

Whats wrong with freight models, and what should we do about it?

Wigan¹, M,R.

Oxford Systematics,

GPO Box 126, Heidelberg, Victoria, Australia

Email oxsys@optusnet.com.au, m.wigan@napier.ac.uk

Phone +61 3 94599671 Fax +61 3 9459 8663

Southworth², F.

Oak Ridge National Laboratory,

PO Box 2008, Oak Ridge, Knoxville, TN 378331-6206, USA

Email sou@ornl.gov

Phone +1 423 576 8153 Fax +1 423 574 3895

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¹ Professor of Transport Systems, Tri, Napier University, Edinburgh, Scotland

² Senior Research Staff, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA

ABSTRACT

After many years of neglect, freight, freight operations, and commodity flow models are now attracting substantial attention, and there is a wide perception among transportation analysts that they all need a careful overhaul. In this paper the range of applications and issues associated with different forms of freight model are considered. Confusion about what one can do with a given model is often founded on a lack of transparency as to the domain of application for which the model was originally designed and set up. In this paper the authors offer a framework for placing existing freight models in the context of both the temporal targets and the valid domains of application for which they were originally developed. A conclusion of this exercise is that, while existing freight models are simply not up to the task of forecasting future freight activity, there are a number of uses for which these models are well suited. This includes the ability to “predict the present”, an objective and also a technical challenge that has been much under-rated to date. The appropriate action is to assess what the user feel is missing, and to rebalance research efforts to match.

³ Professor of Transport Systems, Tri, Napier University, Edinburgh, Scotland

⁴ Senior Research Staff, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA

INTRODUCTION

Freight movement has been under-researched and treated in an inconsistent and uncoordinated manner for several decades. There has been little or no advance on what was done to underpin the first integrated multimodal urban and regional freight policy development (done by the UK Greater London Council in the early 1970s) although significant advances have been made at the national scale (1). In many cases where a freight component has been included in comprehensive studies, the intellectual capital in terms of models, the data resources required, and even the specialized skills needed to deal with this complex system have been found wanting. As freight systems are of pivotal importance in national economies it is hard to understand this under investment in models and the data needed to drive them meaningfully.

Where freight and entrepot⁵ activity has been recognized as being of critical importance to a regional or State economy it is often the case that a study's emphasis quickly swings to major investment projects after only a cursory attempt at capturing some of the cross sectional aspects of relevant freight movements⁶ – with no visible commitment to monitoring, following up, or learning from the data and modeling deficiencies identified during the process.

In many cases freight has been treated as justifying only a comparatively minor research and data support effort when compared with car or even public transport. As the freight system involves a small fraction of the numbers of vehicles used for passenger movement this can be understood only as an expedient to address what in the main have been perceived (and real) road congestion issues. The economic basis for paying close attention to freight, and the economic development multipliers (both positive and negative) associated with it have only comparatively rarely been addressed. This in part has been due to the very different constituencies involved in rail, air and sea operations – and the small fraction of the road fleet that is perceived be 'freight transport'. The attention of the road managers has been directed more towards road damage (a function of axle loads) than towards the economic impacts of freight operations on land use and urban development.

After many years of neglect, freight, freight operations and commodity flow models are now attracting substantially more attention, and there is a wide perception that they all need a careful overhaul. This is not entirely correct. For example, although most of our existing models have limited forecasting capacity, this is not necessarily a problem. Not all applications require this capacity, and predicting the present is entirely satisfactory for a variety of planning and policy decisions. In the rest of this paper the range of applications and issues associated with the different forms of freight modeling are considered in the context of their original application requirements. In doing so a number of gaps in the coverage of existing models are identified and some important analytical needs are highlighted. What emerges from the review is a series of recommendations on where to focus the next round of R&D efforts in order to get the most out of both existing and future modeling frameworks.

⁵ An entrepot is a freight handling and interchange centre, but not necessarily one where freight is directed as an end point, although it can be.

⁶ One example is the State of Victoria in Australia

MODEL APPLICATIONS

Freight and commodity flow models are used in a wide range of situations. Dissatisfaction arises when the expectations of the end users are not well matched to the constraints inherent in the model. There are several quite different types of “freight model”, each suited to a different group of applications, and none of which are suitable for all. Reviews over recent years have been oriented towards either national or urban transport planning (2, 3, 4), and so have adopted a comparatively narrow view of 'freight modeling'. The actual application range is rather wider, and includes:

- Traffic management studies
- Infrastructure needs/investment planning (notably for congestion mitigation; including both port and network capacity expansions)
- Freight logistics/supply chain operations analysis
- Shipper mode and/or carrier choice studies
- Vehicle load factor, vehicle miles, and ton-miles of travel estimation (notably for economic/environmental/safety impacts analysis)
- Light duty commercial vehicle/service industry activity analysis (notably for land use planning)
- Location or facility specific freight traffic generation/attraction estimation
- Warehouse/break-bulk terminal location(s) modeling
- Modal and intermodal market share/market competition modeling
- Modeling the competing needs of passenger and freight traffic movements
- Modeling the effects of alternative user charges, subsidies, standards and/or regulations (on carriers, shippers, storage companies, third party logistics agents, customers)

Traffic planning and management studies have substantial requirements for freight vehicle and movement modeling and capacity management requires detailed simulations of the wide variety of vehicle movement and response characteristics. Logistics operations and optimizations provide a very different and supply driven view of movement patterns. Road freight vehicle issues are generally about congestion, road damage, noise, freight vehicle traffic generation from existing interchanges (ports, depots, transshipment facilities), delivery areas (especially retail activities in areas of high pedestrian activity) and kerb space conflicts. Road damage issues are for the most part limited to large vehicles and especially to the policing of overloading, and the economic arguments for freight typically emerge as part of the public and private sector tradeoffs for greater productivity from larger vehicles.

There are also many other specialised areas, from shipment choice modeling (5, 6, 7, 8, 9) and empty running estimation (10) to containerized and other specialized freight traffic generation modeling (11, 12), to the unresolved role of service industries in urban freight movements (13, 14, 15) The list of issues and modeling solutions continues to grow. In general each of these areas is handled by very different interest groups. For example, retail activity and delivery conflicts involve a few large vehicles but many small ones, and are treated largely as a traffic operations and management issue. Ports and intermodal interchanges are treated predominantly as site specific project issues, and road damage and environmental impact are usually addressed by road authorities in terms of large truck movements.

Some of the models aimed at each of these areas have been reasonably effective in their limited domains, although there are clear shortfalls in modeling capacity, data supply and validation even then. However, the current unease about shortfalls in freight modeling is focused more on issues of forecasting and demand estimation than the operational areas. The rising interest in transport infrastructure as a tool for economic development, and the importance of the freight and logistics industries as forced in their own right, has helped to instigate formal reviews⁷ of what was already widely known in academic and consulting circles – namely that the data and models for freight systems were severely deficient in a range of areas.

MODELING TECHNIQUES

Modeling techniques applied to these various freight applications include an increasingly broad range of techniques geared to specific aspects of the freight planning process, including:

- Linear and non-linear (e.g. logit) regression model estimations of traffic volumes, origin-destination flows, and modal shares
- Spatial interaction, neural network and Box-Cox models of zone-to-zone (region-to-region) freight movements
- Commodity-based, inter-regional input-output models
- Micro-simulation and agent-based models of individual freight vehicle movements
- Engineering cost-based, statistical (regression) based, mixed statistical-engineering cost based, and hedonic freight pricing models
- Least cost-based single and multiple path freight traffic routing models
- Optimal facility location and combined site location-flow allocation models
- Network-based spatial price equilibrium models

For the most part each of these techniques offers a means of estimating the volume, costs, and other (including environmental and safety-related) impacts associated with the physical flows of freight out of, into, across and between places. While some techniques are well suited to specific aspects of freight planning (e.g. regression models of freight traffic generation), a combination of modeling techniques is required if we are to capture all of the major aspects of the freight planning process. To this end, a number of quite elaborate, multi-step freight modelling frameworks have been developed in recent years. These include:

- National or Statewide studies, in Great Britain (16); the Netherlands (17); Sweden (18, 19); and the United States (20, 21, 22, 23).
- Studies of individual urbanized areas or large sub-national regions (14, 24, 25, 26)

The major impetus for these efforts appears to be unacceptable levels of congestion around ports and city centers. Within the United States a series of truck flow maps produced by the Federal Highway Administration's Freight Analysis Framework⁸ project have drawn a good deal of attention to rapidly developing truck-supported traffic

⁷ The UK Department for Transport's major Freight Modelling Review, and the formation of the TRB Freight Modelling Task force are two recent examples.

⁸ http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

congestion along major intercity corridors. For the most part these “comprehensive” freight planning models offer variations on the long-used four step passenger transportation planning process (of trip generation, distribution, mode and route choice), usually including a fifth step in the form of commodity flow-to-vehicle/vessel matching.

As an important variant, a number of the geographically more extensive national and regional studies have applied input-output based commodity flow forecasting techniques to the trip distribution stage. But there has been little focus within any of these studies on the underlying behaviours that drive freight transport, or on the causal business relationships that determine freight origins and destinations, mode, equipment selection, time of day, and routing behaviour.

As a result these largely traditional urban planning models have considerable difficulty in capturing adequately the impact of policy decisions on fully delivered costs, travel times, service reliability, and other critical factors that influence both shipper and carrier behaviour. In contrast to their treatment of physical processes, the modeling of the institutional and decision-making structures that generate these flows and create these costs has received comparatively limited attention.

An illustrative typology of some of the major categories of ‘freight models’ is given as Fig.1. The comparative simplicity of the first column (the four step elements of classical passenger demand modeling) is striking. The layers of complexity swiftly emerge at the next layer, which starts to take into account the very different categories of actors and specification elements in freight and logistics systems. It is then possible to recombine these complexities into a view very similar to passenger models, by aggregating over these layers of complexity from varied actors and processes. The implied assumptions required to be able to do this make most such re-aggregated models unable to respond to quite reasonable changes in view and behaviour of the actors now disguised in the aggregated models of freight, commodity flow and vehicle movements.

These factors go some way towards explaining why freight models often do not appear to do what is ‘expected’ or ‘required’ of them. Fig.2 illustrates a number of the many different ways of addressing freight modeling, linked to where four step approaches are applied, or applicable.

The central column is the area where the concepts are best matched to the structure of the freight and logistics system, but that does not mean that at the levels of aggregated required for specific purposes that the other columns are not useful – simply that they generally cannot respond to changes in the central column of a causal basis. If such changes are not important to a given application requirement, this may not be a major issue – unless there are expectations that the model is indeed suitable for such investigations.

A further layer of hidden complexity is that most freight models assume rationality and optimisation as an underlying factor. These assumptions may be questioned through experimental economics experiments – but at some point some of the actors in freight and logistics systems do not make rational (or at least optimal) judgements, do not seek, or are simply lacking necessary information. At some point agents with less than ideal behaviors are likely to be necessary not only in freight models but for wider transportation policy analysis and projection purposes. Introducing this new factor will not only raise fresh questions about calibration and validation of models, but also will place substantial demands on data collection and indeed simply handling the

very large scale of the multiple agents likely to be needed for more than an exploratory approach.

MODEL CATEGORIZATIONS

The wide range of both model applications and modeling approaches summarized in the two previous sections challenge our ability to put a bound on the term “freight modeling”. Also, as hinted at in the introduction, the clients for freight and related logistics modeling only have a limited overlap with the traditional clients for passenger transport studies, and with their concerns and responsibilities.

For many groups a trip matrix of vehicles is sufficient for most purposes- and need have no causal basis as an aid to development and forecasting of responses to different short-range policies. The bias to date towards vehicle movement patterns, and the comparative neglect of decision structures and causal relationships linking economic development and freight systems, has in many cases been quite sufficient for the needs of many players for many years.

The current resurgence of interest is largely due to the steady growth in freight movements now becoming a significant issue in their own right, and a rising appreciation of the economic importance of freight movements in both economic and environmental terms (and of course the conflict between these frameworks).

This wider group of clients for freight models now extends well into the operational logistics field, as decisions taken in these areas can affect the transport components. In a full logistics framework it is not unusual for the freight transport components to increase in the interests of securing greater cost reductions in other parts of the overall logistic chain.

Industrial planners have a long history of applying modelling and simulation techniques to logistics and supply chain planning (27, 28, 29) and these techniques are well documented in the literature of industrial engineering. While limited, there have of late been a number of promising attempts to apply these techniques in support of broader public policy-oriented ‘transport planning’ studies, in the process drawing in many of the modelling steps required to estimate and put costs on freight movements. In particular, recent efforts on both sides of the Atlantic have begun to combine supply chain concerns within more exacting behaviour frameworks, sometimes using micro-simulation techniques to generate complex vehicle movements (3, 30, 31). As a result of these various developments, more genuinely prescriptive uses of freight models may be in the offing.

These developments make it considerably less straightforward to assess the quality or otherwise of existing freight models against passenger movement models of various types. In the rest of this paper we take a look at where further examples of model development are most needed, and also at those tasks for which current modelling techniques are often adequate to the task.

A TIME BASED CATEGORIZATION

It is always easy to show how complicated a system one is analyzing or modeling, but the key to effective advances is picking appropriate categories within which to undertake

analysis and subsequently build models. No one model can satisfy all clients, no one set of data can calibrate all models. Choices need to be made. We know how to do this for passenger movements, but not so strongly for freight systems.

We propose as one of these steps to use a time horizon based categorization. This is not unique, and indeed there will be many different ones- but the benefit of a time based category system is that the differences between short and long terms needs and approaches can be more clearly spelled out.

Confusion between what one can do with a given model is often founded on a lack of transparency as to the domain of application for which the model was designed and set up. The temporal targets and valid domains of application provide productive distinctions that enable existing models to be examined with less confusion over their applicability. This will help to show where we have got to, and where we still need to go.

At least some of the current general unease is because such distinctions are not drawn. As a result, models are accused of ‘failure’ in domains for which they were simply not designed or calibrated, and so have no capacity to respond to queries in the areas excluded by their designs.

Five major time-based categories can be used to identify where efforts may best be applied to improve the current state of both practice and theory in freight modeling:

- Predictions of the present
- Models aimed at pivot point analysis of variations in freight conditions or demand (variation models)
- Models aimed at predictions of the present and recent past
- Forecasting models (with the emphasis on causal processes of demand generation)

Short-range (including “real time”) traffic monitoring and management models

PREDICTING THE PRESENT

Perhaps the most deceptively easy category is that of “predicting the present”. This phrase was coined specifically to focus attention on the objectives of certain types of models and to ensure that there was no concomitant expectation of usages which rely upon causal relationships –which are essential for forecasting (but not for projection).

Freight vehicle flow matrix estimation, which generates the number of tons and number of vehicles we expect to move between pairs of places on an annual, or its equivalent daily or monthly basis, is a good example of this and existing methods are satisfactory for many user requirements. An increasingly popular approach to flow matrix generation involves the use of input-output (I-O) models as freight traffic generators and attractors, combined with some form of spatial interaction model to generate between-region as well as between-industry flows (32, 33, 34, 35)

Whether starting from I-O modelling, or using land use-based traffic generation and attraction equations, building an origin-to-destination (OD) truck trip matrix to determine freight corridor capacity needs has in the past made heavy use of such flow matrices, subsequently factoring the OD matrices up as a simple way of projecting (if not assessing) future demands.

Such flow matrix building models are aimed mainly at filling in the (expensive) blanks in current information, and as such are now subject to some fundamental rethinking as telemetrically collected “ITS” data become progressively more widely

collected and available. Here a useful technique is that of “link-OD” modeling, where survey-sample based origin-to-destination data and data from link traffic counts are combined within (possibly stochastically) constrained mathematical programming models to yield, in particular, truck trip matrices (36).

With workable approaches available since the early 1980s (37, 38) and a growing methodological literature, this area appears ready to yield improved freight flow matrix estimates for at least individual urban areas.

PIVOT POINT AND SENSITIVITY ANALYSES

Pivot point and sensitivity analyses are essentially a hybrid of predicting the present, and projection. The variations around a base point can reflect the interactions built into the model used for the present, and can provide useful short run predictions. They share with other models of this general type a fundamental limitation to the levels of interaction built into the original model. These interactions may be extremely limited - even though very good when judged on (say) an econometric times series basis.

In this regime elasticity, cross substitution, and logit models. Many of these are estimated using stated preference techniques and often perform well (9) – given their limited scope.

PREDICTING THE PRESENT AND RECENT PAST

The use of indicators and assessment of short run changes requires prediction of both the present (as it advances) and the recent past to pick off the changes as short run measures – or short run impacts – arise.

Forecasting is fundamentally different to projection. This difference resides in the causal nature of the changes expected over time. Projection is based on assuming the current trends will continue. This allocates to ‘projections’ the various variants of time series, ARIMA, neural networks, fourier analysis and other processes that depend on the internal temporal structure of the trends. By this definition the inherent constraint of this approach is that causal changes and linkages are not covered – but the estimation of the existence, locations and scale of changes that arise (either from policy measures or demand changes) can be addressed.

However deficient models designed to do this might appear to a travel forecasting analyst, they are often entirely satisfactory in the applications for which they are used, and not certainly not deficient when addressing the estimation of changes that have already occurred.

FORECASTING MODELS

Forecasting depends on at least one of following factors: exogenous data, models or trends, and requires a causal link between freight activity or demand levels. Econometric models are ambiguous as they often include exogenous variables describing and associating demands levels, time and other factors. These capacities meet the definition of ‘forecasting’, but are not often used. In their place the two major alternatives adopted are:

- General growth trends, applied to large sections of a current freight matrix and then subject to matrix balancing methods to make the matrix of freight movements fit. In some cases this process appears to create new trips (39) in the quest to fit the screen line counts that have been fitted to.
- Entirely exogenous models using input output techniques of the economy, where the changes in the values of different commodity movements are then converted to tonnage and vehicle/train movements as the basis of the forecast freight outcomes.

These two forecasting frameworks can be and are used together. The current matrix updating procedures require growth targets for whole area, and the I/O models can provide them. The limitations of these hybrid models are all too evident. For example no regulatory or similar measures will be responded to, however substantial the localised impacts. Nevertheless efforts to combine forecasting components are badly needed in many situations.

The general view on forecasting models in freight is that the specific problems for which freight information is needed are usually addressed in terms of commodity flow or vehicle/modal split outcomes – and the interactions between the forecasting and projection elements are largely regarded as of lesser importance than securing a sound measure of scale and locality of freight impacts (1). This does not mean that the freight models used are ‘wrong’ any more than any other phenomenological model used to describe complex situations in a manageable and parameterised manner, simply that a clear understanding of what can and cannot be expected of them needs to more widely appreciated. If these issues are not understood, then the models are perceived to be ‘wrong’ in a very different sense.

MONITORING AND MANAGEMENT MODELS

The decision making elements in overall transport systems are no longer always optimal, or even rational, unless a satisficing approach is taken. If the emphasis is moving towards real time monitoring and adaptation then the types of models required will be more and more data intensive and be linked to optimal control approaches, not yet common in the transport arena.

This and other modeling approaches demand data from so-called intelligent transportation system (ITS) sources, and make good use of them (40,41). A recent example of this type of modeling is given by Xu, et al (31, 42), who incorporate micro-simulation of individual truck movements within an enterprise-based supply chain modeling framework—a line of research that might ultimately reveal a measurable connection between traffic congestion-induced delay costs and the price paid for goods.

STRENGTHS AND WEAKNESSES OF CURRENT FREIGHT PLANNING MODELS

The review of the different types of freight models strongly suggests that a better appreciation of exactly what various models can and cannot represent, often dictated by the needs of different planning and policy issues, is most important. While there is no fully satisfactory freight model in terms of understanding and responsiveness to all

aspects of every issue, there are many freight models that do a reasonable job in restricted circumstances.

Only a few applications demand full structural forecasting capacity, linked to economic base (As indeed is the case for other areas of transport and traffic planning) and so the shortfalls and unresolved problems with these approaches apply only in situations where structural forecasting is needed. A practical perspective is to consider the outputs of various freight models as the inputs needed by others. The principal products of current freight planning models can be grouped into three areas:

- Measures of system-wide or region-wide freight activity: such as tons and ton-kilometers moved, and dollars spent on these movements, by mode of transport.
- Measures of the commodity and supporting vehicle/vessel movements between places (i.e. origin-to-destination flows).
- Facility specific measures of the volumes of traffic passing over specific airways, highways, railways and waterways and through pipes and through specific staging yards, warehouses, break-bulk and intermodal terminals.
- Measures of the freight traffic generating propensities of different industries and land use arrangements.

These measures are now well supported by other planning measures such as the typical carrying capacity of different vehicles and vessels, the dollar value of a ton or truckload /carload/or vessel-load moved, and the contribution of vehicles of different sizes to traffic congestion, air pollution and accident costs. Not surprisingly these are all the sort of measures required by the traditional “four-step” metropolitan transportation planning models used extensively in both Europe and North America, and focused largely on passenger rather than freight (and at that largely truck) transport.

While the resulting freight traffic generation and attraction, distribution, mode and route choice models are valuable for putting estimates of existing freight traffic on “roadways”, they leave a good deal to be desired when trying to anticipate, as planners must, the likely future trends in both freight industry demands for services and the responses of shippers, carriers and logistics agents to proposed regulatory, pricing or infrastructure investment policies. Nor does the level of industrial sector/commodity detail in the available datasets often support careful attention to the needs specific industries or land uses.

Missing, in particular, from past modeling efforts has been any in-depth modeling the linkages between industries and land uses, notably in the form of the freight supported supply chains that link businesses together both spatially and economically, although the SMILE model from the Netherlands (17) makes a clear step in that direction.

While person transport models must deal with many different types of households (and institutions such as schools and hospitals), the variety of both actors involved in the delivery of freight, as well as the wide variety of physical and logistical demands placed on vehicle use by products from paper clips to iron girders and from dining room tables to containers full of grain, makes freight a much larger universe to deal with once we try to go behind the physical movement of goods to influence the causal economics and institutional mechanisms underlying it. Current freight planning models reflect a limited understanding of the forces and agents involved.

Challenging further efforts at quantifying what knowledge we can put into better planning models are limitations on existing data sources. Some of these result from proprietary or confidentiality controls on data access. Others result from limited public agency support for freight data collection.

A growing awareness of the need for more and better freight data and supporting analysis may help this situation somewhat. Even so, new looks at freight planning models are in order if behaviourally sound models are to be developed that offer the necessary insight into policy impacts.

Current modeling weaknesses include limited attention to causes and dynamics underlying change in both freight demand and supply.

Current static, cross-sectional approaches (e.g. flow matrix generation) fail by their very nature to capture effects of supply chains, and the likely responses of individual supply chain participants, on future changes in flow patterns.

Current freight planning models also fail to capture the effects of up-to-date market knowledge on carrier and broker, as well as shipper behaviours. For example, knowing the differentials in the market prices offered for local versus export consumption of high volume goods such as field grains can affect carrier offered transport rates, which in turn can alter the percentage of freight shipped via rail, water and truck to export ports, versus that shipped locally, principally by truck on a year to year basis.

While econometric analyses of these sorts of changes are common in trading companies and National Departments of Commerce, little has been done to date to translate this sort of knowledge to freight planning models. As a result, a cross-sectional survey based set of freight movements, perhaps taken every 5 years or so, may prove quite misleading as a basis for long range infrastructure investment planning.

JUDGING THE MODELS WE HAVE

The discussion to this point has focused on what freight models are designed to do (sometimes by default due to the sheer lack of suitable data). A slightly different perspective is to move on and consider what might be right or wrong with models that pass the basic specification and application capacity tests that we have considered to this point. There are several dimensions in this group. A few words about two of the most critical are pertinent. These are:

- Calibration
- Validation

The calibration issue is one where the intrinsic structure of the model is matched via parameter adjustments to the situation where data are available. Such calibrations often need to be repeated when a model is applied to new locations. If they are not, and parameters are carried from one situation and location to another, the model may be excellent but the application substantially deficient – and certainly ‘wrong’ in a practical way.

Validation is a far more slippery process and considerably less easy to address. Validation is more about confirming that the model represents the ‘real world’ structures in some fair approximation. In many cases the distinction is not often considered, but how do we assess models that we are required to use, which may be private, calibrated with unavailable (commercial) data or nontransparent? This is a real situation, and the

decision of the UK Department for Transport, subsequent to their freight models review (4) to consider the MDS-Transmodal multimodal freight model of the UK required an extensive third party audit (43) to assess the 'validity' for this purpose.

While this work covered scenarios and sensitivity runs of the 'black box', and found it to be a reasonable tool for the purposes examined, the questions raised for the purposes of the present paper are the risk involved in having to work with non-transparent models based solely on the responses to a set of test probes. This cannot be a validation in the normal sense of the word, only a limited set of responses (almost pivot point analyses) as a basis for judgment.

The question is left: is one of the things wrong with freight models that they are not all transparent? That the implied assumptions and relationships obscured? Does this mean that the ability to match models (all of which are limited) to application situations is not always possible?

SUMMARY

This paper has considered a range of temporal and target requirement domains for freight transport modeling, and draws conclusions on which forms of new data, what kinds of new theories and what the barriers appear to be to developing the different approaches to modeling and problem formulation most appropriate to meet new and emergent demands in each domain. Some of the unease over the current state of freight modeling is due to the wider range of clients they are asked to serve, and to a lack of correspondence of their goals with traditional transport planners and policy forecasters.

Some is due to the wide range of model types involved, which may range from models of the number of trips generated by a new industrial or residential development to forecasting the likely response of shippers and carriers to changes in operating regulations, financial inducements or increased user charges. The models developed for passenger modes are far better understood, but a simple transfer of the estimation methods to freight vehicles (or shipments) will not in general provide a satisfactory basis for modeling, forecasting or response prediction: the passenger and freight systems are genuinely different.

What is 'wrong' with freight models is not simply the limitations that they have built into their formulations, but also a wide lack of understanding as to exactly what these limitations actually are.

Certainly, shortages of data are a contributing factor, but the central issue is that the rising requirements for freight modeling are a result of growing importance in transport and economic functioning. The forecasting needs are not technically well handled as yet, as they need to handle the economic growth and activity aspects in which transport is embedded considerably better. This is also true of passenger demands, but to a lesser extent, as freight is so tightly connected to economic activity. The technical changes in supply chain management may be presented as where freight models are deficient, but it is equally true that the regulatory instruments are poorly handled. The implied assumption in many economic models, of dull information, is rarely true and so second best models of agents in the freight system working with limited data and less than ideal decision making capacity are as important as the optimizing efficiency of single company supply chain optimizations.

This paper addresses the need to develop a process to spell out the areas of success and failure – and thus where major efforts should be directed. That many freight models are limited and constrained, yet do a sound job for the limited situations for which they were designed is a success. Freight systems are increasingly complex. Our conclusion is that the expansion of the interlinking of industrial, economic and transport systems is placing high demands on freight modeling first. It is also the case that freight modeling starts some way behind passenger modeling.

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LIST OF FIGURES

Fig.1. A typology of categories of 'freight models' linked to '4 step' tools

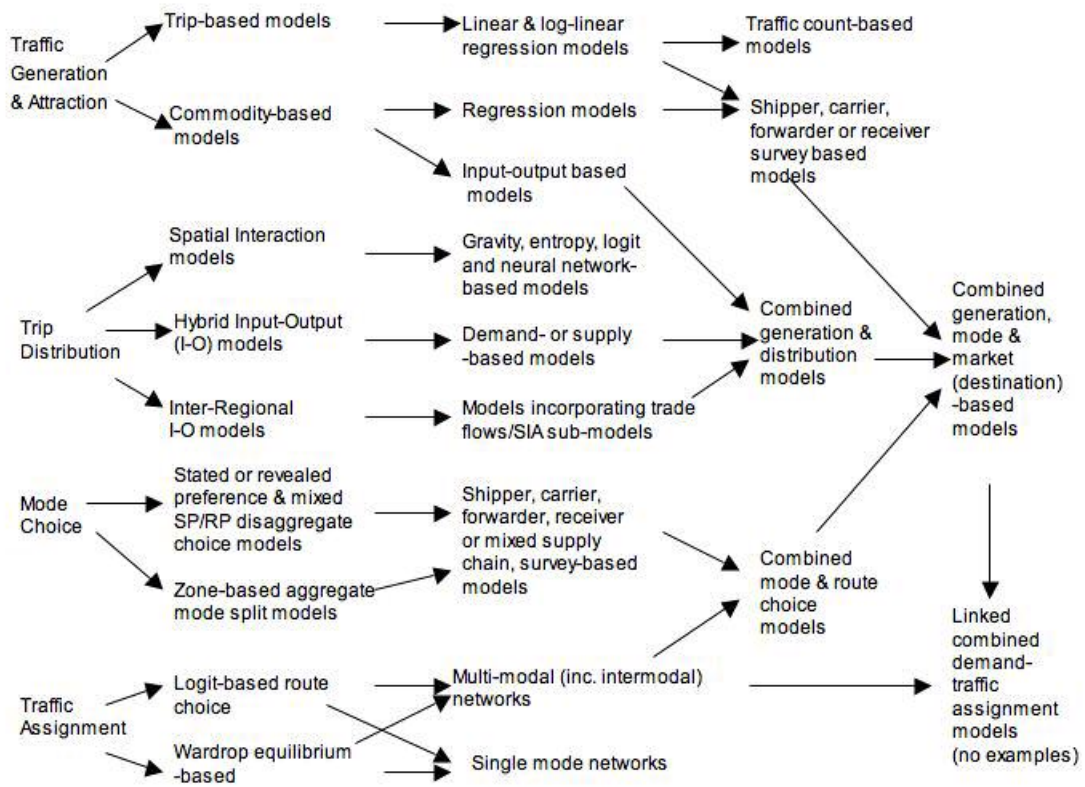


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