The meaning of S in SUE and the implication for welfare-maximising policies in road transport networks

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Probabilistic choice theory is widely applied in transportation science. Instead of deterministic trade-offs, utility is considered as a random variable depending on a deterministic part and a random part. The early developments in the theory of individual choice considered human behaviour as inherently probabilistic and was mainly developed to incorporate error in human decision making (Thurnstone, 1945; Luce and Suppes, 1965). Later on McFadden (1973) and Manski (1977) interpreted the random part of utility as the result of observational mistakes of the analyst. These two interpretations of the randomness of utility result into exactly the same probabilistic choice model, since they only differ in the interpretation of the random component of utility. In the former case, the random term reflects choice errors that individual decision makers would avoid if they were perfectly informed. In the latter, the errors represent idiosyncratic preferences that are not observed by the analyst, but known to the individual decision makers. We refer to the first model as the "error model" and to the second model as the "preference model".

This paper shows that the interpretation of the random part of utility has far-reaching implications for welfare analysis. We consider a congested road network and analyze governmental decisions on the number of routes, road capacities, provision of traffic information, and first-best and second-best congestion pricing. For the error model we use deterministic utility as a welfare indicator for travellers' consumer surplus, because error is not part of the preferences of the individual. The preference model, in contrast, treats the random component as part of individuals' unobserved preferences, and uses the maximum expected utility or log-sum as a measure of consumer surplus (Small and Rosen, 1981; De Jong et al. 2007).

The two models may lead to different evaluations of investment behavior if the government can choose between adding links or widening existing ones. For any aggregate capacity, if the government chooses the number of alternative routes, the error model leads to a lower optimal number of routes than the preference model. This is because in the preference model there are returns to variety; an additional road leads to more potential alternative routes to choose from, leading to a higher surplus. If the number of alternatives is fixed and the government optimizes road capacity, this results in an equal optimal capacity for the preference and the error model. This is because the marginal change in welfare due to a change in capacity is equal in both models. Only the (congested) travel time is affected, and there is no interplay with the number of alternative routes. If the government optimizes both road capacity and the number of routes, we find that the error model results in a lower number of optimal alternative routes and in a higher optimal capacity which is consistent with the previous findings. Not only the qualitative outcomes of the error and preference model may differ. The total welfare conditional on optimal governmental policies also differs, leading to different outcomes of cost-benefit assessments. In other words, the policy conclusions that can be derived from a stochastic user equilibrium model depend in part on the interpretation of the error term.

This conclusion holds even stronger for the second type of policy we consider, namely information provision. Quite tautologically, if travel times themselves are deterministic, there are only benefits of information provision in the error model. Information leads to a lower random component of utility and therefore to more deterministic choices, avoiding choices that can be improved upon. Obviously, when congestion is unpriced, its external cost nature implies that such information provision does not necessarily increase social surplus, but each individual driver is better off with information than without it, given the behavior of all other drivers. For the preference model, there is no private benefit of information because all randomness in utility is attributed to the unobserved preferences of the individual. There is no information to be added to the knowledge that the individual already has.

The third instrument that the paper considers is congestion tolling. Assuming that the number of alternatives and the capacities of the routes are fixed, first-best tolls are equal to marginal external costs both in the error model and in the preference model, since tolling neither affects the perception errors in the error model, nor the idiosyncratic preferences in the preference model. For second-best pricing, however, things can be expected to be different. We consider the case where pricing is in place on one of two parallel routes. If preferences are idiosyncratic, the transfer of passengers from the one to the other route as a result of second-best pricing will have different impacts on social surplus than if randomness in choice stems from perception errors. We will investigate to what extent this difference affects the second-best optimal toll rules, and the welfare gains that these may bring.

References

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