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A time-period choice model for road freight transport in Flanders based on stated preference data

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ABSTRACT

This paper presents one of the first models explaining the choice of time-period in road freight transport. Policies that would shift some fraction of the trucks from peak to earlier and later periods will contribute to the reduction of congestion. Therefore there is an increasing interest in modelling the time-period sensitivity of road freight transport to changes in travel time and cost by period. The model developed here is based on a stated preference survey amongst receivers of goods in Flanders and was implemented in the strategic freight transport model of the Flemish authorities.

1. Introduction

Considerable literature exists on time of day models, which explain the choice when to travel (e.g. in the morning peak, before it, after it) using different discrete time periods. Most of the literature refers to passenger transport (e.g. de Jong et al., 2003; Börjesson, 2008; Koster, 2012). Especially in the academic literature, models for departure or arrival time choice are often based on the scheduling model (Vickrey, 1969; Small, 1982), which represents the trade-off between travel time on the one hand and arriving further away from one's preferred arrival time (PAT) on the other hand. Many travellers, especially for work trips, would prefer to arrive in or shortly after the morning peak, but this would lead to long travel times because of congestion in the peak.

In model systems that are used for forecasting and project appraisal (through cost-benefit analysis), time period choice is usually missing and the allocation to time periods is done using fixed time-of-day fractions. However, there is evidence, especially in passenger transport, that departure time choice is rather sensitive to changes in time and transport costs (often more than mode choice; see de Jong et al., 1998; Hess et al., 2007a,b). There are some practical transport passenger transport models that include a choice model for time period choice, such as the Dutch National Model system LMS (Daly et al., 1990; Willigers and de Bok, 2009; Significance, 2011) or TRESIS (Hensher, 2008) for Sydney. These models usually do not implement a full scheduling model with preferred arrival times (especially because data on PATs are very hard to obtain). An exception is the SILVESTER model for Stockholm (Kristoffersson, 2011).

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In freight transport model studies for transport authorities, time-of-day choice models are almost non-existent. Many freight transport models produce forecasts for a full year as the time dimension and do not consider time scheduling at all. However, freight transport models that include network assignment (especially for road), and especially model systems where the assignment of trucks takes place together with that of cars, need to consider the allocation to time-of-day periods. As in passenger transport, this is then done using fixed fractions.

Car traffic is often heavily peaked and could be spread more evenly over the day if the right incentives were in place. Road freight transport is considerably less peaked than car traffic. This has to do with the fact that freight does not have to arrive at the work starting time, but can be delivered as long as the receiver is open (though a carrier will often have to serve multiple destinations within a single time window). Also carrier firms and shippers with own account transport have an incentive to use their vehicles during the whole day, to reduce the fixed cost per kilometre driven. Nevertheless, there are many trucks on the road during the morning and afternoon peak and congestion could be reduced by shifting not only cars but also trucks to periods before and after the peaks. Transport authorities therefore are interested in learning about the sensitivity of road freight transport in terms of shifts away from the peaks as a result of changes in the level of congestion and possible new transport policies involving road user charges that are higher during the peaks than off-peak.

This paper presents a model for time-period choice of receivers in road freight transport, to be used as a component in the Strategic Flemish Freight Model (SVV). This is a practical freight transport forecasting model used by the Flemish government for the preparation and support of decision-making on large scale infrastructure projects for rail and inland waterways and for the calculation of a truck matrix for the Flemish strategic passenger transport models. The network and zoning system of this transport model contains most of Europe. The study area itself is the Flanders region (the Northern half of Belgium), the base year is 2004. Scenarios are available for 2008 and 2020. The model considers road, railway and inland waterways as possible modes. This model is based on a classical four-step traffic model, but with several additions, such as a (relatively straightforward) logistic module and a vehicle type choice model.

The current SVV does not contain an explicit time-period choice model. But in the new version, a module is implemented that determines how many road freight vehicles will depart earlier/later in response to increasing transport times (i.e. congestion) and/or increasing transport costs (e.g. road user charging that is differentiated by time-of-day). As such, it is one of the first time-period choice models in freight transport in the world.

In the next section of this paper, the existing literature on time-period choice models in freight transport is presented. In the third section, the questionnaire used and the SP experiment on time-period choice in freight are described in detail. The fourth section reports on the outcomes of the survey and the estimation results for the discrete choice models. After this, Section 5 presents simulation results from this new model. A summary and conclusions are provided in Section 6.

2. Time-period choice models in the freight transport literature

Some (larger) firms in freight transport and logistics use optimisation methods and software for scheduling their trips on a specific day. It might be possible to base a time-period choice model on the literature on scheduling within a firm. However, the transfer from individual firms to entire regions or countries is all but straightforward, whereas these private sector models also do not focus on congestion and peak-charging. We decided to restrict the literature review to studies that refer to entire cities, regions or countries.

Examples of time-of-day choice models in the sense of scheduling models in freight transport can be found in Halse et al. (2010) for Norway and Significance et al. (2013), but these were studies to derive values of time and reliability in freight transport, not studies to develop practical freight transport forecasting models.

In the past decade, experiments and model simulations were carried out in New York City concerning policy measures to shift road freight vehicles delivering during the day to delivery during the evening or night (Holguín-Veras, 2008; Holguín-Veras et al., 2006, 2007, 2008, 2012; NCFRP, 2013; Ozbay et al., 2006). Most of the analyses were done by the Renselaer Polytechnic Institute, Rutgers University and Cambridge Systematics. The day was usually defined as between 07:00 h. and 18:00 h., and evening/night as the complement. Policy measures that directly affect the costs borne by the receivers of the goods turned out to be much more effective than tolls with a higher tariff during the day, because most carriers did not increase their rates (only 9% increased the truck rate) or only by a small amount as a response to the toll, and also because these additional costs for the receivers were clearly outweighted by the additional costs of staying open longer. This is an important policy conclusion.

The above-mentioned studies do not present elasticities for changes in transport cost on time period choice. We made some tentative calculations on the basis of the outcomes of the American research (also making additional assumptions, e.g. on the distribution of traffic over the day in the base case and the magnitude of the transport costs; these calculations are available from the authors upon request). This results in period-specific transport cost elasticities for a shift from day to evening/night between -0.2 and -1, where the latter value does not apply to the effects of a toll during the day but to a subsidy to receivers of the goods for receiving deliveries during the evening/night.

Holguín-Veras et al. (2006) also describes a somewhat different policy. This concerns a toll on the bridges and tunnels to New York levied by the Port Authority of New York and New Yersey (PANYNJ). In 1997 an electronic toll system (E-ZPass) was introduced for cars and lorries, initially without a differentiation between time periods. In 2001 there was a change in the tariffs, which made the toll somewhat lower during the non-peak part of the day (and considerably cheaper during the