12 Integration of Freight Network and Computable General Equilibrium Models

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12.1 Introduction

Over the past 30 years very significant progress has occurred in the understanding and modeling of passenger trip making behavior over networks. Yet, corresponding advances in understanding and modeling of freight transportation decision making over inter-regional, inter-modal networks have not occurred. In fact the most recent large scale U.S. freight network model is able to predict equilibrium network link volumes agreeing with Federal Railway Administration (FRA) density codes (reported data describing annual tonnages on every physical link of the rail system) with a frequency of only about 60% (Friesz et al., 1981; 1983a; 1983b; 1985). This is poor performance since density codes denote upper and lower bounds for link volumes; the difference between those upper and lower bounds is frequently of the same order of magnitude as the predicted volumes themselves. Poor as this accuracy is, it is substantially greater (about three times greater) than that reported for earlier models (Bronzini, 1980) and was achieved by straight-forward extensions of the urban passenger network modeling paradigm. Still greater accuracy may be obtained from a model designed specifically for freight applications from the outset.

A highly accurate inter-regional, inter-modal freight network forecasting tool which employs a detailed representation of the actual freight transportation network (rather than a highly aggregate abstraction) is critical to federal policy and decision making related to regulation/deregulation, for it allows volumes, costs, modal splits and the like to be estimated. It also allows the region-specific impacts of transportation policies to be determined. Furthermore this type of tool can prove valuable to private freight companies interested in their competitive posture vis-a-vis other companies. Finally, the methods discussed in this paper allow the transportation sector to be represented in a detailed and theoretically precise manner within a general equilibrium model of the entire U.S. economy.

The accuracy disparity between predictive urban passenger network models and predictive inter-regional, inter-modal freight network models may be traced to the following considerations cited by Friesz et al. (1983a):

1. Freight-related databases necessary to calibrate and validate predictive network models are not as extensive and probably not as accurate as those maintained for passenger travel;
2. Freight transportation decisions are inherently more complex and difficult to model than passenger travel decisions;
Table 12.1. Typology of predictive freight network models

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<tr>
<th>Model</th>
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where Y = Yes, N = No, and * = Not Applicable.

Criteria:
1. Multiple modes
2. Multiple commodities
3. Sequential Loading of commodities
4. Simultaneous loading of commodities
5. Explicit congestion
6. Elastic transportation demand
7. Explicit shippers
8. Explicit carriers
9. Sequential shipper and carrier submodels
10. Simultaneous shipper and carrier submodels
11. Sequential general equilibrium and network model
12. Simultaneous general equilibrium and network model
13. Nonmonotonic functions
14. Explicit backhauling
15. Blocking strategy
16. Fleet constraints
17. Imperfect competition

3. The predictive freight network models which have been proposed have not adequately broken from the passenger network paradigm, whose assumptions are simply erroneous for many freight applications;

4. Sufficiently efficient and inexpensive algorithms for solving theoretically precise freight network problems have not been commonly available or well understood by practitioners; and

5. Large scale predictive freight network models have not been integrated with computable general equilibrium models to forecast consistent national/regional economic activities and prices on the one hand and detailed freight flows on the other.

This paper proposes a spatial computable general equilibrium (SCGE) model in direct response to item 5 above.

12.2 Typology of Predictive Freight Models

In order to place the SCGE model presented subsequently into perspective, it is useful to consider the previous predictive freight models reported in the literature. These are reviewed in detail by Friesz et al. (1983a). Here we only present a typology and summarize the key features of these models in tabular form (Table 12.1). For brevity we will suppress any discussion of these models, and the interested reader is referred to Friesz et al. (1983a) for details. In Table 12.1 we differentiate and evaluate existing models according to a set of 13 criteria developed by and discussed at length by Friesz et al. (1983a). The list of references to this paper also includes key papers which describe the theory and application of the models presented in Table 12.1.

It will be noted in reviewing Table 12.1 that no current model achieves the simultaneous solution of a general equilibrium model and a freight network model. It is precisely this weakness which is addressed in the next section.