Transport Policy 35 (2014) 176–185

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Multi entity perspective freight demand modeling technique: Varying objectives and outcomes

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ARTICLE INFO

Available online 7 June 2014

Keywords:
Freight demand modeling
Freight analysis framework
Freight planning
Multi-modal transportation modeling

ABSTRACT

The importance of freight transportation modeling and forecasting to better address planning issues is well recognized by policy makers. Compared to advancement in travel demand modeling for passenger travel, however, current freight demand modeling methods are not yet in the adequate levels to assess increasingly complex and important planning and policy issues. Three most important players in freight demand modeling are (a) shippers, (b) planners, and (c) policy (decision) makers who have different objectives. Past research is limited in proposing a unified methodology to address the objective of each player and to assess performance of transportation networks under conditions to achieve such objectives.

In this paper, freight demand modeling is designed to address each objective of the three players in a multimodal transportation network. A freight transportation model that combines three geographic scales—national, state, and local—is proposed and developed to capture different characteristics of short- and long-distance freight flows with a focus on state-level modeling in Maryland. Data for the model include freight flows by commodity and by Freight Analysis Framework (FAF) zones, which are further disaggregated to Statewide Modeling Zones in Maryland; a transportation network with detailed link level attributes; user costs in addition to all details needed for the travel demand model. In the modeling framework autos are simulated simultaneously with trucks in a multi-class user equilibrium traffic assignment. The results demonstrate the network performance and key information on travel characteristics for each player. The proposed tool can be used for freight travel demand modeling for analyzing impacts of policies at state, county and local levels.

1. Introduction

In recent years, concerns with traffic congestion, energy consumption, and green house gases are increasingly garnering attentions in United States (US) major metropolitan areas. According to the Texas Transportation Institute (TTI), commuters in 439 US urban areas are spending extra 4.8 billion hours or 34 h per driver in each year, and wasting 3.9 billion gallons of fuel due to congestion (TTI, 2011). In addition, $23 billion of the total delay cost ($101 billion) was the adverse effect of congestion on truck operations without including any value for the goods transported by trucks. Since traffic congestion is an inevitable by-product of a vibrant economy, it is important to cope with it in an effective way in order to make an urban transportation system work efficiently. In particular, moving ahead for progress in the 21st Century (MAP-21) explicitly recognized freight transportation is vital to economic growth. In the past similar transportation authorization, the Transportation Equity Act of the 21st Century (TEA) called for an increase in accessibility and mobility options and enhancing integration and connectivity of the transportation system for freight transportation as well as for passenger travel (FHWA, 1998; Pendyala et al., 2000). Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) allocated funding of over $4.6 million per year over three years to improve research, training, and education specifically for freight transportation planning (FHWA, 2005).

Transportation modeling and forecasting have an important role to address in planning and policy issues, ranging from general and long-range planning and project prioritization to modal diversion and economic assessment. Compared to significant advancements in travel demand modeling for passenger travel in the last four decades, however, current freight demand modeling methods are not yet at adequate levels to assess increasingly complex and important planning issues. The relatively slow progress in freight modeling is due to the evolving nature of behavioral theory and lack of publicly available

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http://dx.doi.org/10.1016/j.tranpol.2014.05.002
0967-070X/

data (Pendyala et al., 2000). Literature suggests that there are three primary stakeholders in the freight industry, who either influence freight transportation policy or get affected by freight policy changes. In addition, past research is very limited in proposing a unified methodology of freight demand modeling to assess performance of a transportation network, carefully taking into account objectives of three players—1) shippers, 2) planners, and 3) policy makers.

Each of these three players has a different objective that is geared towards attainment of self-centered goals. First, the objective of shippers is to transport goods from an origin to a destination at the lowest travel cost (which consists of travel time, distance, and toll). Shippers ideally like to make reliable trips free from congestion and accidents to ensure on-time product delivery to customers. The objective of planners is to design and plan for an efficient, safe, and reliable transportation system through demand management strategies. The objective of policy makers is to bring revenue-generating economic activities in their jurisdiction to enhance growth. The overall goal of these players are quite complex, but the objectives are simplified for an quantitative analysis from a freight demand modeling perspective as discussed in this paper.

The objective of the paper is to examine the network performance and freight travel behavior at national, state and local levels when different goals are considered from shippers, planners, and policy makers. The scope includes:

- Methodology of long distance truck travel demand model
- Scenarios on objectives of shippers, planners, and policy makers
- Application of the methodology in a real world case study

In this paper, in order to clearly account for the objectives of the three important players, a freight transportation model is designed and applied to capture different characteristics of short- and long-distance freight flows in a multimodal transportation network, combining three geographic scales—national, state, and local—with a focus on long-distance truck trips at the state level. These freight flows are modeled in network conditions that vary by time of day and also in uncertain market conditions in which freight demand can vary by each of the three objectives. The proposed model is evaluated in terms of vehicle miles traveled (VMT), congested lane miles (CLM), and vehicle hours of delay (VHD) at different levels of geography, including (1) statewide level, (2) facility type level, and (3) corridor level in Maryland.

This paper is structured as follows. The next section provides a brief literature review of freight demand modeling with a focus on a state-level modeling, followed by sections to describe research objectives, methodology, and data sources. Then details of analysis results and discussion are presented, and the paper concludes with future research agendas.

2. Literature review

The literature review is organized into three parts: (1) entities involved in freight planning, (2) challenges in freight travel demand modeling, and (3) performance measures used in freight planning.

2.1. Entities involved in freight planning

Freight transportation has a number of properties that makes it difficult to directly apply in passenger demand models (Pendyala et al,., 2000). Many different factors certainly influence freight flows, including commodities transported and various players involved in the freight transportation process. Given many different industries that generate truck traffic and different commodities transported, the heterogeneity of freight flows is much larger than person travel. In addition to truck operators, players outside the trucking industry have substantial stakes on how freight transportation works. First, freight trips are derived from the demand of shippers to transport goods from one place to another within a certain time limit. Second, transportation planners manage highway systems for an efficient, safe and reliable transportation system through various demand management strategies. Third, decision makers' policy decisions to bring in economic activities influence freight demand and movement on the roadway system.

The statewide study by New Jersey Department of Transportation (NJDOT, 2007, p.47) took into account different perspectives of stakeholders of freight planning in the private sector (shippers and freight operators in truck, rail, air, and maritime industries) and the public sector (departments of transportation, metropolitan planning organizations, regional port organizations, and municipal, county, and state governments). The considerations based on the survey were categorized into four areas: (1) congestion related, (2) costs associated with inefficiencies in the freight delivery system, (3) operation and coordination of the system, and (4) regulatory issues at the local and state levels. It remains unresolved how these outcomes can be incorporated in a travel demand modeling context. A study in Sweden by Behrends et al. (2008) identified city administrators, shippers, and planners as critical players in freight planning and their main objectives. While the objective of city administrators was to improve land use planning and prevent urban sprawl, shippers and planners were interested in reduction of traffic congestion and better mode split, respectively. Although these studies qualitatively discuss the importance of multiple stakeholders, neither developed a methodology to incorporate their substantial influences in planning, operations, and usage of transportation infrastructure systems.

2.2. Challenges in freight travel demand modeling

While freight can take long distance trips, a significant portion of freight trips are made at the state level. The 2007 Commodity Flow Survey reported that 33 percent ($3.9 million) of the value and 54 percent (7.1 billion tons) of the weight of all shipments were transported for distances less than 50 miles (Bureau of Transportation Statistics, 2007). Thus, the development of a robust statewide freight transportation model is essential for planning and policy decision making. It is also very important for planning purposes to develop statewide freight transportation models capable of incorporating: (1) factors that directly influence the demand of commodities (such as macro economic factors and socio-economic demographics), and (2) factors that indirectly affect the demand through changing the cost and level-of-service of freight transportation services (such as freight logistics, transportation infrastructure, government policies, and technologies) (Cambridge Systematics, Inc., 1997; Pendyala et al., 2000). A recent National Cooperative Freight Research Program (NCFRP) study reviewed the freight demand modeling techniques currently available in the field for decision making for both public and private sectors (NCFRP, 2010). The NCFRP report suggests that lack of modeling techniques prohibits accurately estimating performance measure, particularly for public sector agencies.

Since the 1980s, most freight demand models applied in practice have employed an aggregated analysis based on traditional trip-based person travel demand model, which involves following three major steps: (1) freight generations and attractions by zone, using trip rates by vehicle type and industry classification, (2) distribution of freight trips or volumes to meet demands at trip destinations, and (3) route assignments of origin-destination trips (Kim and Hinkel, 1982; Pendyala et al., 2000). Substantial progress was made in the US in the development of statewide intermodal management systems, including freight transportation, because of