MODELLING COMMERCIAL VEHICLE EMPTY TRIPS: THEORY, NOVEL DEVELOPMENTS, AND APPLICATION

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The 21st century has been characterized by the increasing role of information technology in everyday life. Modern computer systems allow for information to be transferred faster and safer through the Internet, thus making it convenient for consumers to shop online in the comfort of their homes. As this trend continues, the demand for lighter, higher-value goods increases, since they are likely to have a lower cost to the consumer on the Internet. This increase in demand, combined with population growth and other factors, is resulting in an increase in the amount of freight that has to be transported, particularly by truck. The Oregon State Department of Transportation, as well as other ports and institutions all over the United States, expect their freight volumes to more than double by the year 2040, a rate higher than the projected population growth for that state. According to the Federal Highway Administration, about 70% of small package freight is transported by trucks; resulting in a contribution by the trucking industry of 48 billion dollars to the national GDP, a 130% increase from 1990 (USDOT, 1999). In light of these trends, it is clear that better, more efficient forms freight transportation systems are essential.

A hindering factor to efficient ground transportation is the larger commercial vehicle traffic that increases congestion on the roads. This results in a significant increase in air and noise pollution as well as the number of dangerous traffic accidents involving trucks. A study by the Organization for Economic Co-Operation and Development revealed that in some European countries noise from truck traffic resulted in a property loss equivalent to nearly .4% of the national GDP.

The increase in truck traffic, along with the accompanying increase in externalities, puts pressure on the trucking industry and on Metropolitan Planning Organizations (MPOs). The trucking industry will need to handle larger delivery volumes, facing lower revenues due to the level of competition and increasingly stringent regulations for externalities. MPOs will have to improve their planning processes in order to accommodate the ever increasing demand for goods transportation. In order to do this, the organizations need more efficient demand models than the ones currently in use. In many cases, MPOs use adaptations of passenger car models to estimate freight demand in the area. Although these simplistic approaches can sometimes provide rough estimates, they are fundamentally flawed since they do not capture the key dynamics of freight phenomena.

One recurrent misconception involves equating commercial vehicle traffic to freight transportation demand, when in fact commercial vehicle traffic is an expression of how the trucking industry organizes itself to satisfy the demand, i.e., the commodity flows. As a result, a significant number of freight demand models focus on modeling vehicle-trips, which is analogous to attempting to model passenger demand for a transit system by modeling the flow of buses and disregarding the passenger flows.

Currently there are two major platforms for modeling freight transportation demand: vehicle-trip and commodity based models (Ogden, 1992). Vehicle-trip models focus on modeling the actual number of vehicle trips, which has some practical advantages. Among them are the relative ease and high-quality with which data can be obtained due to an increasing number of Intelligent Transportation Systems. Also, since the model focuses on vehicle trips it has no problem generating the number of empty trips between regions. However, these models have two fundamental limitations. The first one is that these models cannot be applied to multimodal transportation because the vehicle-trip is in itself the result of a mode choice and the selection process is not represented in the data (Holguín-Veras, 2000; Holguín-Veras, 2002). Furthermore, since the models assume that the vehicle is the unit of demand, as opposed to the commodity being transported, the model neglects the economic characteristics of the shipment that have been found to play a significant role in the majority of choice processes in the trucking industry (Holguín-Veras, 2002).

Commodity based models, as the name points out, focus on modeling the flow of goods from one region to the other (measured in a unit of weight). Since the commodities are the unit of demand, the modeler can capture the underlying factors that determine freight movement, such as value, weight, and volume. In this platform, the loaded trips are estimated by dividing the total flow from one region to the other by an average payload from all loaded trucks. The problem with commodity-based models is that they are unable to model empty trips because the commodity flow in one direction determines the loaded trips, but does not bear a relationship to the number of the empty trips in the same direction. To resolve this, some complementary models have been developed, (Noortman and van Es, 1978; Hautzinger, 1984; Holguín-Veras and Thorson, 2003).

<u>This is not a marginal issue, all the contrary.</u> The statistics show that about 20-25% of the truck traffic in urban areas, and 40-50% of intercity trucks are traveling empty (Holguín-Veras and Thorson, 2003). The official statistics in the United States clearly indicate the magnitude of the problem: <u>about 57% of the miles traveled by straight trucks, and 33% of the miles traveled by semi-trailers are empty (U.S. Census Bureau, 2004).</u> Obviously, not properly modeling such important flow—that as said cannot be proportionally added to the loaded traffic—is bound to lead to major estimation errors. The research conducted indicated that not properly modeling empty trips lead to errors on the estimation of directional traffic that are four to seven times larger than when appropriate empty trip models are used (Holguín-Veras and Thorson, 2003).

The paper reviews the modeling approaches that have been suggested to model empty trips, and proposes novel formulations that lead to improved estimation performance. The models range from simple naïve formulations to some more complex ones involving trip chains, destination choice processes, and memory components. The performance of the alternative formulations to model empty trips is assessed by applying these models to sample data sets from different countries. The formulations developed and discussed in the paper have been successfully applied in a number of different countries including Sweden, Norway, Guatemala, and Colombia. The paper starts with some background information on the subject, followed by a brief description of previous developments in the area, a description of the test cases for the model, the methodology, and finally the results and conclusions.

1.1 References

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