INTERMODAL DECISION MAKING IN BRAZIL

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ABSTRACT

This article presents a stated preference experiment developed to model logistics decision making on a strategic level to select road or intermodal alternatives for general cargo transport in Brazil.
It starts from the premise that this kind of decision making involves a tradeoff among logistics cost, service level attributes and a subjective attribute related to the "Brazilian road transport culture", in other words, the natural tendency of cargo owners to use truck transportation.
From the modal split model calibrated, it was possible to formulate a utility function that when incorporated into a multinomial logit model showed a good representation of Brazilian transport of general cargo, 87% of which is carried by road and 13% by intermodal transport.
The sensitivity analysis of the attributes of the utility function calibrated showed the relative importance of the logistics cost, service level and modal tendency attributes, verifying their possible impacts on the relative uses of road and intermodal transport. The results showed that logistics cost is the main attribute considered when making a strategic choice among different alternatives for hauling general cargo in Brazil, so that an intermodal alternative costing 20% less than the pure truck alternative can capture 100% of demand.

Keywords: intermodality, intermodal decision making, stated preference technique, general cargo in Brazil

INTRODUCTION

In Brazil, the use of intermodal transport for general cargo is still incipient. Studies conducted by the National Land Transportation Agency (ANTT, 2004), the federal land transportation regulator, indicate that approximately 87% of general cargo is carried by trucks and trains. Since railway, coastal and river-borne transportation have lower unitary costs than truck transportation, changes in the Brazilian transportation matrix would allow goods to reach end consumers at lower costs.

This article presents a procedure developed through a stated preference technique experiment (SPT) to propose based on scientific literature, criteria used for decision-making at the strategic-planning level for the choice between road and intermodal transport for general cargo in Brazil. This procedure enables evaluation, in the opinion of cargo owners, logistics planners and experts, of the relative importance of selected attributes for the choice among different logistic alternatives for general cargo transportation.

The study investigates the hypothesis that there is an unexploited intermodal potential for general cargo transportation in Brazil. To evaluate this hypothesis, we start from the premise that the attributes for analyzing logistics alternatives for the flow of general cargo in Brazil involve a tradeoff between the logistic cost and service level attributes and another attribute related to the "Brazilian road transport culture", which is the natural tendency of cargo owners to use trucking in detriment to other transport modes.

First we describe the current context of the use of intermodal transport of general cargo in Brazil, especially rail combined with cabotage (coastal and river shipping[1]). Then we present a brief review of the literature on the procedures that have been used to analyze modal transport choices, based on the SCE to model the problem. After that, we present the results and a critical analysis of the survey of general cargo carriers and specialists, before presenting our final considerations.

INTERMODAL TRANSPORT OF GENERAL CARGO IN BRAZIL

Since 87% of general cargo in Brazil is transported by truck, there is great potential to increase the use of intermodal transport, particularly using railroads and coastal/river shipping. Some of the advantages of railway in comparison with roadway transport are the potentially lower total costs obtained by scale gains and the greater security from fewer accidents and thefts. However, according to Gonçalves (2005), the dependability of trains in meeting delivery schedules is still a negative factor for some potential cargo owners.

Despite this reluctance by shippers, Brazilian railroads have been carrying increasing amounts of general cargo, especially in containers. This trend became markedly stronger after the privatization of the national railroad system in the 1990s. According to the National Land Transport Agency (ANTF, 2007), in 1997 the country's railroads carried 3,460 TEUs (twenty equivalent units), while in 2006 this figure was 205,370 TEUs, a huge increase of 5835%.

The main railway operators carrying general cargo in Brazil are América Latina Logística (ALL), Vale Logística and Transnordestina Logística S.A. (TN)[2]. These companies are implementing customized intermodal projects to increase their general cargo flows. Table 1 summarizes the main aspects of the intermodal projects developed by these companies, to carry products for the mining and metals, food and beverage industries.

Analysis of Table I shows that intermodal transport can provide advantages to customers. These mainly consist of cost reductions and/or better service levels. These projects have

[1] Particulary on the Amazon, which is navigable by oceangoing ships past the city of Manaus.

[2] The first two are principally carriers of soybean and of iron ore and other minerals for their mining and steel company owners, respectively.

entailed close interaction between the logistic companies and their customers at all steps: formulation, implementation, monitoring results and efforts to achieve improvements.

Table I - Examples of intermodal projects implemented in Brazil

Companies	Cargos	Origins	Destinations	Type of loading	Intermodal options	Advantages
SLC Alimentos	Processed rice	Procesors in the cities of São Borja (RS), Alegrete (RS) e Carnaquã (RS)	Retail outlets in the states of São Paulo, Rio de Janeiro and Minas Gerais.	Palletized cargo	Road- Railway-Road	logistic cost redutions
CSN	Siderurgic products	Plant in the city of Volta Redonda (RJ)	Clients of the state of Rio Grande do Sul	Fractioned cargo	Railway- Road	logistic cost reductions and better service levels
Coca-Cola	Soda cans	Plant in the city of Fortaleza(CE)	Supply center in the cities of Teresina (PI), Crato (CE) and Salvador (BA)	Palletized cargo	Road- Railway-Road	better service levels
AMBEV	Beer crates	Plant inthe city of Fortaleza(CE)	Distribution center in the city of São Luiz (MA)	Palletized cargo	Road- Railway-Road	better service levels (reduction in damage and theft rates)
	Empty beer bottles	Distribution center in the city of São Luiz (MA)	Plant in the city of Fortaleza(CE)	Fractioned cargo	Road- Railway-Road	better service levels (reduction in damage and theft rates)

Source: ALL (2008), TN (2008), MRS (2008), adapted by the authors.

Coastal and river shipping is another viable transport alternative to compose the supply chain of certain productive sectors in Brazil. According to the National Waterway Transport Agency (ANTAQ, 2007), cargo movement by cabotage is still incipient. In 2007 this flow was approximately 44.8 million tonnes (metric tons). Of this total, about 23% referred to general cargo. Currently the main general cargo concentrating port is Santos, accounting for some 25% of cabotage operations. Other important ports for this type of shipping are Paranaguá (13.3%), São Francisco do Sul (12.6%), Suape (10.5%), Itaguaí (10.3%) and Manaus (8.4%).

According to the ANTT (2004), the two main logistic operators engaged in cabotage in Brazil are Aliança Navegação e Logística Ltda. and Mercosul Line Navegação e Logística Ltda., both of which offer door-to-door service at the main Brazilian and other South American ports. These operators' voyages mainly carry foods, chemicals, paper and construction materials from the South and Southeast regions of Brazil to the country's North and Northeast regions, and electrical/electronic appliances and beverages from the Manaus Free Trade Zone[3] and steel and chemical products from the cities of Salvador, Recife and Fortaleza in the Northeast region to the South and Southeast regions.

REVIEW OF THE LITERATURE – PROCEDURES USED TO MODEL THE MODAL CARGO TRANSPORT CHOICE

Harker (1985) argued that the modal choice for carrying cargo involves evaluation of a large number of factors, related to the market, actors, infrastructure, legislation and technology. Furthermore, according to him, this choice is also related to the organizational objectives of

[3] Created to foster production of products with high aggregate value in the Amazon region's main city.

customers regarding economics and production and distribution systems, as well as external characteristics, such as the socioeconomic setting.

Investigation of the literature shows there are a wide range of methods utilized to model the freight transport modal choice. These procedures are normally composed of more than one step, in which different methods and tools to model cargo transport demand are employed.

The use of a disaggregated behavioral model of the multinomial logit type (MLM), adjusted based on a utility function calibrated by the stated preference technique (SPT), has frequently been used to model modal choice for freight transport. Examples are the works of Vieira (1996), Senna & Staton (2003), Effron & Rose (2003), Novaes et al. (2006) and Danielis & Marcucci (2007).

Other works have employed procedures involving the use of revealed preference (RP) data, i.e., real observations of modal choices made by cargo owners to calibrate the representative utility function of the modal choice model. Among them are the studies of Rich et al. (2009), Malchow & Kanafani (2004), Tsamboulas & Kapros (2000), Abdelwahab (1998), Nam (1997) and Castro (1988).

The joint adjustment of the utility function with stated and revealed preference data, as proposed by Hensher et al. (1999), is another possibility to model the choice of cargo mode, but it is still incipient. We did not find any studies of cargo modal choices using this approach, which is more often applied to passenger modal choices, as in the works of Cherchi & Ortúzar (2002), Cherchi & Ortúzar (2006) and Espino et al. (2007).

Baumol & Vinod (1970), examining the modal choice by shippers, demonstrated that the optimal choice involves a tradeoff among freight rates, speed, dependability (expressed as variances in operating speed) and en-route losses. From this analysis they proposed an inventory theoretic model (ITM), which analyzes the modal choice from a perspective of total logistic cost.

This perspective, widely disseminated in the field of business logistics, such as in the works of Lambert & Stock (1998), Novaes (2004), Ballou (2006) and Christopher (2007), has been revisited recently in scientific works on cargo transport modal choice, as in the studies of Wang (2008), Vernimnen et al. (2008), Kutanoglu & Lohiya (2008), Eskigun et al. (2007) and Jong & Ben-Akiva (2007).

The incorporation of external costs in modal choice modeling is increasingly frequent among both transport planners and shippers. While for the latter the measurement of external costs can be converted into carbon credits and help improve the organization's socio-environmental image, for the former the measurement of attributes related to social and environmental aspects can help make a determined infrastructure investment feasible.

Janic (2007) proposed including the joint analysis of external and internal costs for modal choice in European transportation policy planning. The procedure for analyzing external costs in the modal choice process normally entails measuring them for the different levels of demand that can be attracted by intermodal transport and subsequent analysis of the cost-benefit ratio from implementing a particular operation or not.

The external costs usually measured are related to environmental costs such as air pollution from burning the various fossil fuels used and social aspects related to accidents, noise levels and number of jobs created. In this line of investigation, Ricci & Black (2005) presented a method to calculate the external costs over an intermodal chain.

To facilitate the modeling and choice of freight transport modes, specific decision support systems have been developed, such as SMILE in Holland (Tavasszy et al., 1997), ITIC-IM in the United States (USDOT, 2005) and SISLOG in Brazil (ANTT, 2004).
Table II summarizes the procedures and respective authors consulted.

Table II – Procedures and authors reviewed

Procedures	Authors
Multinomial logit model with stated preference technique	Vieira (1996), Senna & Staton (2003), Effron & Rose (2003), Novaes et al. (2006), Danielis & Marcucci (2007)
Revelead preference data	Castro (1988), Nam (1997), Abdelwahab (1998), Tsamboulas & Kapros (2000), Malchow & Kanafani (2004), Rich et al. (2009)
Conjoint use of revelead preference data and stated choice methods	Hensher et al. (1999), Cherchi & Ortúzar (2002), Cherchi & Ortúzar (2006), Espino et al. (2007)
Iventory theoretic model	Baumol & Vinod (1970), Lambert & Stock (1998), Novaes (2004), Ballou (2006), Christopher (2007), Eskigun et al. (2007), Jong & Ben-Akiva (2007), Wang (2008), Vernimnen et al. (2008), Kutanoglu & Lohiya (2008)
Analysis of external costs	Ricci & Black (2005), Janic (2007)
Use of systems to support decision	Tavasszy *et al.* (1997), ANTT (2004), USDOT (2005)

STRUCTURED PROCEDURE TO ADDRESS THE PROBLEM

The main analytic instrument of the procedure developed here is a disaggregated behavioral model of the multinomial logit type (MLM), adjusted by a utility function calibrated by the stated preference technique (SPT), as done by Vieira (1996), Senna & Staton (2003), Effron & Rose (2003), Novaes et al. (2006) and Danielis & Marcucci (2007).
According to Novaes (1986), behavioral models seek to relate users' basic motivations with the attributes of the transportation system. For him, the behavioral focus permits a deeper analysis of the user's decision process, in an effort to answer questions not covered by conventional models, such as whether or not the user will choose a particular service.
According to him, one of the premises of the behavioral focus is that the individual subjectively or objectively establishes a list of alternatives in an order of preference, and always chooses the most desirable, given the set of personal costs and according to the economic and financial conditions and available opportunities. A second premise is that individuals, although including subjective factors in their decisions, maintain the same behavior pattern over time. In other words, it is assumed that behavior patters, even though partly subjective, are not erratic or totally random. Instead, they are affected by determined conditions. Another premise utilized in behavioral models to predict transport demand is that the product the consumer or user acquires is not something singular or unique, but rather a package of options.
For Schmitz (2001), the SPT can be defined as a set of methods to obtain information on individuals' behavior or possible changes in their preferences by presenting them with some hypothetical scenarios. According to him, one of the main characteristics of the SPT is the possibility of dealing with the expected behavior of interview subjects instead of their real behavior. This occurs because the respondents are encouraged to demonstrate their preferences when faced with real and/or hypothetical scenarios defined in advance by the researcher. These scenarios inform the respondents about the most relevant implications of

the options that are proposed, with the intention of not only creating realistic settings, but also of exploring as much as possible the tradeoffs associated with the choices made.
According to Schmitz (2001), the main advantages of the SPT are:

- The perception of value attributed by users to different attributes being analyzed;
- The possibility of evaluating qualitative variables, such as dependability, hazard levels, etc.;
- The possibility of evaluating alternatives, scenarios or situations the do not exist yet.

The preferences of users (consisting of cargo owners and transport planners) can be quantified and formulated by means of a utility function, which can be calibrated from the results of a survey applying the SPT. The utility function normally assumes the form of additive compensatory models, since one attribute can improve when another worsens while still maintaining the same utility level. This function has the following general configuration:

$$\mathrm{Ui} = \mathrm{a} \cdot \mathrm{X}_{1\mathrm{i}} + \mathrm{b} \cdot \mathrm{X}_{2\mathrm{i}} + \ldots + \mathrm{c} \cdot \mathrm{X}_{\mathrm{ni}} \qquad (1)$$

Where: U_i: utility of alternative 'i';

X_{1i}, X_{21}, X_{ni} : attributes related to alternative 'i';

a, b, c: coefficients of the model.

The model's coefficients (a, b, c) can be used for various purposes, among them to determine the relative weight of each attribute included in the model.

Once the utility model is calibrated, the data necessary for using the MLM are obtained, as presented in Equation 2, from which it is possible to specify the probability of choosing each alternative in the demand forecasting models and to analyze the sensitivity of the attributes evaluated, to verify their elasticities and impacts on transport demand.

$$P_i = \frac{e^{Ui}}{\sum^{n} e^{Uj}} \qquad (2)$$

Where: P_i: probability that alternative 'i' is chosen;

U_i: utility of alternative 'i'

U_j: utility of the 'j' alternatives considered;

e: the base of the natural logarithms (2.78182…).

To estimate the coefficients of the utility function (Equation 1) to be incorporated in the multinomial logit model (Equation 2), we used the maximum likelihood method. According to Ortúzar (1994), the aim of this method is to estimate the parameters of the model from a sample so as to maximize the probability of obtaining the particular event analyzed. In this study, we performed this procedure with the LMPC software.

STATED PREFERENCE STUDY

Our aim is to develop a procedure to evaluate the relative importance, in the opinion of general cargo shippers and specialists in logistics and freight transport planning in Brazil, of certain attributes for choosing among different transport alternatives, at a strategic planning level. For this purpose, we first performed an exploratory stated preference survey, as described below.

Experimental Setup

We divided the design of the experiment into two steps: (i) selection of attributes and (ii) dimensioning of the alternatives and formatting the survey questionnaire.

Selection of Attributes

The first step in designing an experiment using the SPT is to choose the attributes to be evaluated. This is a key step in modeling the problem, because the attributes must incorporate the main aspects to be analyzed.

There is no consensus in the literature on which attributes must be utilized in modal choice models for freight transport.

Cullinane & Toy (2000) carried out an extensive review of the literature on modal choice models applied to cargo transport, trying to identify the most relevant among the attributes employed. They identified 14 attributes in these works: cost, dependability of delivery time, traceability, frequency, lost and damaged cargo, inventories, infrastructure availability, services offered, previous experience, annual sales, merchandise characteristics, distance, speed, and flexibility. Among these attributes, cost, dependability of delivery times, services offered, merchandise characteristics and speed were those most recurring and relevant in the articles reviewed.

Tsamboulas & Kapros (2000), seeking to shed light on the opportunities and barriers to the use of intermodal transport in the European Union, conducted an ample survey of the process for choosing intermodal freight mode. They interviewed actors drawn from cargo owners, trucking companies, shipping companies and customs forwarders to assess the relative importance of 14 attributes that could affect the intermodal decision, classified according to the following aspects:

- Economic aspect: transport cost;
- Internal aspects of the cargo owner: size of the lot, type of cargo, regularity of shipment, location of distribution centers, tradition of the company (how long it has maintained the same transport contract);
- Aspects related to the quality of the services rendered: dependability, flexibility and security;
- External aspects related to the logistics service provider: adequate frequency of services, additional logistics services, availability of information systems;
- Political aspects: transport policies and tax incentives adopted in Europe.

From interviewing 92 decision makers from large European countries, Tsamboulas & Kapros (2000) found that transport cost and dependability are the main attributes that affect the modal choice.

Baumol & Vinod (1970) examined how shippers make their transport choices as well as how their total demand for transport services varies. They showed that the optimal transport choice involves a tradeoff among freight rates, speed, dependability (expressed as variance in speed) and en-route lossage. All of these attributes could be encompassed in a single attribute, the total logistics cost.

Abdelwahab (1998), using a discrete choice probit model to analyze the demand elasticity of different products in the United States, evaluated the relative influence of product type, market, lot size and mode and found that all these attributes are relevant, to a greater or lesser extent, in modal choice.

Shingal & Fowkes (2002) investigated the attributes determining the modal choice for freight transport in India from a survey of shippers of manufactured products and logistics operators. They analyzed the relative importance of cost, door-to-door delivery time, dependability and frequency and found that frequency is the most relevant attribute in the model calibrated.

Effron & Rose (2003) utilized the SPT to evaluate the attributes with bearing on the choice between trucks and trains for general cargo transport in Argentina. They analyzed the influence of eleven attributes: product scale, frequency, security, transport cost, dependability, time, information, after-sales service, documentation operation, degree of responsibility for accidents and damages and image of the service provider with the customer. In the opinion of the shippers questioned, the most important attributes were product scale, frequency, security, cost, dependability and time.

In the applied study carried out by Nijkamp et al. (2004), analyzing the flows of chemical products in Europe, the authors considered the attributes cost, time and distance in the modal choice model and found that cost was the most relevant.

Danielis et al. (2005) utilized adaptive conjoint analysis to investigate the attributes determining the decisions of logistics managers when making modal choices for cargo transport in India. The attributes evaluated were door-to-door cost, dependability and security. The results of the model calibrated indicated that with the exception of costs, all the other attributes are relevant in the opinion of the respondents.

Novaes et al. (2006) used the SPT to verify the opinion of Brazilian shippers of high-value freight and logistics specialists about the relative importance of the attributes cost, dependability, time, frequency and security when choosing from among truck, rail or cabotage. The results indicated cost and dependability as the main factors influencing the modal choice for the cargos analyzed.

Danielis & Marcucci (2007) used STP to investigate the attributes determining the choice between truck and truck-train intermodal transport for shippers of manufactured goods in Italy. They analyzed the relative importance of the attributes cost, door-to-door time, delivery delays, frequency, losses and damages, flexibility and mode, and found that cost is most relevant in the respondents' opinion.

In the studies based on the inventory theoretic model (ITM) – Baumol & Vinod (1970), Swensseth & Godfrey (2002), Ballis & Golias (2004), Jong & Ben-Akiva (2007), Wang (2008), Vernimnen et al. (2008) – total logistics cost is the only attribute considered in the modal choice.

The procedures developed by Eskigun et al. (2007) and Kutanoglu & Lohiya (2008) seek to optimize the total logistics cost subject to the time-window constraint. These procedures involve models in which the available time for delivery is a determining factor in the modal choice. Therefore, total logistics cost and time are considered equally relevant in these studies.

Table III presents the attributes selected and considered most relevant in the studies reviewed. Note that although there is no consensus among the authors as to the attributes that should be used in the modal choice, the attributes evaluated normally involve cost, time, dependability, security, lot size and services offered.

Table III – Selected and most relevant attributes in the studies reviewed

AUTHORS	ATTRIBUTES SELECTED	MOST RELEVANT ATTRIBUTES
Baumol & Vinod (1970)	1. Freight 2. Speed 3. Dependability (variance in speed) 4. En-route lossage	Total logistic cost (groups the attributes evaluated)
Abdelwahab (1998)	1. Lot size 2. Product type 3. Market 4. Mode	Lot size Product type Market Mode
Tsamboulas & Kapros (2000)	1.Transport cost 2. Dependability 3. Regularity of shipment 4. Frequency 5. Flexibility 6. Security 7. Lot size 8. Availability of information systems 9. Additional logistics services 10. Tradition 11. Location of distribution centers 12. Type of cargo 13. Tax incentives 14. National polices 15. Local polices	Transport cost Dependability Frequency Regularity of shipment Security
Cullinane & Toy (2000)	1. Cost 2. Dependability of delivery time 3. Traceability 4. Frequency 5. Flexibilidade 6. Lost and damaged cargo 7. Inventory 8. Infrastructure availability 9. Services offered 10. Previous experience 11. Annual sales 12. Merchandise characteristics 13. Distance 14. Speed	Cost Dependability of delivery time Serivces offered Merchandise characteristics Speed
Swensseth & Godfrey (2002)	1. Total logistic cost	Total logistic cost
Shingal & Fowkes (2002)	1. Cost 2. Door-to-door delivery time 3. Dependability 4. Frequency	Frequency

Table III – (Continued)

AUTHORS	ATTRIBUTES SELECTED	MOST RELEVANT ATTRIBUTES
Effron & Rose (2003)	1.Cost 2. Dependability 3. Frequency 4. Flexibility 5. Security 6. Product scale 7. Information 8. After-sales service 9. Documentation operation 10. Image of the service provider with the customer 11. Degree of responsibility for accidents and damages avarias	Cost Product scale Frequency Security Time Dependability
Ballis & Golias (2004)	1. Capacity of an intermodal terminal 2. Operational cost of an intermodal terminal 3. Operational time of an intermodal terminal	Total logistic cost (groups the attributes evaluated)
Nijkamp et al. (2004)	1. Cost 2. Time 3. Distance	Cost
Danielis et al. (2005)	1. Cost 2. Door-to-door delivery time 3. Dependability 4. Security	Door-to-door delivery time Dependability Security
Novaes et al. (2006)	1. Cost 2. Door-to-door time 3. Dependability 4. Frequency 5. Security	Cost Dependability
Eskigun et al. (2007)	1. Total logistic cost 2. Available time for delivery (time-window constraint)	Total logistic cost Available time for delivery (time-window constraint)
Jong & Bem-Akiva (2007)	1. Total logistic cost	Total logistic cost
Danielis & Marcucci (2007)	1. Cost 2. Door-to-door time 3. Delivery delays 4. Frequency 5. Losses and damages 6. Flexibility 7. Mode	Cost
Wang (2008)	1. Total logistic cost	Total logistic cost
Vernimnen et al. (2008)	1. Total logistic cost	Total logistic cost
Kutanoglu & Lohiya (2008)	1. Total logistic cost 2. Available time for delivery (time-window constraint)	Total logistic cost Available time for delivery (time-window constraint)

To contribute to this analysis, we conducted an exploratory survey among 12 representatives of Brazilian general cargo shippers and 10 specialists in logistics and cargo transport planning. The respondents were asked to attribute scores of 1 to 5 (1 – attribute without bearing on the modal choice; 5 – attribute fundamental to the choice), for the attributes transport cost, inventory cost, logistics cost, dependability, frequency of services, door-to-door time, security, merchandise characteristics, lot size, and modal tendency (tradition of the company to use trucks). We found (Figure 1) that all the attributes are considered important in the modal choice (average score higher than 3), but dependability and transport cost are the most relevant in the opinions of those interviewed, followed by logistics cost, door-to-door time and security.

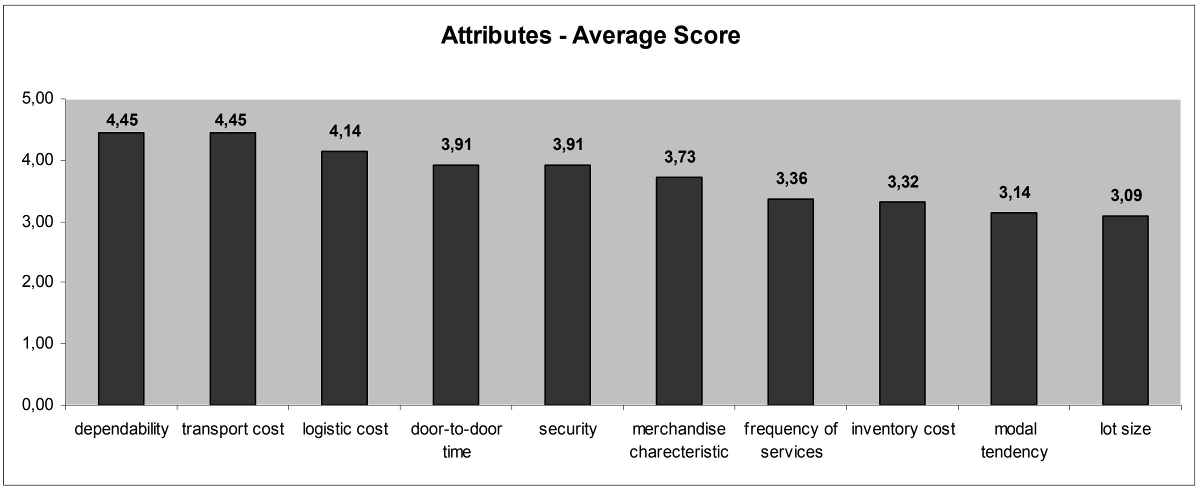

Figure 1 – Selection of attributes: results of exploratory survey

Therefore, based on the analyses of Baumol & Vinod (1970) and Novaes (2006) along with the results of our exploratory survey (Figure 1) and the premise that the criteria for analysis and choice of logistics alternatives for general cargo necessarily involve a tradeoff among logistics cost, service level and the subjective attribute related to the "Brazilian road transport culture" (the inertial tendency of shippers to rely preferentially on trucks), we formulated the experiment with the following attributes:

- Logistics cost: sum of the costs of transport, inventories, handling and storage from origin to destination;
- Level of service: the level of mutual trust between the cargo owner and carrier regarding delivery delays, losses and damages;
- Modal tendency: reflecting the tendency to choose trucks when there are intermodal services available that are identical in all the other attributes analyzed.

Dimensioning of the alternatives and formatting the survey questionnaire

The second stage of the experiment involves the design scenarios to be analyzed in the interviews. To do this it is necessary to establish varying levels of selected attributes and then to group the alternatives generated. For the attribute logistic cost, we chose two variation levels, since for each existing transportation means (road or intermodal), there already are variations relating to logistic cost. For the service level attribute, assuming that the same levels of service level can occur both for road or intermodal transport, we established three levels of variation. The absolute values of the logistic cost are only a reference for calculating percentage variations between logistic alternatives, parameter that is presented to the respondents in the stated preference research. The described service levels represent operations with great, regular and bad service level.
The selected attributes and their respective variation levels are presented in Table IV.

Table IV - Variation level of selected attributes

ATTRIBUTE	ALTERNATIVES	
	ROAD	INTERMODAL
Modal Tendency	1. Choice for the road based alternative	2. Choice for the intermodal alternative
Logistic Cost	1. 270.00 US$/t 2. 260.00 US$/t	1. 260.00 US$/t 2. 240.00 US$/t
Service Level	1. Loads delivered without delays and damages 2. Loads delivered with some delays and damages 3. Loads delivered with a lot of delays and damages	1. Loads delivered without delays and damages 2. Loads delivered with some delays and damages 3. Loads delivered with a lot of delays and damages

The combination of the level of the attributes for each of the logistic alternatives resulted in 12 different logistic alternatives (Table V), which were grouped 3 by 3 to generate 4 blocks with 3 alternatives each (Table VI). The alternatives were grouped so as to guarantee the tradeoff among the analyzed attributes in the comparison of each block's alternatives.

Table V - Possible alternatives

Alternatives	Transportation Means	Logistic Cost (US$/t)	Service Level
1	Road	270.00	loads delivered without delays and damages
2	Road	270.00	loads delivered with some delays and damages
3	Road	270.00	loads delivered with a lot of delays and damages
4	Road	260.00	loads delivered without delays and damages
5	Road	260.00	loads delivered with some delays and damages
6	Road	260.00	loads delivered with a lot of delays and damages
7	Intermodal	260.00	loads delivered without delays and damages
8	Intermodal	260.00	loads delivered with some delays and damages
9	Intermodal	260.00	loads delivered with a lot of delays and damages
10	Intermodal	240.00	loads delivered without delays and damages
11	Intermodal	240.00	loads delivered with some delays and damages
12	Intermodal	240.00	loads delivered with a lot of delays and damages

Table VI - Alternatives blocks

Blocks	Alternatives
A	1 5 12
B	2 6 9
C	4 7 11
D	3 8 10

It was chosen a best-worst question (BWQ) type of experiment, whereby a scenario is presented to the interview respondents with three different logistic alternatives, and the respondents indicate the best and worst alternatives in their own opinions. According to Louviere (2000), people tend to give their opinions more precisely when they have to choose between extreme alternatives – the best and worst alternatives – rather than when asked to place preferential alternatives in order.

RESULTS

Twenty five interviews were conducted, five with logistic analysts, ten with general cargo owners and ten with transportation and logistics experts. Those interviews generated 200 choices, which were enough to obtain satisfactory statistical results according Louviere (2000) and thus calibrate the utility function.

Calibration of the utility function

We used the LMPC software to calibrate the utility function. The results are presented in Table VII.

Table VII – Results of the interviews

Attribute	Coeficient	t - student	Rho Square
Logistic Cost (LC_i)	-43.821	-5.744	0.324
Service Level (SL_i)	2.663	3.786	
Modal Tendency (MT_i)	1.844	3.179	

In a first analysis, the signs of the coefficient were as expected. The modal tendency and service level attributes, which are directly proportional to utility, were calibrated with positive signs and the logistic cost attribute, which is inversely proportional to utility, was calibrated with a negative sign.
The Student's t-test showed that all the attributes were significant at 98%, considering a double-tailed test with (n-2) equals 198. Another important statistic is the Rho Square, which was 0.324. According to Louviere (2000), an acceptable Rho Square interval in a stated preference experiment should be between 0.2 and 0.4. This way, we calibrated the utility function shown in equation 3.

$$U_i = -43.821.LC_i + 2.663.SL_i + 1.844.MT_i \quad (3)$$

Where: U_i – Utility of logistic alternative 'i';

LC_i – Logistic cost o logistic alternative 'i';

SL_i – Service level of logistic alternative 'i'.

MT_i – Modal tendency of logistic alternative 'i'.

Mutinomial Logit Model Apply

Although the structured procedure allows the analysis of more than two alternatives through MLM, a Binomial Logit Model (BLM) was applied in the next analysis, which will consider two logistic alternatives for general cargo transportation, road transport or intermodal transport.
Thus, from the calibrated utility function (Equation 3) and applying the BLM, having like reference the modal split reported in ANTT (2004), which considers 87% of general cargo moved by road, the following referential scenario representative of Brazilian reality was reached:

- Logistic cost: intermodal logistic cost in a determined operation is 3% smaller than road logistic cost at the same operation;
- Service level: owners of general cargo consider the service level of road transportation great and the service level of intermodal transportation regular;

Modal tendency: cargo owners have the perception that road transportation is more efficient than intermodal transportation and when pure trucking and intermodal service with the same logistic cost and service level are offered, the tendency is that cargo owners will choose trucking.

Table VIII presents the parametric values of the attributes in the referential scenario described and modal split obtained using the calibrated utility function and the MLB, considering this values.

Table VIII – Parametric values of attributes and modal split in the referential scenario

Alternative	Logistic Cost (LC i)	Service Level (SL i)	Modal Tendency (MT i)	Modal Split
Road	1.00	1.00	1.00	87.0%
Intermodal	0.97	0.50	0.00	13.0%

Sensitivity Analysis

The sensitivity analysis of the utility function calibrated has the aim to verify the impact of changes in the analyzed attributes on the modal split between road and intermodal alternatives. Based on the referential scenario described in the previous section, for the sensitivity analysis of each attribute, changes were performed only in the values of the attribute in question.

With changes in the attributes considered, in comparison with the other attributes analyzed, logistic cost proved to have the biggest impact on the modal split. As can be seen Figure 2, an intermodal operation with a 20% lower logistic cost than trucking has the potential to capture 100% of demand.

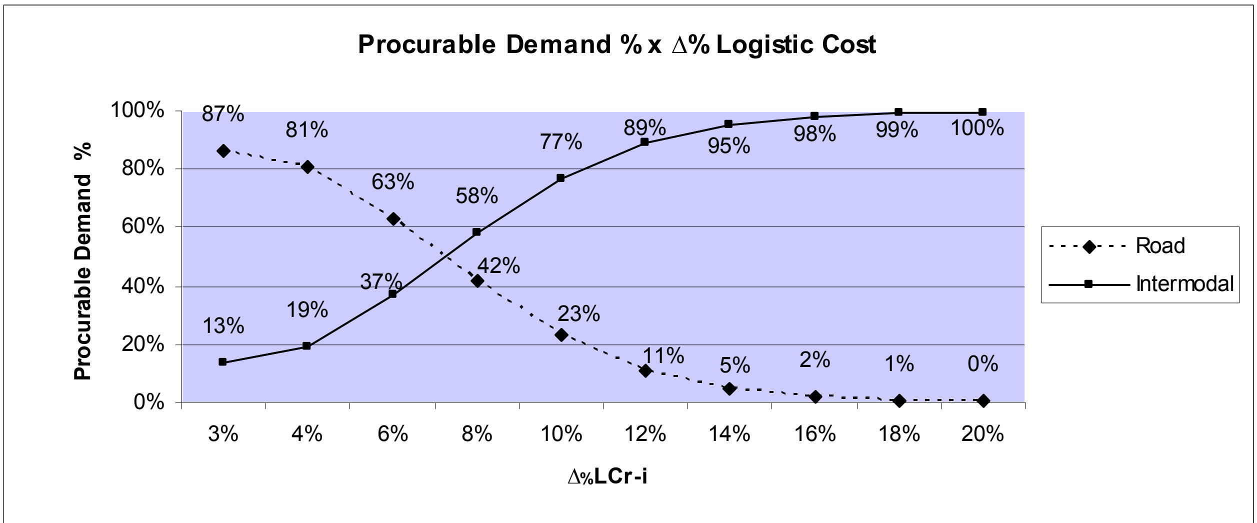

Figure 2 - Sensitivity analysis of the logistic cost attribute

Modal tendency also proved to be a highly useful attribute in the choice of a logistic service. The increase in usage of intermodality in Brazil, and the improvement in quality of services

may influence the perception of general cargo owners of the viability of opting for intermodal service.
The gradual improvement in the intermodal option viability perception rate, to the point where decision-makers become indifferent to the characteristics intrinsic to the intermodal or road services, opting only in function of logistic cost and service level, would equal the market share of intemodality with the trucking alternative, as can be seen in Figure 3.

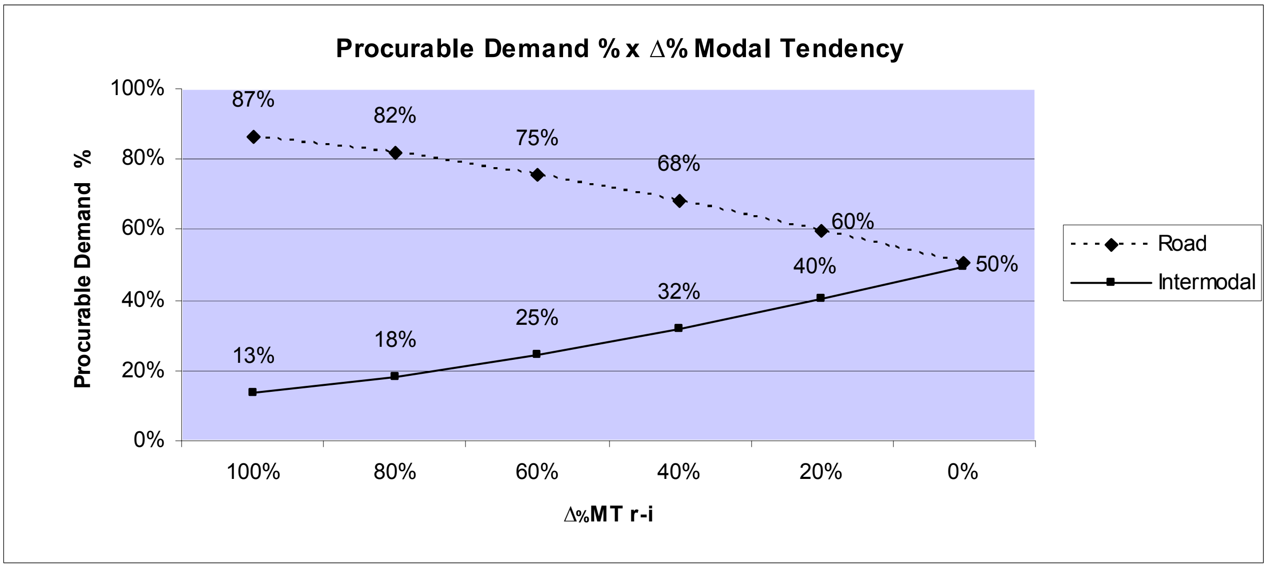

Figure 3 - Sensitivity analysis of the modal tendency attribute

Increases in service level rates of the intermodal services offered presented a minor impact on the market share of intermodal transportation. Figure 4 shows that if the service level of the intermodal alternative reached those of trucking, the latter would be able to capture 37% of the general cargo analyzed.

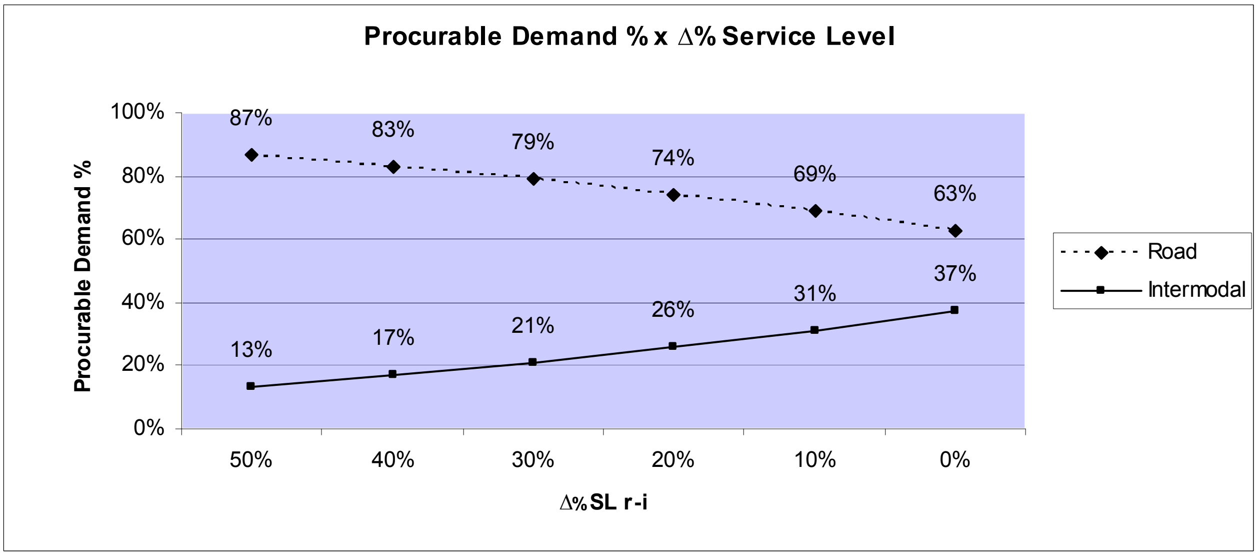

Figure 4 – Sensitivity analysis of the service level

FINAL CONSDERATIONS

The results of this study show that the use of intermodal transport for general cargo in Brazil is still incipient, accounting for only some 13% of total cargo carried in the country. Our belief that this leaves ample room for increased demand for intermodal services in Brazil prompted this study.

The literature review showed there are a wide and heterogeneous range of procedures to model the modal choice for freight transport. These procedures normally are composed of more than one step, in which different methods and tools to model freight transport demand are brought to bear. Among these methods, the main ones are the stated preference technique, the inventory theoretic model and external cost analysis. Among the authors reviewed, there is no consensus on the attributes that best represent the modal choice for cargo transport.

We believe that our initial proposal of presenting a procedure developed from the SPT to model the criteria to be used for reaching decisions at the strategic level regarding road or intermodal transport of general cargo in Brazil have been attained.

According to the survey results, total logistics costs is the main factor influencing the choice between road and intermodal transport of a determined type of general cargo.

The sensitivity analysis of the attributes logistics cost, level of service and modal tendency showed that logistics cost is the principal factor for the strategic choice of transport mode for general cargo in Brazil. The modal tendency attribute, although subjective, can be measured by surveys and proved here to have significant bearing on this choice as well.

Service level was the least important of the three attributes in the model calibrated, because according to the respondents the lack of dependability due to delays, a factor that directly affects the level of service offered, can be circumvented through larger inventories. This can be calculated into the logistics cost, which is the preponderant factor in the modal choice.

This study contributes by reinforcing the importance of analyzing logistics costs in planning new intermodal services for transport of general cargo in Brazil. The implementation of new and competitive services can gradually change Brazil's entrenched "road transport culture", enabling the construction of a more balanced and efficient transport matrix.

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