Task 6.1.3 The Role of Accessibility Terms in the Model

Discussion

It is well-known that, other things being equal, car ownership levels are lower in urban areas than in rural. A major study in the UK (RHTM, 1978) established that there was a more or less continuous decline with measures of urbanisation, such as net residential density. A somewhat better relationship was found using a measure of "accessibility".

It was not clear, however, whether such measures represented a convenient summary measure of urbanisation or whether they had some explanatory power *per se*. For example, if residential density declined in a given area, without any other changes, would we expect an increase in car ownership? The approach taken in the UK was merely to use the measures to **classify** zones into broad bands – the measures themselves were not recalculated as a result of changes over time.

One particular reason for this stems from a naïve interpretation of the accessibility measure. If, for example, we define "accessibility" as a standard "Hansen" index : $A_i = \Sigma_j E_j \exp(-\lambda G_{ij})$ where G is car generalised cost, then we expect a declining propensity to car ownership with increasing A. However, increasing congestion in urban areas will lead to a decline in A, suggesting (counter-intuitively), that car ownership will **increase**.

The development of more explicit theories of car ownership has introduced the concept of "differential accessibility". In other words, part of the justification for owning a car is in terms of the additional accessibility which may be obtained, over and above that afforded by non-car modes (including public transport). If this is carefully specified, then it avoids the counter-intuitive predictions just mentioned.

The following represents a preferred approach. It uses a single differential accessibility based on employment and generalised cost by mode.

Consider that there are three modes: 1 = walk/cycle, 2 = public transport, 3 = car. For convenience, we assume a model of mode choice conditional on destination. For someone <u>confined</u> to the "slow" mode, the utility of a journey from i to j can be represented by the sum of the utility of the destination U_j and the (dis)utility of the travel from i to j by mode 1 U_{ij1}. In the usual way, we assume a generalised cost approach with

$$U_{ij1} = - \lambda \, GC_{ij1}$$

Consistently with general theory, we will assume that the dominant "attraction" of a zone is the number of people employed, though this could be changed without difficulty. We make use of the theory of "size" variables, whereby $U_j = \ln(E_j)$.

To represent a possible hierarchical structure between destination and mode, we introduce a structural parameter θ, where $0 \leq \theta \leq 1$. Hence we write:

$$TU^{[1]}_{ij} = \ln(E_j) - \theta \, \lambda \, GC_{ij1}$$

where TU represents the "total utility" of the journey, and the [1] indicates that only the walk mode is available.

For someone who could make use of either walk or public transport, we need to substitute the appropriate <u>composite</u> generalised cost in this formula. For convenience we will assume a single level mode choice model, but a more complicated structure could be catered for (once the number of modes exceeds 2, that is). Thus we use the formula:

$$TU^{[12]}_{ij} = \ln (E_j) - \theta \lambda GC_{ij*[12]}$$

where the composite GC is defined in the usual way as:

$$GC_{ij*[12]} = -1/\lambda \ln [\Sigma_{m=1,2} \exp (- \ddot{e} GC_{ijm})]$$

Finally, consider someone who, in addition to slow modes and public transport, also has a car available. In an exactly comparable way we use the formula:

$$TU^{[123]}_{ij} = \ln (E_j) - \theta \lambda GC_{ij*[123]}$$

where the composite GC is defined as:

$$GC_{ij*[123]} = -1/\lambda \ln [\Sigma_{m=1,3} \exp (- \lambda GC_{ijm})]$$

As usual, it is not possible for the Generalised Cost to <u>increase</u> as a result of more modes being available. The extent to which it decreases depends on both the value of λ and the relative performance of the added mode.

So far we have focussed on a single destination. We now need to extend the process, effectively by compositing over all possible destinations available from a given origin. This again follows standard procedures, and we use the formula:

$$TU^{[K]}_{i*} = \ln [\Sigma_j \exp (TU^{[K]}_{ij})]$$

where K represents the set of available modes.

The additional utility gained from car ownership for residents at origin i can then be written as:

$$\Delta U[car]_i = TU^{[123]}_{i*} - TU^{[12]}_{i*}$$

This can be converted into GC-like units by dividing by $(-\theta \lambda)$.

This provides a principled way of introducing the accessibility effect into the car ownership model. It has many of the features of the existing model, but it represents a theoretical improvement, while the effort required in calculation is essentially similar.

Decision

In the event, we decided not to include accessibility terms for a number of reasons:

- this was not a research project and our budgets were constrained;
- the precedent of the accessibility terms in the previous model was not convincing;
- we anticipated difficulties in statistically distinguishing accessibility from other locational effects;

- we were concerned about the consequent requirement to include iterations between the networks and car ownership model, which would substantially increase model running costs;
- given the high levels of car ownership in Wellington and relatively low future growth, we did not expect the accessibility effect to have a significant on the model forecasts.