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A two-stage approach for estimating a statewide truck trip table

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ABSTRACT

This research develops a two-stage approach to estimate a statewide truck origin-destination (O-D) trip table. The proposed approach is supported by two sequential stages: the first estimates the *commodity-based* truck O-D trip tables primarily derived from the commodity flow database, and the second refines the O-D estimates using the observed truck counts. The first stage uses national commodity flow data from the Freight Analysis Framework Version 3 (FAF^3) database to develop a commodity-based truck trip table, while the second stage uses the *path flow estimator* (PFE) concept to refine the truck trip table obtained from the first stage using the truck counts from the statewide truck count program. The model allows great flexibility for data incorporation at different spatial levels in terms of estimating the statewide truck O-D trip table. To show proof of concept, a case study is conducted using the Utah statewide freight transportation network to demonstrate how the two-stage approach can be implemented in practice. The results show that the proposed approach is applicable for estimating a statewide truck O-D trip table with limited resources, and can be used to conduct truck corridor analysis to determine congested links and potential bottlenecks in Utah.

1. Introduction

Statewide models including passenger and freight movements are frequently used for supporting numerous statewide planning activities. Many states use them for traffic impact studies, air quality conformity analysis, freight planning, economic development studies, project prioritization, and many other planning needs (Horowitz, 2006). According to the figures provided by the Federal Highway Administration (FHWA, 2009) and the U.S. Census Bureau (U.S. Census Bureau, 2010, 2012), the United States (U.S.) transportation system shipped a total of 17.6 billion tons of goods in 2011 to serve almost 117 million households and 7.4 million business establishments. The importance of truck demand has increased in the statewide planning process because of its strong influence on state and nation economies. Trucks are the dominant mode of freight transportation; the industry hauls 11.9 billion tons in 2011, equating to approximately two-thirds (i.e., 67%) of all freight transported in the U.S. (FHWA, 2009). Truck transportation will continue to grow over the next decade so long as the U.S. economy maintains its steady growth, international merchandise trade increases, freight sector productivity improves, and as demand for an extensive multimodal transportation network becomes available (Bureau of Transportation

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Statistics (BTS), 2004). According to the Freight Analysis Framework (FAF) database, trucks share 75% of all *domestic* freight shipments and it will be stable from 2007 to 2040 (FHWA, 2009). However, freight transportation capacity, especially roadway transportation, is expanding too slowly to keep up with demand (Cambridge Systematics, 2005). This imbalance in growth could significantly contribute to congestion at highway segments, interchanges, and highway bottlenecks or chokepoints (i.e., locations physically narrow and/or congested and hence very susceptible to incidents and disruptions). Congestion is also caused by restrictions on freight movement, such as the lack of space for trucks in dense urban areas (FHWA, 2008) as posted on the roadways due to height, length, width, weight limits, incident, or construction.

The truck origin-destination (O-D) trip table is an important component that can be used to help strategic transportation planners, providers, and government agencies to identify the potential bottlenecks in their areas. The subsequent results of a truck trip table obtained from the proposed framework will be beneficial for assisting the state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) on evaluating operational strategies to address the consequent impacts due to truck traffic including congestion, infrastructure deterioration, safety, and environment. The demand forecast can further support the long-term strategies for the infrastructure management and investment decisions.

The current practices in estimating a statewide truck origin-destination (O-D) trip table use the truck trip rates estimated either in the Quick Response Freight Manual (QRFM) developed by Cambridge Systematics (2007) or in a commercial freight database (i.e., TRANSEARCH developed by IHS Global Insight, Inc.). However, because of the nature of the shared databases, the state DOT has to spend tremendous efforts to improve the accuracy of the estimations to match the local observations (e.g., truck counts, vehicle-miles of travel (VMT), etc.). The calibration process is usually a lengthy process and requires specialized technical staff to operate. In addition, commercial freight databases (e.g., TRANSEARCH by Global Insight, Inc.) are typically proprietary, not available for public access. Many small states usually do not have sufficient resources to conduct freight surveys or employ technical staff to develop the freight demand model. Many existing models thus overlook this component or just simply make assumptions that freight trips follow some behavioral mechanism similar to passenger trips (that is, truck traffic is estimated as a function of passenger-car traffic) (Ogden, 1992). This could be a potential weakness of truck demand modeling in the statewide model, where truck flow characteristics have been determined by other contributing factors such as location factors (i.e., places of production and market), physical factors (i.e., method by which goods can be transported: in bulk, tank, flat bed, or refrigerated container), geographical factors (the location and density of population may influence the distribution of end products), and so on (de Dios Ortuzar and Willumsen, 2002).

Holguín-Veras and Thorson (2000) summarized different methods of modeling freight transportation demand, and divided them into two major modeling approaches: trip-based modeling and commodity-based modeling. For the trip-based modeling approach, the model has three major components: trip generation, trip distribution, and traffic assignment. The trip-based model does not need a modal split step as it assumes mode choice has already been selected. List et al. (2002), for instance, used the trip-based modeling method to estimate a truck O-D trip table from partial and fragmentary truck observations in the New York region. The main advantage of the trip-based modeling method is that it typically requires less data (i.e., only truck traffic counts) to reproduce an O-D matrix. However, the trip-based modeling method tends to overlook the behavioral characteristics of commodity flows. The commodity-based modeling method, on the other hand, uses the commodity flows to estimate truck flows produced and attracted by each zone in the study area. Sorratini and Smith (2000), for example, developed a statewide truck trip model using commodity flow data obtained from the commodity flow survey (CFS) and improved the estimation using the input-output (I-O) economic data. Although the commodity-based models can capture the fundamental economic mechanisms of freight movements more accurately than the trip-based models, the truck O-D trip tables estimated from commodity-based models often overlook the *non-freight* truck trips (e.g., light commercial truck or empty truck trips).

To fill this modeling gap, this research proposes a two-stage approach to estimate a statewide truck O-D trip table. The proposed approach is supported by two sequential stages: Stage 1 estimates the commodity-based truck O-D trip table primarily derived from the commodity flow database, and Stage 2 adopts the concept of path flow estimator (PFE) to refine the commodity-based truck O-D trip table using the observed truck counts. The proposed approach uses the secondary data sources available for public and research access such as the Freight Analysis Framework (FAF) database, statewide traffic counts, and socioeconomic and land use data to estimate statewide network truck traffic. A case study using the Utah statewide freight transportation network is conducted to demonstrate the application of the proposed method. This paper is divided into five sections. Section 2 provides an overview and review of methods for estimating truck O-D trip table including commodity-based and trip-based models. Section 3 explains the approach for estimating the statewide truck O-D trip table. Section 4 presents the analysis and findings in the Utah statewide freight transportation network. In Section 5, we conclude and discuss the findings and future research direction.

2. Literature review on truck O-D estimation

Holguín-Veras and Thorson (2000) summarized different ways that could be used for modeling freight demand and divided them into two major modeling platforms: (1) trip-based modeling and (2) commodity-based modeling. Fig. 1 depicts the modeling of these two approaches. This section provides a literature review based on these two modeling approaches.