NOTES AND COMMENTS

“GENERALISED COST” OR “GENERALISED TIME”

A Note on the Forecasting Implications

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Many practitioners have noted that the use of a weighted sum of travel times and costs to characterise the “separation” of two zones in the classical approach to trip distribution leads to a crucial ambiguity (McIntosh and Quarmby, 1970; Wagon and Wilson, 1971). When the weights are adjusted to reflect changing “values of time” resulting from forecasts of changing income levels, the apparently arbitrary choice of time units or money units for the separation matrix can be seen to lead to one of two very different forecasts of overall travel behaviour. For example, holding all money costs and journey times constant between base year and forecast year and increasing the “value of time” to allow for increasing income levels would lead to either:

(a) increasing the separation of every pair of zones in “generalised cost” terms,

or

(b) decreasing the separation of every pair of zones in “generalised time” terms.

Other things being equal then, with conventional distribution models, the choice of units will determine whether shorter or longer trips are forecast. The dilemma, when recognised, has sometimes been resolved by an appeal to intuition (see for example TPG, 1981), and this has usually favoured a choice of time units. Consideration of this problem from the viewpoint of random utility theory suggests that there is a real difficulty, that the difficulty is not fundamentally one of a choice of a system of units for separation, and that the question can be expressed more clearly. A more important point is that neither time nor cost is likely to provide a plausible unit system for conventional forecasting.

THE “OTHER FACTORS”

The generation of conventional trip distribution models from the perspective of a random utility theory is well documented (see for example Lambe, 1969). Conventional “gravity” models can be generated on the hypothesis that each of a population of travellers examines all possible destinations, assigning to each a “utility”

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on the basis of the attractiveness of that destination, the access costs in travel time and money, and a myriad of other factors too complex to identify. Characterising the contribution of the “other factors” to the utility function by a particular probability distribution and assuming that the travellers are “utility maximisers” then leads to the conventional model forms. The key to the dilemma of the unit system lies in a recognition of the role of the “other factors” within this theory.

In an earlier issue of this Journal, Cochrane (1975) sets out the derivation of the conventional singly-constrained gravity model with negative-exponential deterrence function. He makes the assumptions outlined above and assumes that the “other factors” can be characterised by a particular bell-shaped probability distribution with known mean and unknown standard deviation. His derivation demonstrates that the unknown parameter in the deterrence function (the “lambda” parameter, in popular parlance) is proportional to the inverse of the standard deviation of this distribution of the “other factors”. This is the crucial result for the issue of “unit systems”. It is not sufficient to predict the relative values of time and money for the forecast year; the absolute value of the standard deviation of the distribution of the “other factors” must also be supplied, in whatever unit system is adopted. This should reflect expected changes both in the incidence of the “other factors” and in their relative value in the chosen unit system.

As a simple illustration, suppose that the “other factors” could be reduced to a single aspect, say “comfort”. The contribution of the comfort factor to the individual traveller’s utility function would depend on his perceptions of the comfort level and his valuation of comfort. We can suppose that the “value of comfort” in some units is agreed across the population of travellers, but that perceptions vary according to the appropriate bell-shaped distribution. In a forecast year, either or both of these components may change; for example, rising income levels might lead to higher “values of comfort” in money units, and advertising might lead to less variation in perceptions. The change in the “value of comfort” in money units, combined with the simultaneous change in the money value of time, would determine some change in the “value of comfort” in time units also.

In general, the net result will be a change in the importance of the “comfort” factor in whatever unit system is adopted. In other words, in the conventional gravity model framework, we would not expect the lambda parameter to remain constant for either “generalised cost” or “generalised time” networks. The apparent dilemma of the choice between money units and time units is merely a symptom of a more basic inadequacy of conventional forecasting methods.

The “explanation” of the differences in travel patterns between forecasts using adjusted “generalised cost” networks and adjusted “generalised time” networks follows very simply. Holding the lambda parameter constant amounts to fixing the importance of the “other factors”. Holding this parameter constant in money units and increasing the “value-of-time” results in increasing the importance of time-and-cost in the utility function; in turn, this means that the shorter distance options will be chosen more frequently (that is, have largest utility with higher probability) and average trip lengths decline. Holding lambda constant in time units, on the other hand, is an entirely different hypothesis. Now the time value of the money component decreases, and thus the importance of time-and-money in the utility function decreases, relative to the role of the “other factors”. Distance plays a less important
part in the selection of destinations, and as a result trip lengths increase. The “unit system” issue is fundamentally a red herring. Any arbitrary unit system may be chosen, but then the forecast lambda parameter must be compatible with that unit system. For example, the hypothesis that the standard deviation of the “other factors” will remain constant in money terms is equivalent (in our simple example) to the hypothesis that in time terms it will increase proportionately to the expected increase in the value-of-time. Thus a lambda calibrated to a generalised cost network of a base-year could be left constant and applied to a generalised cost network of a future year network; a lambda calibrated to a generalised time network of a base year would require deflation in inverse proportion to the expected change in the value-of-time for forecasting use with a generalised time network. The results are then identical.

PRACTICAL DIFFICULTIES

We are thus led away from arguments about unit systems to questions about changes in the importance of the “other factors”. If we agree on these, any convenient unit system may be used; in general, however, the base-year lambda parameter will require some adjustment.

Conventional practice has completely obscured this issue, with the result that only two hypotheses about the changes in the importance of the “other factors” are usually considered—“no change” in money terms, and “no change” in time terms. Neither of these is very attractive. However, having argued that the selection of an appropriate hypothesis is a matter of considerable practical importance, we must admit that it is also a matter of considerable practical difficulty. Indeed, the probabilistic treatment of the contribution of the “other factors” has been adopted precisely because they defy closer examination. One possible resolution of this difficulty might be to accept the unknown nature of the lambda parameter in the forecast, treating it as a parameter to be estimated on the basis of some extra forecast supplied to the model. The approach outlined by Southworth (1979), using forecasts of travel expenditures, is an obvious candidate.

In conclusion, we have argued that an apparent sensitivity of the conventional methods for forecasting spatial interaction to the system of units chosen for spatial separation is merely a symptom of the inappropriateness of the conventional assumption about fixity of parameters in the deterrence function. Random utility theory helps us to understand why these parameters should be adjusted, but suggests that the choice of an appropriate adjustment may be difficult in the extreme. A different approach may be desirable, to ensure that the important assumptions underlying the forecast are made explicit.

REFERENCES


