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## Article

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## **Freight transport distance and weight as utility conditioning effects on a stated choice experiment**

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### **Abstract**

Within a freight transport context, the origin-destination distance and the weight of the shipment play an important role in the decision of the most preferred transport service and in the way logistics managers evaluate the transport service's attributes. In particular, the attributes commonly used in order to describe a freight transport service in a stated choice framework are cost, time, punctuality and risk of damages, respectively. This paper investigates the role of origin-destination distance and weight of freight transport services introducing a conditioning effect, where the standard utility function is conditioned on the freight transport distance. We refer to this model form as a heteroskedastic panel multinomial logit (panel H-MNL) model. This model form outperforms the underlying unconditioned model and suggests that an appropriate conditioning effect leads to an improved understanding of the derived measures, such as measures for marginal rates of substitution.

*Keywords: freight transport, Swiss logistics managers' valuations, choice experiments, utility conditioning effect, heteroskedastic logit*

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# 1 Introduction

Within a freight transport context, the origin-destination distance and the weight of the shipment play an important role in the decision of the most preferred transport service and in the way logistics managers evaluate the transport service's attributes (Regan and Garrido, 2002; Chow et al., 2010). In particular, the attributes commonly used in order to describe a freight transport service in a stated choice framework are cost, time, punctuality and risk of damages, respectively (see for example, Bolis and Maggi, 2002; Danielis et al., 2005; Fowkes, 2007).

The reliability of the stated choice experiment is typically increased by pivoting the attribute values of the hypothetical alternatives around revealed values stated by the logistics managers for a typical transport service. A set of secondary information is then collected about additional details of the typical transport service, such as origin-destination distance and weight of the shipment, and their significant contribution in explaining the logistics managers' preferences is well documented within random utility function specifications. In particular, Masiero and Maggi (2012) suggest the significance of these two transport specific variables in capturing the preferences of logistics managers towards different modes of transport. However, the theoretical nature of discrete choice models, where only differences matters, allows the introduction of all choice-invariant characteristics in a maximum of  $J-1$  alternatives (where  $J$  is the total number of alternatives), unless interacted with specific attributes (see, Train 2003). The investigation of transport specific variables is therefore limited, especially in the case of stated choice experiment where the choice is restricted between a set of unlabeled hypothetical alternatives.

A recent econometric specification of non-linear mixed logit models have been derived by Andersen et al. (2009) in order to capture the risk preferences of the respondents in a binary choice over lotteries. In particular, they propose a specification that defines non-linear functions over the set of the coefficients associated with the attributes of the experiment. Within a stated choice experiment, Hensher and Rose (2010, in press) introduce a non-linear utility specification defining the conditioning effect as a function of the respondent perceived acceptability of the alternative chosen and let it be further conditioned on the threshold attributes whereas Hensher et al. (2011) propose a non-linear logit model specification for perceptual conditioning and risk attitude in a travel time variability context. As stated by Hensher and Rose (2010, in press), the conditioning effect is a form of heteroskedasticity, which specifically affects the systematic part of the utility function variables (attributes and alternative specific constants). In this context, different discrete choice model specifications have been proposed in the literature in order to account for different forms of heteroskedasticity. In particular, Munizaga et al. (2000) investigate two forms of heteroskedasticity, namely, between options and between observations, whereas Greene and Hensher (2007) introduce heteroskedasticity in the parameters within a mixed logit model framework. Heteroskedasticity has also been introduced in logit models in order to account for design dimensions (Caussade et al., 2005) and design complexity (Danthurebandara et al., 2010) in stated choice experiments. Anderson et al. (2009) make that point that the conditioning effect introduced in each utility function specified in the maximisation problem could also help to overcome the limit associated with the identification of choice-invariant characteristics. Indeed, depending on the function used, the conditioning effect creates the interactions between alternative characteristics and individual (or choice-invariant) characteristics.

The aim of this paper is to investigate the role of origin-destination distance and weight of freight transport services using a non-linear utility specification where the standard utility function is conditioned on the freight transport distance. The analysis relies on a stated choice experiment conducted among Swiss logistics managers for the valuation of both inbound and outbound freight transports. The particular model proposed is a heteroskedastic panel multinomial logit (panel H-MNL) model where the heteroskedastic influence that conditions each 'traditional' utility expression is captured through a dummy variable distinguishing between short/medium-distance and long-distance freight transport services. The conditioning effect is further expressed in terms of a continuous variable expressing the weight of the shipment. Furthermore, the investigation continues allowing the conditioning effect to be also explained by the four attributes that characterize the stated choice experiment. In this context, the paper proposes the analysis of the impact of both 'respondent' specific and alternative specific variables on the conditioning effect derived in the first stage of the research. Finally, as a further investigation of the models proposed, the paper reports the derived willingness to pay for these models.

The paper is organized as follows. In section two we describe the data used in terms of stated choice experiment and descriptive. The theoretical background is outlined in section three and model results in section four. Finally, conclusions and future directions are presented in section five.

## 2 Data

The data refers to a freight transport stated choice experiment conducted among Swiss logistics managers in 2003 to investigate the preferences for the most relevant characteristics in freight transport service<sup>1</sup>. In particular, due to the consistent monetary and time costs of field CAPI research, the population target has been restricted to medium (50 to 249 employees) and large (more than 249 employees) companies of the food and wholesale sector (with a consistent variety of products considered), since it represents one of the most relevant market segments.

Four attributes were considered for the stated choice experiment, transport cost (in CHF<sup>2</sup>), transport time (in hours), transport punctuality (as the percentage of transport services arriving on time on a yearly base) and damages (as the yearly percentage of transport services that result with damages), respectively. Table 1 provides a description of the attributes and attributes levels used as well as the setting of the experiment<sup>3</sup>.

The experimental design followed a partial reference pivoted approach, where cost and time attributes for the hypothetical unlabeled alternatives were generated according to deviations from a typical transport previously described by each logistics manager interviewed. While logistics managers also reported punctuality and damages values for the typical transport described, these two attributes have been treated in absolute values in order to avoid inappropriate attribute levels (i.e., above 100 percent for punctuality and below zero percent for damages).

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<sup>1</sup> For more details on the study, see Maggi and Rudel (2008)..

<sup>2</sup> Approximate exchange rate 1 CHF = 1.08 USD.

<sup>3</sup> The values of the attributes levels differ from those reported in the Table in Maggi and Rudel (2008) which by mistake are not correctly reported there.

Table 1 Description of the stated choice experiments

<b>Attributes and Levels</b>	
Transport Cost (CHF)	-40 %, -20 %, Reference, +20 %, +40 %
Transport time (hours)	-40 %, -20 %, Reference, +20 %, +40 %
Transport Punctuality (%)	96 %, 98 %, 100 %
Damages (%)	6 %, 4 %, 2 %
<b>Design</b>	
Experiment	Unlabeled
Alternatives	Alternative A and Alternative B
Reference in Design	Not included
Number of Choice tasks	20

The choice experiment considers two hypothetical and unlabeled alternatives<sup>4</sup>, namely alternative A and alternative B. The reference alternative (i.e. the typical transport described by the logistics managers) is not included in the choice set forcing the respondents to choose either alternative A or alternative B in each choice task.

Along with the description of the typical freight transport service in terms of characteristics used in the stated choice experiment, logistics managers were also asked to give additional information such as the origin-destination distance of the transport and weight of the shipment. Table 2 reports the descriptive statistics for the typical freight transport service described by logistics managers. In particular, a typical freight transport service costs on average 673 CHF and the delivery door-to-door takes on average 11 hours. However, it should be noted the high standard deviation for both cost and time distributions, which is consistently narrower for punctuality and damages attributes, indicating a consistent homogeneity no matters what the price and the time of the transport service. As for additional details of the typical transport, the mean origin-destination distance is over 250 kilometres, however half of the distribution is concentrated within 153 kilometres, indicating a high variation for long-distance transport which in this study we assumed, according to the geographical context, all transports longer than 250 kilometres. The average shipment weight is 9.1 tons with a pronounced standard deviation.

Table 2 Descriptive statistics for typical transport service

Variable	Mean	Median	SD	Min	Max
Cost (CHF)	673.4	550.6	574.0	6.9	3000.0
Time (hr)	11.2	4.8	22.9	0.4	201.6
Punctuality (%)	94.3	95.0	3.3	90.0	98.0
Damages (%)	4.0	4.0	1.6	2.0	6.0
O-D distance (km)	287.8	153.0	302.7	18.0	1307.0
Weight (ton)	9.1	6.5	8.4	0.004	26.0

<sup>4</sup> Note that being the hypothetical alternatives unlabeled, the mode of transport is not specified. Therefore, the combination of attributes levels proposed to the logistics managers do not necessarily refer to the road mode of transport.

The collection of the data for the choice experiment involved face-to-face interviews based on Computer Assisted Personal Interview (CAPI), where logistics managers were asked to indicate their preferred alternative in each of the 20 binary choice tasks. A list of companies from the main economic association were contacted by telephone and asked to participate in the survey. In total, 35 logistics managers were interviewed and, since a subset of respondents agreed to perform the experiment for both inbound and outbound freight transport services, 66 experiments were conducted. In particular, both inbound and outbound transport services were outsourced by 33 of the 35 companies included in the sample. From the data gathered, six experiments have been removed due to very extreme values. Therefore, the final dataset considered in the following analysis is comprised of 60 valid experiments consisting in 1200 choice observations.

### 3 Theoretical Background

In a multinomial logit (MNL) context, the utility function, associated with respondent  $n$  for alternative  $j$  in choice task  $s$ , is typically assumed to be linear in parameters and defined as follows:

$$U_{njs} = V_{njs} + \varepsilon_{njs} = \sum_k \beta_k x_{njsk} + \varepsilon_{njs} \quad (1)$$

where  $V_{njs}$  is the systematic part of the utility (i.e., the observed part) defined as a combination of  $K$  parameters associated with  $K$  observed attributes and variables ( $X$ ), and  $\varepsilon_{njs}$  is the random part (i.e., the unobserved part) that is commonly assumed to be Independent and Identically Distributed (IID) extreme value type 1.

In line with Andersen *et al.* (2009), a non-linear utility specification is obtained by defining (non-)linear functions over the set of the coefficients associated with the attributes of the experiment. Formally, the utility function takes the following form:

$$U_{njs} = V_{njs} + \varepsilon_{njs} = H \times \left( \sum_k \beta_k x_{njsk} \right) + \varepsilon_{njs} \quad (2)$$

where  $H$  is a (non-)linear function or a conditioning effect that multiplies the systematic part of the utility function expressed in equation (1). In particular, Hensher and Rose (2010, in press), proposed a conditioning effect that is further expressed in terms of other variables, as follows:

$$H = \left( 1 + \beta_{CE} CE + \sum_p \beta_{(CE|z)p} z_p \right) \quad (3)$$

where  $\beta_{CE}$  is the coefficient associated with the conditioning effect ( $CE$ ) and  $\beta_{(CE|z)p}$  are the coefficients associated with the  $P$  explicative variables ( $Z$ ) that are assumed to explain the heterogeneity around the conditioning effect.

In this line, the first heteroskedastic panel multinomial logit (panel H-MNL) model proposed in the following analysis introduces the conditioning effect capturing the heteroskedastic influence through a dummy variable built on a characteristic of the reference transport service described by logistics managers, namely the origin-destination distance. In particular we assume that the logistics managers' perception of the attributes and attributes levels differs according to the origin-destination distance of the freight transport that each logistics manager is dealing with. In order to

accommodate this assumption, we have created a dummy variable for long-distance freight transport and treated it as the conditioning effect. The conditioning effect is further expressed in terms of another transport specific variable which indicates the weight of the shipment. Formally, the utility function is defined as follows:

$$V_{njs} = (1 + \beta_{kmd} Kmd + \beta_{kmd|weight} Weight) \times (ASC_j + \beta_{cost} Cost_j + \beta_{time} Time_j + \beta_{punct} Punct_j + \beta_{damage} Damage_j) \quad (4)$$

where  $\beta_{kmd}$  is the coefficient associated with a dummy variable ( $Kmd$ ) that takes value one for freight transport origin-destination distance above 250 kilometres and zero otherwise<sup>5</sup>. This implies that, for long-distance transport, each attribute (in each alternative) is conditioned by the distance of the transport (along with the weight of the transport). In particular, Equation (4) introduces two forms of heteroskedasticity, between short/medium-distance and long-distance transports, as a function of the dummy variable ( $kmd$ ), and within the long-distance transport, as a function of the variable associated with the weight of the shipment<sup>6</sup>. Hence, if the conditioning effect is positive, the standard deviation of the error term for long-distance transport becomes lower than that of the error term for short/medium transport. However, for long-distance transport it is reasonable to expect a larger error term and therefore, the underlying hypothesis is that the conditioning effect would be negative. The part of the function in the second bracket reflects the part of the utility commonly expressed within a linear specification and it is used, in the next section, as a base MNL model to compare against the H-MNL models proposed. In particular, it accounts for the alternative specific constant as well as for the four coefficients associated with the four attributes considered in the stated choice experiment, cost, time, punctuality and damages, respectively.

Starting from the specification in equation (4), the following analysis proposes the estimation of a second model (M2) where the conditioning effect is not only explained by the weight of the shipment but also by the four attributes characterizing the stated choice experiment. Formally,

$$V_{njs} = (1 + \beta_{kmd} Kmd + \beta_{kmd|weight} Weight + \beta_{kmd|cost} Cost + \beta_{kmd|time} Time + \beta_{kmd|punct} Punct + \beta_{kmd|damage} Damage) \times (ASC_j + \beta_{cost} Cost_j + \beta_{time} Time_j + \beta_{punct} Punct_j + \beta_{damage} Damage_j) \quad (5)$$

where  $\beta_{kmd|cost}$ ,  $\beta_{kmd|time}$ ,  $\beta_{kmd|punct}$  and  $\beta_{kmd|damage}$  are the coefficients explaining the heterogeneity of the  $Kmd$  dummy variable in terms of cost, time, punctuality and damages, respectively. All the other coefficients are the same as in equation (4). As for the heteroskedasticity, in Equation (5) we introduce an additional source (in this case alternative specific) within the long-distance freight transports as a function of the four attributes considered in the stated choice experiment.

The estimation of models expressed in equations (4) and (5) follows the standard random utility maximization paradigm, where the probability that respondent  $n$  chooses the alternative  $j$  in choice task  $s$  is given by:

<sup>5</sup> Note that in this context the choice-invariant characteristics (as origin-destination distance and weight of the shipment) are introduced in all  $J$  alternatives.

<sup>6</sup> Note that the two form of heteroskedasticity are individual specific (i.e., transport specific).

$$P_n = \prod_s \frac{\exp\left[H \times \left(\sum_k \beta_k x_{njsk}\right)\right]}{\sum_j \exp\left[H \times \left(\sum_k \beta_k x_{njsk}\right)\right]} \quad (6)$$

where  $H$  is the conditioning effect defined above and  $s = 1, \dots, S$  indicates the panel structure of the data represented by the choice tasks. The imposed correlation structure makes the numerical integration not computationally feasible (see for example, Hensher, 2001) and, therefore, the choice probabilities are simulated. The estimation of the coefficients relies on the following simulated log-likelihood function:

$$LL_n = \ln \frac{1}{R} \sum_r \prod_s \frac{\exp\left[H \times \left(\sum_k \beta_k x_{njsk}\right)\right]}{\sum_j \exp\left[H \times \left(\sum_k \beta_k x_{njsk}\right)\right]} \quad (7)$$

where  $r = 1, \dots, R$  indicates the standard random normal draws used for the simulation. In particular, the following analysis refers to 1000 replications drawn from the Halton sequence<sup>7</sup>.

## 4 Model results

Two heteroskedastic panel multinomial logit models (panel H-MNL) have been estimated by introducing a conditioning effect reflecting long-distance transport (i.e., transport origin-destination distance above 250 kilometres). In particular, the first model (M1) explains the conditioning effect through a continuous variable expressing the weight of the shipment. The second model (M2) further investigates the relationship between the conditioning effect and the four attributes considered in the analysis. Additionally, a base panel MNL has been also estimated in order to evaluate the improvement provided by the conditional effect introduced in the two panel H-MNL models proposed in the analysis.

The results of the three estimated models are presented in Table 3. The statistics for the model fits are illustrated in the bottom part of the table. In particular, for the three models we report the log-likelihood assuming that the all parameters, excluding the constant, are equal to zero as well as the log-likelihood at convergence. These two statistics are used in order to calculate the third measure reported in the table that is the McFadden pseudo rho-squared<sup>8</sup>. The Akaike's Information Criterion (AIC) is also provided as additional measure (the lower the statistic, the better the model fits the data). Finally, for models M1 and M2 we report the result of the log-likelihood ratio test which corrects for differences in the number of parameters estimated from each models, comparing the base model against model M1 and model M1 against model M2, respectively.

Looking at the parameter estimates associated with the four attributes considered, we find that all are strongly significant and of the expected sign. In particular, coefficients associated with cost, time and damages have a negative sign reflecting a decrease of the marginal utility as the values for cost, time and damages increases. On the contrary, the more punctual is the freight transport service, the more utility the

<sup>7</sup> For details on Halton draws, see Train (2003).

<sup>8</sup> Calculated as  $(1-L(\beta)/L(asc))$ , where  $L(\beta)$  is the final log-likelihood.

logistics managers experience. As expected, the alternative specific constant, introduced for alternative A, is not statistically different from zero indicating that none of the two unlabeled alternatives have been preferred a priori (i.e., absence of lexicographic bias).

Turning to the conditioning effect for model M1, we note that the dummy variable expressing long-distance transport is highly significant ( $p < 0.01$ ) and has a negative sign, confirming our underlying hypothesis of larger standard deviation of the error term (or, equivalently, a reduction of the response-scale) associated with the overall utility function for long-distance freight transport. In particular, this indicates that for long-distance transport the overall utility, calculated at the mean values, decreases if compared to the overall utility for short/medium-distance transport. Interestingly, we note that the weight of the transported goods is significantly related to the conditioning effect. In particular, it shows a positive sign indicating that the reduction in the overall mean utility experienced for long-distance transport is moderated by the weight of the transported goods. In order to better understand this concept, we illustrate in Figure 1 the overall mean utility function (model M1) calculated for the average values of the attributes (see Table 2). In particular, the

Table 3 Estimation results for panel MNL and panel H-MNL models

	<b>Panel MNL (base model)</b>		<b>Panel H-MNL (M1)</b>		<b>Panel H-MNL (M2)</b>	
	Coeff.	(t-Ratio)	Coeff.	(t-Ratio)	Coeff.	(t-Ratio)
<i>Linear utility coefficients</i>						
Constant Alternative A	0.08016	(1.04)	0.09895	(1.07)	0.09008	(0.97)
Cost	-0.00664	(-12.39)	-0.00700	(-15.83)	-0.00750	(-16.68)
Time	-0.03828	(-2.73)	-0.04577	(-4.07)	-0.02954	(-1.94)
Punctuality	0.13731	(9.66)	0.14464	(12.73)	0.14334	(12.68)
Damages	-0.40890	(-13.56)	-0.42002	(-18.86)	-0.41053	(-18.33)
<i>Conditioning effect</i>						
O-D distance	-	-	-0.37701	(-3.17)	-6.99325	(-2.702)
<i>Heterogeneity on conditioning effect</i>						
O-D long-distance Weight	-	-	0.02395	(3.16)	0.03220	(2.48)
O-D long-distance Cost	-	-	-	-	-0.00048	(-2.86)
O-D long-distance Time	-	-	-	-	0.01636	(1.59)
O-D long-distance Punct	-	-	-	-	0.06281	(2.29)
O-D long-distance Damages	-	-	-	-	0.22564	(2.00)
<i>Model fits</i>						
Observations	1200		1200		1200	
Log-likelihood (ASC)	-831.40		-831.40		-831.40	
Log-likelihood at convergence	-560.20		-557.02		-548.38	
Log-Likelihood ratio test			6.36 ( $p < 0.05$ )		17.28 ( $p < 0.05$ )	
McFadden pseudo $\rho^2$	0.326		0.330		0.340	
AIC	1132.40		1128.05		1118.76	

continuous line represents the utility for short/medium-distance transport (i.e., no conditioning effect applies) whereas the three dashed lines indicate the utility for long-distance transport with a weight of the shipment of 5 tons (green line), 9 tons<sup>9</sup> (blue line) and 15 tons (red line), respectively.

The improvement of the panel H-MNL specification in model M1 with respect to the reference base panel MNL is suggested by the increase of the McFadden pseudo rho-squared and the reduction of the AIC statistic. The higher performance of model M1 is further supported by the Log-likelihood ratio test that reports a Chi-squared statistic of 6.36 with a significance level of 0.05.

Turning to the conditioning effect for the second panel H-MNL model estimated (model M2), we find that is still negative and statistically significant, albeit its magnitude is consistently bigger than for model M1. Notably, all the variables introduced in order to explain the conditioning effect for long-distance transport are statistically significant except for the interaction with the time attribute which is significant only at an alpha level of 0.11. In particular, the interpretation of the coefficient associated with the weight of the transported goods is similar to what discussed for model M1; that is the magnitude of the reduction in the overall mean utility for long-distance transport (compared to short/medium-distance transport) decreases as the weight increases, namely by 0.0322 per ton of the weight of the long-distance transport considered. The interaction between the conditioning effect and the cost attribute has a positive sign, indicating that the lower overall mean utility experienced for long-distance transport further decreases as the cost of the freight transport service increases. The interactions with the other three attributes, namely time, punctuality and damages, are positive in sign, suggesting that increases in any of these attributes tend to temperate the reduction in the overall mean utility as a consequence of the conditioning effect.

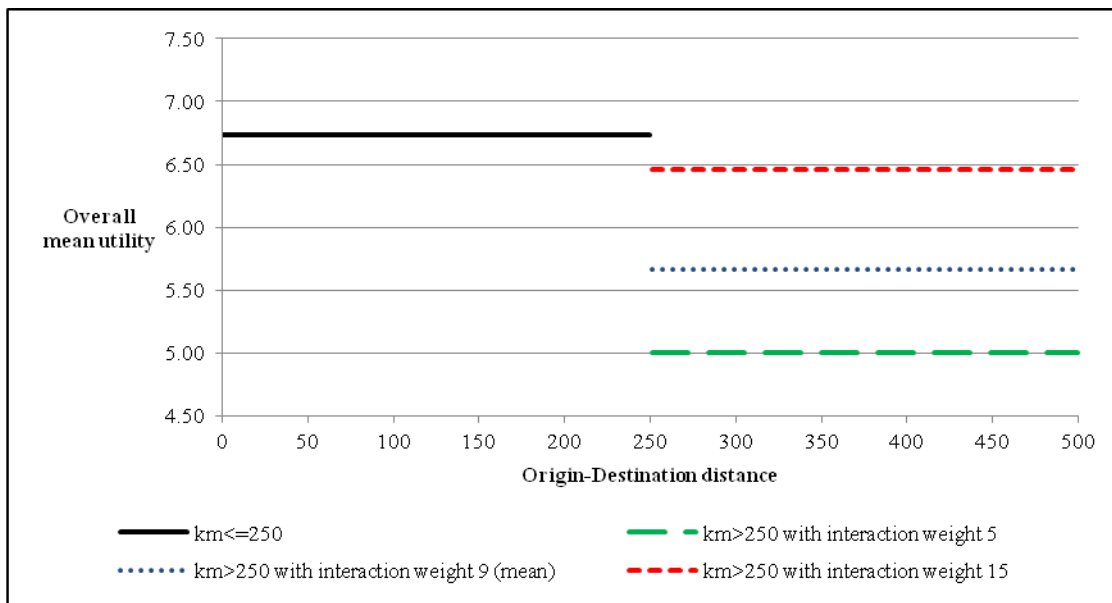


Figure 1 Utility function (model M1) with conditioning effect for different levels of weight

<sup>9</sup> Note that 9.1 tons represents the average value for the weight of the shipment (see Table 1).

In terms of model fits, we note that model M2 outperforms model M1, with an improvement in the final log-likelihood of 8.64 points giving a statistically significant log-likelihood ratio test. The AIC statistic and the McFadden pseudo rho-squared further support model M2 against model M1.

The models proposed in the analysis are further investigated in terms of marginal rate of substitution estimates with respect to the price attribute, commonly known as willingness to pay (WTP). The estimate for WTP is easily obtained by dividing the coefficient associated with a quality attribute (i.e., time, punctuality or damages) by the coefficient associated with the cost attribute. However, for model M2 we need to account for the interaction between the conditioning effect and the attributes that applies for long-distance transport. In particular, the derivation of the mean WTP for long-distance transport is as follows:

$$WTP(long - distance)_k = \frac{\frac{\partial V_{nj}}{\partial X_k}}{\frac{\partial V_{nj}}{\partial Cost}} = \frac{\beta_{X_k} + 2x_k \beta_{X_k} \beta_{knd|X_k}}{\beta_{cost} + 2Cost \beta_{cost} \beta_{knd|cost}} \quad (8)$$

Table 4 shows the mean WTP estimates derived for the three models along with the t-statistics which has been calculated using the Delta method.

We note that the willingness to pay estimates derived from the base model and model M1 are similar for all the three attributes considered. In particular, the willingness to pay for time, i.e., value of travel time savings (VTTS), is 5.77 and 6.54 CHF/hour for the base model and model M1, respectively. Furthermore, the mean monetary evaluation for a one percent increase in punctuality is about 21 CHF whereas a one percent decrease in the annual probability of experiencing damages is evaluated on average about 60 CHF (61.6 CHF) according to the base model (model M1).

Table 4 Mean Willingness to pay estimates

	<b>Panel MNL (base model)</b>		<b>Panel H-MNL (M1)</b>		<b>Panel H-MNL (M2)</b>	
	estimate	(t-ratio)	estimate	(t-ratio)	estimate	(t-ratio)
WTP time	5.77	(2.76)	6.54	(4.06)	-	-
WTP punctuality	20.68	(8.75)	20.66	(16.10)	-	-
WTP damages	61.58	(11.21)	60.00	(19.28)	-	-
<i>short/medium-distance</i>						
WTP time	-	-	-	-	3.94	(1.93)
WTP punctuality	-	-	-	-	19.11	(16.27)
WTP damages	-	-	-	-	54.74	(19.24)
<i>long-distance</i>						
WTP time	-	-	-	-	15.08	(2.41)
WTP punctuality	-	-	-	-	91.87	(6.90)
WTP damages	-	-	-	-	158.41	(4.72)

Regarding the WTP estimates obtained from model M2, different values for short/medium-distance and long-distance transports (see Equation (8)) are reported. As for the short/medium-distance transport, we note that the WTP for punctuality is similar to the estimates obtained for both base and M1 models, whereas the VTTS and the WTP for damages result in lower values compared with the first two models (base and M1 models), with VTTS reporting a consistent reduction.

Interestingly, we note that the mean willingness to pay for the three attributes considered increases significantly for long-distance transport compared to the values estimated for short/medium-distance transport within the same model (model M2). In particular, the VTTS increases to 15.1 CHF/hour whereas the monetary evaluations for a one percent increase in punctuality and a one percent decrease of damages increase to 91.9 CHF and 158.4 CHF, respectively. We also note that the combined values (i.e., not conditioned on the transport distance) obtained from both base and M1 models lay in between the WTP values estimated within model M2 for short/medium and long distances. In this context, it is important to note that we have estimated a base model with two different coefficients for each attribute, according to the two distance bands (i.e., coefficients associated with short/medium-distance and long-distance transports, respectively). The results (available on request) indicate no statistically significant differences between the coefficients associated with short/medium-distance and long-distance transports, for cost, time and damages attributes<sup>10</sup>, respectively.

## 5 Conclusions

This paper has investigated the origin-destination distance for freight transport service as a conditioning effect in the utility specification within an unlabeled stated choice experiment conducted with logistics managers in Switzerland. In particular, a choice-invariant dummy variable for long-distance transport has been introduced in each alternative proposed in the choice experiment and conditioned to a linear combination of attributes and alternative specific constant. The paper has proposed two heteroskedastic panel MNL models (other than a basic panel MNL model for comparison purpose) where the conditioning effect is firstly explained by the weight of the transported goods and further explained by the four attributes characterizing the stated choice experiment.

The results suggest a negative sign for the conditioning effect indicating that for long-distance transport (in comparison to short/medium-distance transport) the overall utility, calculated at the mean values<sup>11</sup>, decreases. Results also show that the weight of the transported goods is significantly and negatively related to the conditioning effect suggesting that the reduction in the overall mean utility experienced for long-distance transport is moderated by the weight of the transported goods. Results from the second H-MNL model estimated (model M2) further indicate a negative (positive) interaction effect between long-distance transport and cost attribute (time, punctuality and damages attributes). Both the two H-MNL models proposed outperform the basic MNL, with model M2, that introduces the conditioning effect as a function of both transport specific variables (i.e., origin-destination distance and weight) and attributes (cost, time, punctuality and damages), the most preferred.

<sup>10</sup> Asymptotic t-ratio tests for differences between two means.

<sup>11</sup> Note that the utility can possibly take negative values if calculated at the individual level, making the interpretation more complex. This is indeed a direction for future research.

The estimates for the marginal rates of substitution suggest that for the three attributes considered, namely time, punctuality and damages, the mean willingness to pay for long-distance transport increases compared to short/medium-distance transport. The results obtained also show how the heteroskedastic specification in model M2 can capture different WTP estimates in respect of two different categories of origin-destination transport distance.

The heteroskedastic specification proposed in this paper is appealing for the analysis of choice-invariant characteristics within a random utility model framework. Indeed, it allows us to better investigate the effect that important characteristics play (conditioned to other characteristics and/or choice attributes) in the decision of the most preferred alternative. In this context, it is important that the analyst specifies the most suitable form of heteroskedasticity. We investigated two heteroskedastic MNL models, and although the specifications are intuitive and outperform the base model, the heteroskedastic specification conditioned to both transport characteristics and choice attributes not only resulted in the best overall goodness-of-fit, it also provided more exhaustive indications about derived measures, such as measures for marginal rates of substitution.

Regarding the limitation of the study, the models proposed do not account for sources of heterogeneity in any of the four attributes considered in the choice experiments leading to a potential bias of the estimates (in particular, we should note the values for VTTS which are in general lower than expected) . Indeed, the heterogeneity in the attributes (especially cost and time attributes) is well recognized in the literature in the framework of both passenger and freight transport. However, within the heteroskedastic model specification (and the dataset) used in this analysis, the introduction of random parameters did not improved the performance of the models. The difficulties experienced in trying to combine the proposed specification with random parameters, for this data set, suggest the need for future research. It would be interesting to analyse similar models within different datasets and within more sophisticated specifications in order to also account for respondents' heterogeneity in choice attributes.

## 6 References

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