On the valuation of travel time variability, and longer travel times than expected

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1 Background

The duration of travel time, caused by traffic congestion or other reasons, varies substantially from day to day. Typically, travellers have dislikes travel time variability, and there has been an extensive interest in the literature to incorporate the value of travel time variability into transport policy evaluation. There are two basic approaches. First one can assume that individuals values characteristics of the travel time distribution per se. For instance, in the mean-variance approach it is assumed that individuals value the mean and the standard deviation of travel time in a linear specification. Second, in the indirect approach, also known as the scheduling approach, the impact of the stochastic travel time duration upon travellers' scheduling decision is considered. There are two strong scheduling models: Vickery [10] proposed a time varying scheduling utility with time spend at origin and at destination; Small [9] presented a linear utility from early or late arrivals at work. The direct and indirect scheduling approach were later reconiled in Fogerau and Karlström [3] for the case of the Small model, and Fosgerau and Engelson [2] for the case of the Vickrey model.

However, the results of [2] and [3] hinge critically on the assumption of no discrete lateness penalty per se (see Small et al. [9]; Noland and Small [7]; Koskenoja et al. [5]) in the scheduling models. Generally speaking, it is not possible to derive an analytical closed form a solution of optimal departure time to maximize a scheduling utility containing such a lateness penalty. More generally, empirical evidence suggest that it may be important to allow stronger asymmetry in the preferences towards shorter travel times versus longer travel times (for instance, longer travel time than expected).

2 Model

The main purpose of this paper is to develop a model which allows for a discrete penalty for longer travel times, while maintaining the theoretically attractive properties of the Small and Vickrey models as derived in [2] and [3].

The model we propose introduce a penalty when travel time exceeds expected travel time. By this definition of a discrete penalty, it is easy to see that the optimal departure remains the same as it derived from a basic model (Small or Vickrey model) without such a penalty, while the maximal expected utility now depends on the shape of the travel time distribution. As a result, beside the value of mean travel time and the value of travel time variability, an additional value of unexpected long delay is further introduced.

3 Preliminary results

We estimate the proposed model on a stated choice data set used in Börjesson, et al. [1]. In the data set we use in this paper, individuals are facing binary choices with uncertain travel times, in a standard stated preference framework for valuation of travel time variability. There are a number of technical problems with estimating the Small model, which is inherent in the design of the SP study, and the approaches chosen to address these issues are discussed.

Estimation results are shown in Table 1. As is evident, including the discrete penalty for longer travel time greatly improves the fit, and the corresponding parameter is highly significantly. For the Small model, it also provids more precise estimates for the other parameters. Without the discrete penalty, the Vickrey and Small models provides more or less the same fit to the data, while the Vickrey model is slightly better when in the penalty model. It should also note that the valuation of the probability of travel times longer than expected is quite high, while the value of travel time variability is not greatly affected. In fact, it becomes even higher in the Vickrey model with penalty, compared with the Vickrey model without penalty. These results are further discussed.

Scheduling model	Small model				Vickery model			
	without		with		without		with	
estimtes	Value	Robust-t	Value	Robust-t	Value	Robust-t	Value	Robust-t
α or η	-0.128	-7.702	-0.166	-14.496	0.095	4.412	0.102	4.742
β or ν	-0.096	-5.182	-0.035	-6.849	-0.002	-4.356	-0.001	-2.577
γ or ω	-0.476	-4.829	-1.030	-6.978	0.009	2.970	0.026	6.349
λ	-0.123	-9.510	-0.151	-15.063	-0.154	-13.802	-0.137	-12.213
θ	NaN	NaN	-0.010	-8.887	NaN	NaN	-0.066	-7.265
No. of obsevation	2996		2996		2996		2996	
Log of Likelihood	-1783.4		-1757.1		-1783.4		-1755.4	

Table 1: Results from scheduling MNL models, with and without a discrete penalty (θ parameter) for travel time longer than expected.

We briefly report mixed logit models of the Vickrey model, see Table 2. Again, the model with θ achieves better goodness of fit, and is to be selected by any information criterion. We further discuss the mixed logit estimation of the Small model

Vickery model	without		with	
estimtes	Param	Robust-t	Param	Robust-t
η	0.091	2.310	0.144	3.859
ν	-0.005	-4.741	-0.002	-3.003
ω	0.032	5.720	0.042	7.172
λ	-0.232	-12.501	-0.209	-11.437
θ	NaN	NaN	-0.071	-5.343
σ_η	0.140	4.414	0.183	8.815
σ_ν	0.003	4.811	NaN	NaN
σ_λ	0.157	7.982	0.148	8.383
No. of obsevation	2996		2996	
Log of Likelihood	-1660.15		-1647.59	

Table 2: Results from Vickery MXL models

Lastly, inspired by Koster and Verhoef [6], we derive both Small and Vickery scheduling model including the discrete penalty in the context of rank dependent utility (RDU). Hjorth [4] found significant probability weighting in Norwegian data, and the results depends on the assumed functional form of the weighting funtion. We choose a weighting function from Rieger and Wang [8] and apply it in the indirect approch. The parameterized probability weighting function estimated in the Small model indeed indicates a nonlinear subjective perception. Again, introducing the discrete penalty gives a highly significant better fit to the data.

The main conclusion is that the models with a discrete penalty for travel time longer than expected provides a highly significant better fit to the data, compared with the Vickrey and Small models without such a discrete penalty. The proposed model maintains the attractive theoretical features of the Small and Vickrey model without such a discrete penalty, namely linearity in standard deviation and variance, repectively. Our result also indicates that the individuals value other characteristics of the travel time distribution apart from the mean and standard deviation (variance). In particular, we show that individuals have a valuation of travel time that are longer than expected.

References

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