



Carrier or Mode? – The Dilemma of Shippers’ Choice in Freight Modelling

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Conference paper STRC 2008

STRC

8th Swiss Transport Research Conference

Monte Verità / Ascona, October 15 – 17, 2008

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October 2008

Abstract

What choice alternatives do shippers actually have when shipping their products to a customer: do they choose among a number of transport services offered to them by certain transport providers, or is it a choice between physical transport modes (e.g. road, rail, intermodal transport etc.)?

This question arises regularly in freight demand modelling, when Stated Preference (SP) experiments are carried out to investigate shippers' behaviour in transport chain organisation. Most research published so far has focussed on transport mode choice, whereas more recent projects have considered choice of transport service provider and not transport mode explicitly. Both approaches appear to be correct depending upon the design context. Researchers, however, often seem to neglect this question, although it is a potentially crucial design factor that must be considered when planning an SP experiment. The effect that this design decision has on freight mode choice models is as yet unexplored. This paper paves the way towards answering the question of which of these alternatives should be adopted and under what circumstances.

After a short introduction to freight demand modelling, section 2 will provide a literature review of freight mode choice studies focusing on the choice of alternatives presented to shippers in SP experiments. In the third section we will describe the design of shipper alternative choices in recent studies by the authors to help identify the factors that affect the appropriateness of different alternative designs for mode choice. We will finally draw some conclusions and end with some remarks on directions for future research in this field.

Keywords

Freight transportation, Freight demand modelling, Transport mode choice, Stated Preference (SP)

1. Introduction

Over the last decade demand modelling in freight transportation has undergone a strong development not only in Europe but in all countries, that are confronted with continuously growing freight volumes. Freight transport models have been established on regional, national and even international levels to support policy makers and transport planners in questions, such as regulation policies or infrastructure planning.

Most of these freight models, which are able to forecast in detail traffic flow volumes on the underlying network, are based on the common place four-step methodology originally developed for modelling passenger transport flows. The third of these four steps comprises the determination of modal-split functions, i.e. the distribution of the total freight volume to the alternative transport modes (for land transport mainly road, rail, and inland waterway transport). This is done by first identifying the main factors determining transport mode choice (e.g. transport cost/price, reliability, time, etc.) and second estimating the demand elasticities of the decision makers to changing values of these relevant factors. One of the most commonly used methods for estimating demand elasticities in passenger or freight transport is the administration of Stated Preference (SP) surveys.

Demand elasticities are of great interest not only for determining modal-split in the context of transport models but also for market analyses in general. In the freight transport sector this is relevant e.g. for freight operators or logistics service providers (LSP) in terms of demand forecasts for strategic and long-term planning.

In comparison to passenger transport the decision process in freight transportation is much more complex. While the passenger can choose himself which transport option suits best, a freight shipment must be organised and steered by a responsible logistics expert. The logistics expert organising the transport must know the logistics requirements of each shipment depending on the commodity shipped, the related production processes, and the available budget. In practise, the shipper (i.e. the company in charge of a shipment, in most cases identical to the sender) either has its own logistics managers or contracts an LSP to organise the entire transport chain. This is directly dependent on whether the shipper is in possession of his own rolling stock (i.e. lorries, semi-trailers, or railcars). If this is the case, then the probability is much higher that the shipper himself is in charge of the transport organisation.

For the estimation of demand elasticities using SP surveys it is essential in each experiment to present to the interviewed logistics expert alternatives (i.e. transport service offers), that are as realistic as possible. Otherwise the results from the experiments will not necessarily reflect the real-world behaviour of the respondent. This implies that the experiments must include only such attributes, which are really relevant for the decision.

At this point we are coming back to the question asked in the title of this paper: is the actual transport mode really relevant for shippers, or do they consider only price and quality attributes (e.g. on-time reliability, transport time, etc.) by choosing between the offers of different LSP (i.e. let the LSP determine the appropriate transport mode for their shipment)? In other words, which actor in transport logistics is actually in charge of the mode choice decision?

In the following section we will discuss in more detail the factors determining whether a shipper chooses between transport modes or rather between the transport offers of different carriers and give recommendations on the optimisation of the design of SP experiments.

Section 2 will provide a literature review of freight mode choice studies focusing on the choice of alternatives presented to shippers in SP experiments. In the third section we will describe experimental designs in recent studies by the authors to help identify the factors that affect the appropriateness of different designs in a given research context. We will finally draw some conclusions and end with some remarks on directions for future research in this field.

2. Experiences from existing freight demand studies

Freight demand models have been developed since the 1960s. Right from the beginning different modelling approaches were employed leading to two principal groups of models: aggregate and disaggregate freight models [WINSTON 1983]. In comparison to aggregate demand models, disaggregate models reflect in more detail the behavioural realities of freight transport decision-making including the above-mentioned question of which actor actually makes the relevant decision. The main topic of this paper is therefore relevant only in the field of disaggregate freight demand models, which covers the majority of applications over the last years.

In the following sections we analyse relevant literature with regard to the question of whether transport mode is a relevant attribute directly influencing shippers' demand for freight transport services.

2.1 Early research on shippers' freight transport demand

Although in passenger transportation research the methodology of SP surveys was introduced as early as the 1970s by Louviere and his associates (e.g. [LOUVIERE ET AL. 1973]), it was not until the early 1990s that first experiences were made with SP methods in freight demand research (e.g. [TRANSEK 1990], [DE JONG ET AL. 1992], [WIDLERT AND BRADLEY 1992], [SWAIT ET AL. 1993]). The question of mode choice in freight transportation was nevertheless

subject to studies already in the 1980s (e.g. [WINSTON 1981], [WILSON ET AL. 1986], [JEFFS AND HILLS 1990]). Among other things, these projects dealt with the question of attributes relevant for freight transport demand but generally agreed on the manufacturing firm as the relevant actor for transport chain organisation and thus for mode choice. WINSTON 1981 pointed out that besides the shipper it may also be the receiver choosing transport mode. This, however, is not really relevant for the design of shipper surveys, since both actors are on the same level regarding the organisational structure of a transport chain. Furthermore, in most cases the shipper knows the logistics requirements of the receiver and respects them in his choice of transport service and vice versa.

2.2 Designs including transport mode as a relevant attribute

The approach of shipper mode choice is also prevalent in more recent literature including studies using SP data for estimating shippers' demand elasticities as well as value of time (VOT) and value of reliability (VOR), respectively. BOLIS AND MAGGI 1999 applied Adaptive Stated Preference (ASP) experiments to estimate the monetary values of relevant demand attributes of shippers in Northern Italy. Transport mode was included as an attribute in the experiments with road, rail, and intermodal transport as available options.

JIANG ET AL. 1999 used Revealed Preference (RP) data from a shipper survey in France to estimate demand elasticities of relevant attributes for four transport modes (own-account trucking, commercial road, rail, and intermodal transport). The estimation of different elasticity values for each mode makes clear that the researchers considered the shipper as the responsible actor for mode choice.

In order to determine modal-split functions for a regional freight transport demand model in the French region "Nord – Pas-de-Calais", VELLAY AND DE JONG 2003 performed a combined RP/SP analysis based on two different shipper surveys in this region. In the SP experiments respondents had to choose between two transport mode alternatives, that were characterised by transport cost and five quality attributes (transit time, on-time reliability, additional logistic services offered, flexibility and delivery frequency). Transport modes considered were own-account trucking, commercial road, rail, and intermodal transport, intercontinental maritime shipping, and European short-sea shipping.

The research by MAGGI ET AL. 2005 focused on identifying quality attributes relevant for shippers' choice of transport services rather than on mode choice explicitly. Data was collected using an SP survey among Swiss shippers mainly from the foodstuff and retail sector. The authors considered mode choice as relevant for shippers but as directly dependent on a company's general logistics strategy. Nevertheless transport mode was included as an attribute in the experiments.

A similar goal was pursued by SHINGHAL AND FOWKES 2002 in the context of analysing shippers' freight demand characteristics in India. An SP survey was administered among shipping and freight forwarding companies shipping freight on the Delhi – Mumbai corridor. The ASP experiment design included as attributes transport mode and cost, transit time, reliability and frequency of service. Concerning the survey population this research included a mixture of shippers and freight forwarders thus putting the forwarders on the same organisational level as shippers. Therefore we conclude that the question of responsibility for mode choice seems to have been irrelevant to the researchers, i.e. that they consider mode choice as equally relevant to shippers as to forwarders.

In addition to the literature on shipper mode choice further research has been completed on transport mode choice of freight forwarders and carriers (e.g. [FOSGERAU 1996], [BVU ET AL. 1999]). In these two studies on the traffic demand for the fixed Storebælt and Fehmarnbelt crossings the decision to include transport mode as a characteristic attribute was made implicitly, because the SP surveys were conducted by directly contacting truck drivers at different freight terminals. The drivers' alternatives were simply whether to use the bridge or to continue using the ferry service.

BÜHLER 2006, however, in the context of an SP survey among logistics service providers (LSP) in Germany, assumes that most shippers having outsourced their own transport activities consider transport mode as not primarily relevant for choosing freight transport services. He concludes that, given a continuing trend towards outsourcing of transport activities, the LSP is in most transport cases in charge of transport mode choice.

2.3 Designs not including transport mode as a relevant attribute

This leads to a second (smaller) group of research projects that have not included transport mode directly as a relevant attribute for freight transport services demand. Not including mode was done either to avoid potential correlations between mode and other quality attributes or under the hypothesis that transport mode is not primarily relevant for a shipper's choice of presented alternatives in an SP choice task (see above).

WIGAN ET AL. 2000 considered carrier choice in the long-distance trucking market in Australia using a "Contextual Stated Preference" survey. Since the interest was in the trucking market, mode was included implicitly and was not something about which respondents had any choice. This type of survey is sometimes called a within-mode survey. DANIELIS ET AL. 2005 investigated the preferences of shippers' logistics managers for freight transport service attributes in two Italian regions (Friuli Venezia Giulia and Marche) using Adaptive Conjoint Analysis (ACA). Being aware that choice of freight transport services mostly depends on more than one logistics actor, the authors decided not to include transport mode as an attribute

in their ACA experiments. This was mainly due to the risk of correlations between the mode and other quality attributes. The choice alternatives were described by the attributes cost, transit time, reliability, and damage only.

The research of BOUFFIOUX ET AL. 2006 had a similar goal for a Belgian study. The researchers administered an SP survey among 113 shippers including a couple of third party logistics providers (3PL). In the design of the SP experiments transport mode was not directly included. Instead respondents were asked after the completion of the experiment whether in reality they would accept a change of transport mode in case a better transport solution (compared to the status-quo) was offered to them. This experimental design clarifies the perception of BOUFFIOUX ET AL. 2006 that shippers primarily focus on quality and cost attributes before checking whether the associated mode is generally suitable for a given shipment.

From this literature review we conclude that our research question cannot be answered in a straightforward way. A major part of the published research (whether or not applying SP methods) assumed that transport mode is somehow relevant for a shipper's choice of an appropriate transport service. Other work, however, has not included transport mode as a characteristic attribute in SP experiments due to different (and well argued) reasons.

Before giving some recommendations on how to deal with this question in the future, we present in the following section our own experiences from designing SP experiments and explain how this problem was treated in the specific applications.

3. Experiences from recent freight demand studies in Canada and Switzerland

This section describes the process of designing SP experiments for two surveys among shippers and 3PL in Canada and Switzerland.

3.1 Freight demand survey for the Quebec – Windsor corridor

This study has been described before in [PATTERSON ET AL. 2007] and [PATTERSON ET AL. 2008]. The description here concentrates on the question of how mode was incorporated into the SP survey of shippers in the Quebec City – Windsor Corridor (the Corridor) in Canada.

3.1.1 Survey description

The purpose of the research was to evaluate the extent to which intermodal transportation could compete directly with truck-only freight transportation in the Corridor. In particular it

looked at the potential for Premium-intermodal services to compete with truck-only transportation. Premium-intermodal services prioritize on-time reliability (through scheduled services and short loading and unloading times), minimize damage risk (through the use of smooth-ride technologies), and provide service schedules that allow carriers to provide the same services to their clients as truck-only services.

3.1.2 Survey population

The survey population included all Corridor “end-shippers”, which were either manufacturing facilities with more than 50 employees, or wholesalers and retailers that were either head offices or single locations with more than 50 employees at that location and all third party logistics companies. Third party logistics companies (3PLs) organize shipments on behalf of other companies. The firm’s shipping manager was the target respondent. The list of companies used for the survey was Dun & Bradstreet’s Million Dollar Database (MDDI) of all companies in Ontario and Quebec with more than \$1 million in sales or more than 20 employees. In total, 7,004 companies fell into this population.

The reasoning for the use of “end-shippers” as the sampling frame for this study requires a bit of background. In this study shipping decision-makers are generally classified into three categories: shippers, receivers and carriers. Shippers are the agents that have a shipment that needs to be delivered. The receiver is the agent to whom the shipment is destined. Carriers are the agents (trucking company, rail transport company, etc.) that actually move the shipment from the shipper to the consignee. These categories are not necessarily mutually exclusive. For example, it is possible for shippers to own their own equipment and deliver their own goods, so-called private shippers. Shippers who hire others (carriers) to ship their goods are referred to as ‘hire and reward’ shippers or shippers using for-hire carriers: referred to here as “end-shippers.” It is also possible for receivers to organize shipments. In this case, receivers can be thought to behave as shippers.

Potentially, two agents decide about using intermodal services: shippers (in this study including intermediaries such as freight forwarders, 3PLs, etc.) and carriers. In the context of the Quebec City – Windsor Corridor, carriers generally decide on mode, since the carrier organizes the movements of consignments from end-shipper to receiver.¹ So, while one might think end-shippers are indifferent to how their shipments are carried, provided they arrive in

¹ It is not necessarily the case that carrier chooses mode. In other cases it can also be shippers, receivers or intermediaries who decide on mode.

good condition and on time, carrier decisions about using intermodal services will ultimately be constrained by shipper preferences. In effect the end-shipper can be seen as the true backstop for the demand for intermodal services. As such, it was end-shippers who were the target population for this survey.

The survey occurred between mid-August and early December 2005. All companies in the list sent to the marketing firm were contacted (7,004). Of these companies, 680 agreed to participate. In the end, completed results were obtained for 392 respondents. Respondents came from all of the industries in the initial survey in the approximate proportion of the original company list, with roughly two-thirds from manufacturing and a quarter from wholesalers and retailers. Third party logistics companies were, however, slightly underrepresented at around 6% whereas there were around 10% in the entire company list. The respondents represented a relatively large spectrum of establishment sizes with the smallest being a 3PL of only a few employees and the largest an electronics wholesaler with 1,400 employees.

3.1.3 Mode in the SP survey

As described in Section 2, mode is incorporated in various ways in different studies. In some, choice is between different carriers within the same mode, so-called within-mode studies. In others, mode is included explicitly and respondents are asked to choose between alternative modal configurations for their shipments. Considerable effort was expended in trying to establish what the most appropriate method was to communicate information about shipment mode to the respondent. After a large number of interviews with potential respondents, it became clear that “end-shippers” did not generally choose the mode of their carriers. Instead, they tended to choose their carriers who might employ either truck-only or intermodal transport. In order to test the effect that mode had on the choice of carrier, this information was deemed critical to the study. As a result, mode was presented to respondents as a characteristic of their carrier and not as an explicit alternative. An example of a survey question is provided in Illustration 1.

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It is the beginning of your work day. You are responsible for sending a pallet of televisions from Montreal to Chicago. This is a by-appointment shipment that is supposed to arrive at 11 AM in two days.

Given the characteristics of the carriers, please select which carrier you would choose for this shipment:

Company	Company C	Company A	Company B
Price	\$500	\$450	\$550
On-Time Reliability	98%	85%	92%
Damage Risk	0.75%	3%	1.5%
Security Risk	0.5%	1%	1.5%
How the shipment will be carried	By rail on a portion of the trip	By rail on a portion of the trip	Truck only

Follow these links for more information on [carrier attributes](#), ["by-appointment shipments"](#), or other [shipment attributes](#).

Illustration 1: Example of Survey Question

Because of this, the form of survey instrument was most similar to a within-mode end-shipper survey of freight service choice such as that undertaken by Wigan et al. 2000. The main difference is that the Corridor study included not only standard carrier and shipment attribute information, but also information on whether the shipment would be carried by rail on a portion of the trip. We refer to this type of study as a carrier choice study.

Results of the survey and the carrier-choice model can be found in PATTERSON ET AL. 2007 and PATTERSON ET AL. 2008. For the purposes of this paper, one key result will be reported – that is the effect of mode on carrier choice. Although, according to sample respondents in survey development, they did not generally choose the mode of their shipments, knowledge of mode had an important effect on carrier choice. In fact, results imply that the odds of choosing a carrier that carries a shipment intermodally are half those of a truck-only carrier. End-shippers may not be choosing mode directly, but it certainly matters to them.

3.2 Freight demand survey in Switzerland

The latest freight demand survey in Switzerland is currently being administered in the context of a project focussing on the impact of environmental aspects on shippers' freight transport demand as described in FRIES 2007. The survey's goal is to estimate demand elasticities for the impact of freight transportation's emissions as compared to the elasticities for "conventional" attributes, such as price, reliability, transit time etc. This implies that the

research focus lies rather on the relevance of different quality attributes than on transport mode choice (cf. [MAGGI ET AL. 2005]). The underlying hypothesis is that (even if environmental concerns are not the most relevant aspect in freight transport demand), a logistics manager can in certain cases be sensitised to give higher relevance to environmental aspects when organising transports by providing a him or her with information on the environmental performance of the firm's shipments.

Regarding the survey population the SP survey therefore focuses on manufacturing companies (i.e. shippers). It covers all commodity groups relevant for freight transportation in Switzerland.

For the experimental design the main goal was to include the most important attributes of shippers' demand plus a variable representing greenhouse gas emissions (GHG) while limiting the total number of attributes displayed in each choice task to four or five. Based on the recommendations of a group of logistics experts from the retail and freight forwarding industry as well as on experiences made during an earlier SP survey in Switzerland [RAPP TRANS AND IVT 2008], we decided to include in the experiments price, on-time reliability, transit time, GHG emissions, and transport mode.

The question whether or not to add transport mode as an attribute was subjected to careful consideration. In order to gain empirical evidence, a number of shippers from the 2007 survey were contacted again to state whether they tend to choose between offers of different LSP or rather directly between transport modes. Although a sum of 18 responses cannot be considered as representative, the results show a clear tendency (see Table 1). Generally it must be differed between shippers using own-account trucking (i.e. an own vehicle fleet) for at least part of their shipments and others that are not in possession of own vehicles.

	Transport mode	Logistics service provider (LSP)
Own-account trucking	7	0
No own-account trucking	4	7

Table 1: Results of the preliminary survey (number of responses counted per category)

The result that 100% of the shippers using own-account trucking choose the transport mode themselves appears logical, since the shipper himself must decide for each shipment whether to "make" or to "buy". In case the shipper has outsourced all of his own transport activities, the situation is less clear. Seven shippers out of eleven (64%) stated that they tend to choose between different LSP.

There are several reasons for different decision-making processes among the specific firms, but one central aspect are certainly the shipment characteristics: if a shipment's special logistic requirements (e.g. careful handling, cooling, etc.) are low and if it can be shipped in standardised transport units (e.g. pallets, containers, etc.), then no special equipment is needed for transport, transshipment, and storage. In this case the specific characteristics and abilities of the single transport modes are less important to the shipper so that it can rather leave the proper mode choice to the LSP. This hypothesis is also supported by the empirical results: 69% of the transport examples² of the shippers choosing between LSP were palletted goods and other general cargo with no special logistic requirements.

The decision to include transport mode in the SP experiments was finally made based on the idea not to limit the survey to only one of the shipper groups (i.e. with or without own-account trucking), since this would have reduced the total survey population significantly. The result was a compromise similar to the one made in the Canadian survey (see above): the alternatives in each choice task were not labelled as "modes" explicitly but rather as neutral transport service offers (denoted as A, B, and C). Transport mode was included as a characteristic attribute of these offers. In other words, interviewed shippers have to choose between offers of different LSP. Mode is just one attribute out of five (i.e. mode plus price, on-time reliability, transit time, and GHG emissions), which were identified as potentially relevant for the shipper. Using this experimental set-up the respondent does not necessarily have to consider mode in his choice, but it is equally possible for him to exclude a given alternative due to mode-specific constraints.

4. Conclusions and recommendations

In this paper we have reviewed different research projects that have used Stated Preference methodologies for demand modelling in freight transportation. The first conclusion is that the mode by which freight is shipped is important to the shipper. At the same time, there is no simple "yes" or "no" to our main question: do shippers choose transport mode explicitly or is mode simply a characteristic of different carriers or logistics service providers (LSP).

The main problem is that we must distinguish between two different types of shippers: on the one hand "private" (or "own-account") shippers transporting their shipments with their own vehicles, and on the other "hire-and-reward shippers" (or "end-shippers"), that completely outsource freight transport activities. These two types of shippers each have a different focus concerning freight transport demand.

² These transport examples were collected during the 2007 main survey to be used in the SP experiments.

End-shippers do not own their own transportation equipment. They rely on other companies that *do* own equipment to carry their shipments. As such, they appear to choose between specific offers of different LSPs but not mode explicitly. It is LSPs that decide on shipment mode based on the shipper's price and quality requirements. A transport service's price and quality characteristics (including transit time, on-time reliability, damage rate, etc.) are crucial for the end-shipper, but mode plays a non-negligible role that is an implicit part of their choice. Some possible reasons for the importance of mode on LSP choice are for example certain mode-specific characteristics (e.g. larger shipment sizes in rail transport or the greater time-flexibility for loading and unloading railcars due to longer dwell times at the loading platforms) or simply positive or negative experiences the shipper's logistics manager has made with a specific transport mode in the past.

Private shippers appear to choose transport mode. Since these companies possess their own vehicle fleets (be it lorries and/or railcars), they actually have the possibility of choosing to use their own equipment or not thus implicating an explicit choice of mode. If a private shipper uses for example own lorries, it can choose to have them travel by road or by intermodal transport. If it decides not to use own equipment for a shipment, the private shipper must choose whether to mandate a commercial trucking service or whether to use another mode.

Based on these findings we recommend considering the question of shippers' mode choice very carefully when setting up SP surveys for freight demand modelling. The following questions may be used as a checklist to assure choosing an appropriate experimental setup for a specific target group:

1. What type of survey is planned? Are several or only one transport mode considered?
2. Is the question of mode choice relevant in the context of the project?
3. Which actor in the organisational structure of the transport chain does the survey focus on? (Try to avoid any mixture of actors.)
4. If the survey includes shippers, what type of shippers will be considered in the survey population (private shipper, end-shipper, or both)? If end-shippers are considered, avoid explicit mode choice designs; better include mode as an attribute of an LSP's offer.

Concerning future research, it would certainly be worthwhile verifying the results of this review by a formal testing of the models resulting from the different experimental setups subject to the two types of shippers. The statistical significance of the mode parameter could be taken to test the hypothesis that mode is a relevant factor. Another possibility would be to

test different surveys on respondents from the same sampling frame. For example, a future study on freight mode choice could include two different surveys: one that included mode explicitly and the other that included mode as a characteristic of carriers. Different models could be estimated using the different datasets, and an evaluation of the resulting models could then be made. In this context the transferability of the results to other geographical regions would also be a question to discuss. Although the comparison of the Canadian and the Swiss survey suggests a similar behaviour of shippers in different markets, a more general verification would be interesting.

Furthermore, based on the questions above, it would be helpful to expand these recommendations to a proper checklist in form of a structural diagram. The goal would be to create a more detailed decision structure that researchers could follow when designing an SP survey on freight transport demand.

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