

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 : $A_i = \sum_j E_j \exp(-\lambda G_{ij})$ 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 confined 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 composite 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:

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

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:

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

As usual, it is not possible for the Generalised Cost to increase 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:

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

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:

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

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.