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Process validation of urban freight and logistics models

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Abstract

A number of innovative modelling approaches for the analysis of urban freight demand and its impact upon the built environment and transport infrastructure have been proposed over the past several years. These range from new and more robust synthetic models to tour-based formulations based on truck survey data to agent-based microsimulation models. As impressive as these contributions are, most have only included nominal validation efforts, typically limited to comparing the flow estimates to observed traffic counts. In many cases in both research and practice the quality and quantity of these counts are disappointing, and definitive conclusions about model validity and accuracy are difficult to draw from them. Fortunately, increasing the number of counts is far from the only option open to modellers. A far more expansive practice known as process validation can not only overcome the limitations of count data, but admit a far wider spectrum of information, data, and knowledge to the task. This paper illustrates how the process was applied to a tour-based microsimulation model of urban freight, and offers suggestions how it can be more widely applied to freight and logistics models.

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1. Introduction

The paucity of behavioural data from which to build robust and comprehensive urban and freight and logistics models has long been lamented (Wigan 1971, Meyberg & Mbwana 2002, Wigan & Southworth 2006, to cite but a few). Most researchers and practitioners have devised novel methods to overcome the

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lack of data, to include the use of synthetic data, derivation of demand matrices from count data, use of theoretical or expert knowledge, and synthesis of composite trip rates and other behavioural data by fusing multiple surveys. The Quick Response Freight Manual (Cambridge Systematics 2007) is an example of a widely used source of such data in the USA. Even when travel survey data are available they are often small in size, expensive to collect, and reveal large variances among otherwise similar shippers and carriers. Faced with scant data about a population exhibiting a high degree of variability most modellers use all available data for model estimation or calibration, leaving little or none for model validation. As a consequence most models that report validation results do so by comparing modelled flows to observed ones. In too many cases even the count data are sparse compared to the magnitude and extent of freight flows within an urban area or region (Turnquist 2008, Donnelly 2008), making comparisons to them suspect.

Even when adequate count data are available the entropy maximization basis of most deterministic urban freight models admits the strong possibility that several different combination of inputs could have given rise to modelled flows that resemble reality (de la Barra 1989, Wilson 2006). Even models not based upon entropy maximization methods, such as agent-based or activity-based travel models, may reveal several plausible outcomes whose derived network flow patterns resemble reality. Donnelly (2007, 2009), using an agent-based microsimulation of urban freight in Portland, Oregon (USA) found that repeated simulations gave rise to substantially similar network flow patterns. Thus, it would appear that almost any model of urban freight is capable of mimicking the flow patterns revealed by comparing a model to observed counts alone.

A more expansive approach to model validation can help overcome both problems. Admitting information other than just counts to the validation process can overcome the problem of too few counts, or an adequate number of them in unhelpful places. A wider spectrum of data can also ensure that the validation process is applied to all parts of the model, not only at the end of the modelling chain. However, the literature in transport modelling in general, and freight modelling in particular, appears largely devoid of innovative or expansive validation techniques. Fortunately, contributions in other realms can be adapted to the practice of freight modelling with good results. One such technique is *process validation*, pioneered in the fields of systems dynamics and software engineering. However, the technique does not appear to have been applied in transport modelling to date. This paper describes its adaptation to urban freight modelling and offers suggestions about it might be more widely applied.

2. Fundamentals of process validation

Process validation is an elegant relativist framework for validating complex models, and is particularly useful in cases where data are scant, assumptions are numerous, and behaviour is modelled piecemeal. It is based upon the premise that not only is the reproduction of behaviour necessary in order to consider a model valid, but that how a model gives rise to such behaviour is equally important. Barlas (1996) argues that, “what is crucial is the validity of the internal structure of the model.” Process validation stands as a viable alternative to subjective or neglected assessment of model performance in cases where a statistical approach is not appropriate. Whilst others have written about process validation (Cook & Wolf 1999, Janssen 1995) they are not as well-structured and comprehensive as the approach laid out by Barlas.

Process validation is a qualitative process, although it can easily admit quantitative measures. That does not distract from the rigour of the approach, which is as systematic and comprehensive as formal statistical testing. The framework includes two groups of structure tests and two groups of behaviour tests, as shown in Figure 1. The first two groups examine the internal validity of the model, using a combination of direct and indirect tests. Once confidence is gained in the structural test outcomes the second group of tests focus on emergent behaviour.

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