$$

K, Kernel function,
x_i , value taken by x,

The form of this curve reveals the underlying hypothesis of triangular distribution: there will be a non-zero density for very low values of the cost coefficient β_c which will imply a non-zero density for very high value of time.

Figure 2: Kernel density of the value of time [11]



n, number of observations for the variable x,

h, bandwidth.

[11] Kernel function: normal; bandwith: 2,54 ; number of observations: 93. The 2 observations with highest vot value have been suppressed because they both correspond to values of the cost coefficient that are very close to 0. The adequate treatment of such occurrences is still an object of investigation.

5. Discussion and conclusions

The main finding of our paper is that, based on a micro-founded formulation of the shipper and hauliers profit maximisation, and introducing the relevant distinctions, it is possible to formulate an adequate representation of the value placed by firms on the reduction of transport time and thus to explain the differences in the valuation of transport time by different firms. This approach can be summarized in three phases.

Explaining heterogeneity

From a theoretical point of view, we placed at the forefront of the analysis of freight value of time the difference between specific and generic goods. The distribution of the freight value of time will then depend on:

1 - the nature of each single shipment with regard to this distinction, and
2 - inside each of these categories, it will depend on the parameters that are determining the willingness to pay.

As far as generic goods are concerned, in the approach proposed by Baumol and Vinod (1970), shippers' willingness to pay will depend on the inventory costs accruing on the shipment during transportation, and on the costs of the optimal stock.

As far as specific goods are concerned, the willingness to pay will depend on:
1 - an inventory cost based on the value of the good during its transport.
2 - another term that reflects, the sensitivity of the revenues to the duration of transportation, the sensitivity of production costs to the production duration, the sensitivity of supplying costs to the supplying duration, these three different marginal costs being equal when the producer respects the marginal temporal conditions resulting from profit maximisation.

Once an analysis of the cause of value of time heterogeneity is available, it becomes possible to model heterogeneity.

Modelling heterogeneity

The Random Parameter Logit is an appealing tool to represent the heterogeneity of preferences. Compared with interaction terms, they do not specify the source of heterogeneity. This feature can be considered as an advantage or a drawback. An advantage because it permits us to represent heterogeneity even when there is no theoretical or no empirical element to specify it. A drawback, because it provides no elements to understand the sources of heterogeneity. This uncertainty is however not a hindrance because the two approaches RPL and interaction terms are compatible, with the only drawback that some degrees of freedom are lost in the estimation process.

The next question is then the choice of a relevant probability distribution for the different stochastic coefficients. Regarding this question we have found no definite selection criteria but only two conjectures. The first conjecture is that the willingness to pay of shippers is the sum of different components. This additive feature is compatible with the normal distribution. However the different additive components are not numerous, and we have no evidence about whether they are of similar influence and independent, as a rigorous application of the central limit theorem would require. The second conjecture is based on a retropolation procedure that permits us to retropolate the distribution of shippers' willingness to pay based on the distribution of hauliers willingness to pay. It then becomes possible to use empirical results available suggesting a lognormal distribution for hauliers' willingness to pay, to assume that such a distribution would also be suitable for the shippers' value of time. However, this reasoning could be contested as the number of results suggesting a log normal distribution for hauliers' distribution is limited, and, more important, by the "noise" that exists in the retropolation procedure.

Eventually we find only two conjectures in favour of a log normal distribution or a normal distribution for the shippers' value of time, these two conjectures being incompatible one with the other.

Measuring heterogeneity

The empirical application that we have made based on a shipper interview in three Italian regions has provided some empirical results.

First, it underlines the importance of the survey design used for SP survey. With regard to this we find that the range of value proposed for the "damage" attribute during data collection has been the cause of several difficulties in the processing of the data.

Second, we note the low magnitude of the value of time that we obtain compared to some other results that are present in the literature (see for instance de Jong 1996, de Jong et ali 1995, Wynter, 1995, Kawamura 1999). This low value of time can be explained, beyond the idiosyncrasies of the shippers in the surveyed regions, by empirical or by methodological reasons. First, from an empirical point of view, let recall that the shipments that gave rise to an interview were selected by eliminating the ones that were not likely to use intermodal transportation. One should then recall that the characteristics of intermodal transportation, especially with regard to the weight of the shipments, are negatively correlated with the value of time. Second, from a methodological point of view, the weakness of the value of time measured in this study could also be due to the amplitude of the variations proposed for the transport time variable: such durations vary form 12 to 48 hours. In the area of travellers transportation, Widlert (1994) analyses how values of time measured by SP survey are contingent to the elicitation process. its analysis underlines that the results vary greatly based on the range of time saving value proposed during the survey. This could shed light on a possible explanation for the low magnitude of the value of time that we obtain.

The next observation that can be made regards the dispersion of the individual values of time. The generality of the results is relative insofar as some specification could not be estimated. This is the case of estimates where we assume a lognormal distribution for the time coefficient, and of many specifications where we assumed a normal distribution of those coefficients. One estimate, based on a triangular distribution of the coefficients provides satisfactory results. The fitting criteria are clearly improved compared with the fixed coefficient specification. These gains appear larger than the ones that it is usually possible to obtain when one wants to improve the specification of a model in the framework of a fixed coefficient logit.

Moreover the use of stochastic coefficients appears as a complement, rather than a substitute to the use of interaction terms. These two techniques, used together, provide better results than those obtained when using only one of the methods. This observation, that was already made in travellers transportation (Ben-akiva and Gopinath, 1996), should be consolidated by other results in the area of freight transportation.

Future researches

Eventually, our paper suggests two paths for the future research. First, our approach should be applied to wider data sets. This deals not only with the size of the data sample, but also with its generality: our data concentrate only on a few sectors, and only on goods that are admittedly eligible for intermodal transportation. Second, the distinction between specific goods and generic goods seems to deserve further investigation. On the one hand, evidence is necessary to understand how these categories relate to more familiar categories of freight transport analysis and in particular to different sectors. The information on the speficicity/genericity of the different good categories may prove important as much of the data available for the analysis of freight movement is usually classified based on sectors. For this reason, a questionnaire has been commissioned to obtain complementary data on specificity and genericity of the goods. The results based on this extra survey will be the object of other communications.

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Annex: Notations

Durations

d_{μ} , duration for trip (metakinesics) operations of the hauliers.

$d_{\bar{\mu}}$, duration for non trip (ametakinesics) operations of the hauliers.

d_t , duration of the (outbound) transport process = $d_{\bar{\mu}} + d_{\mu}$

d_s , duration of the supplying.

d_p , duration of the processing.

Production costs

of the shipper

$cs(d_s)$, cost of the supplying in relation with the duration of the supplying.

$cp(d_p)$, cost of the processing in relation with the duration of processing.

$ct(d_t)$, cost of outbound transport in relation with the transport duration.

$ci(d_t)$, generalised immobilisation costs during the outbound transport.

of the haulier

$c\mu(d_{\mu})$,cost of metakinesic operations in function of the duration of these operations.

$c\bar{\mu}(d_{\bar{\mu}})$, cost of ametakinesic operations in function of the duration of these operations.

Willingness to pay:

wtp^h , willingness to pay of the hauliers for a marginal reduction of travel time (metakinesic).

wtp^s , willingness to pay of the shippers for a marginal reduction of transport time.

Appendix

Table 4: value of the attributes proposed to the interviewees

Attribute:	**Level:**
Cost:	15%, -10%, -5%, current cost, +5%, +10%, +15%
Time (door to door):	-1/2 day, current duration, +1/2 day, +1 day, +2 day
Punctuality (percentage of the shipments arriving with a delay inferior to one hour or half day[12]):	100%, 85%, 70%
Loss or damages (percent of the shipment with loss or damage):	0%, 5%, 10%, 20%
Flexibility:	High, low
Frequency:	High, low
Mode:	Road, Intermodale

Table 5: full sample and segment based estimates

	Sample	**Dimension**		**Shipment value**		**Production management**		**Direction**	
	Full	Staff		euros		On order	Stock		
		<67	>67	<21445	>21445		management	Outbound	Inbound
Status quo	1,04	0,65	1,37	0,78	1,23	0,96	1,07	1,03	1,14
	(10,2)	*(4,2)*	*(9,5)*	*(5,1)*	*(8,9)*	*(6,7)*	*(7,4)*	*(9,6)*	*(3,7)*
Cost (%)	-10,8150	-11,7882	-11,2435	-11,5454	-10,3696	-10,3377	-11,4165	-10,3205	-15,0628
	-(15,9)	*-(11,6)*	*-(11,3)*	*-(11,6)*	*-(10,9)*	*-(10,5)*	*-(12,0)*	*-(14,4)*	*-(6,8)*
Mode (road, intermodal)	0,58	0,69	0,42	0,76	0,43	0,52	0,63	0,66	
l)	*(3,9)*	*(3,0)*	*(2,0)*	*(3,4)*	*(2,1)*	*(2,3)*	*(3,2)*	*(4,1)*	
Duration (days)	-0,39	-0,29	-0,50	-0,32	-0,46	-0,49	-0,29	-0,41	
	-(5,6)	*-(2,8)*	*-(5,0)*	*-(3,1)*	*-(4,7)*	*-(4,6)*	*-(3,1)*	*-(5,5)*	
Punctuality (% shipments)	0,52		1,12		0,93	0,86		0,53	
	(3,3)		*(4,9)*		*(4,0)*	*(3,6)*		*(3,2)*	
Dammages (% shipments)	-14,6	-25,3	-8,5	-20,8	-10,7	-20,0	-11,2	-14,8	-15,0
	-(14,5)	*-(12,5)*	*-(7,1)*	*-(11,7)*	*-(8,5)*	*-(11,3)*	*-(9,0)*	*-(13,6)*	*-(5,2)*
Frequency (high,low)									
Flexibility (high,low)	-0,38							-0,44	
	-(2,4)							*-(2,6)*	
LogLIkelihood	-913,8	-407,4	-461,9	-427,0	-467,3	-422,9	-475,5	-790,7	-118,4
Number of observations	1455	720	735	720	735	750	705	1260	195
LogLik. ratio proba		7,84E-16		5,13E-06		1,52E-04		0,312	

[12] Note that two different definitions of reliability have been used during the survey.

Table 6: model estimate for different sectors

	Full Sample	Sector				
		Mechanics	Steel industry	Furniture	Chemical	Electronic
Status quo	1,04		0,88	0,66	1,32	
	(10,2)		*(3,9)*	*(3,0)*	*(4,0)*	
Cost (%)	-10,8150	-18,3528	-9,0327	-10,8722	-14,0118	-16,3893
	-(15,9)	*-(9,6)*	*-(7,1)*	*-(8,2)*	*-(5,3)*	*-(3,6)*
Mode (road, al)	0,58			0,94		
	(3,9)			*(3,4)*		
Duration (days)	-0,39	-0,87		-0,33	-1,10	
	-(5,6)	*-(4,9)*		*-(2,5)*	*-(3,7)*	
Punctuality (% shipments)	0,52	0,67		3,95	6,09	
	(3,3)	*(2,2)*		*(4,5)*	*(3,8)*	
Damages (% shipments)	-14,6	-53,3	-15,4	-15,2	-3,0	-39,4
	-(14,5)	*-(10,4)*	*-(7,1)*	*-(7,8)*	*-(4,0)*	*-(3,9)*
Frequency				-0,79		
				-(2,5)		
Flexibility	-0,38					
	-(2,4)					
LogLIkelihood	-913,8	-162,7	-239,7	-247,6	-75,7	-33,6
Number of observations	1455	450	360	420	135	90
LogLik. ratio proba		8,3591E-260				

	Full Sample	Sector				
		Mechanics	Steel industry	Furniture	Chemical	Electronic
Status quo	1,04		0,88	0,66	1,32	
	(10,2)		*(3,9)*	*(3,0)*	*(4,0)*	
Cost (%)	-10,8150	-18,3528	-9,0327	-10,8722	-14,0118	-16,3893
	-(15,9)	*-(9,6)*	*-(7,1)*	*-(8,2)*	*-(5,3)*	*-(3,6)*
Mode (road, al)	0,58			0,94		
	(3,9)			*(3,4)*		
Duration (days)	-0,39	-0,87		-0,33	-1,10	
	-(5,6)	*-(4,9)*		*-(2,5)*	*-(3,7)*	
Punctuality (% shipments)	0,52	0,67		3,95	6,09	
	(3,3)	*(2,2)*		*(4,5)*	*(3,8)*	
Damages (% shipments)	-14,6	-53,3	-15,4	-15,2	-3,0	-39,4
	-(14,5)	*-(10,4)*	*-(7,1)*	*-(7,8)*	*-(4,0)*	*-(3,9)*
Frequency				-0,79		
				-(2,5)		
Flexibility	-0,38					
	-(2,4)					
LogLIkelihood	-913,8	-162,7	-239,7	-247,6	-75,7	-33,6
Number of observations	1455	450	360	420	135	90
LogLik. ratio proba		8,3591E-260				

Table 7: value of time for different segments (euro per hour and per shipment)

	Dimension		Shipment value		Production management	
Full Sample	Staff <67	Staff >67	euros <21445	euros >21445	On order	Stock management
1, 6	1, 8	2, 1	0, 4	3, 2	2, 0	1, 1

Table 8 models with interaction terms

	Coeff	Proba (t)
Fixed coefficients		
Duration (days)	-0, 32	0, 0%
Costs (%)	-17, 10	0, 0%
Punctuality	0, 56	0, 0%
Frequency	-0, 32	0, 0%
Flexibility	-0, 42	1, 6%
Status Quo Constant	1, 04	0, 0%
Mode	0, 56	0, 0%
Damage (%shipment)	-11, 40	0, 0%
Interaction terms		
DamageXSect1	-37, 24	0, 0%
PunctXSect4	5, 11	0, 0%
DamageXsect5	-20, 96	1, 4%
DamageXsect4	8, 89	0, 0%
DamageXDim1	-9, 99	0, 0%
Cost%XSect1	-7, 03	0, 1%
Cost%Xoutbound	5, 18	0, 7%
DurationXSect4	-0, 72	1, 0%
PunctXVal2	1, 24	0, 0%
CostsXSect2	4, 60	0, 3%
ASCXDim1	-0, 65	0, 0%
PunctXsect3	3, 20	0, 0%
CostsXOutbound	5, 18	0, 7%
DurationXsect1	-0, 44	1, 7%
adj rho²		0, 52
Log likelihood		-756
number of obs (choices)		1455
number of interviews		97