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Value of time and mode choice in freight transport: case study of Rio de Janeiro and Rio Grande do Sul

Valor do tempo e escolha modal no transporte de carga: estudo de caso de Rio de Janeiro e Rio Grande do Sul

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ABSTRACT

This paper analyses shippers' decision structure from two Brazilian states: Rio Grande do Sul (RS) and Rio de Janeiro (RJ). Discrete choice models are estimated to analyze the mode choice of cargo shippers from Stated Preference data. The results evidence and quantify the impact on cargo carriers' preferences of minimizing time, costs, and delay in merchandise shipment. Also, quantify the reliability effect, mode availability, and type of service in the modal choice. The results show the complementarity of the RJ and RS data in the models' estimation. Cargo shippers from both states similarly perceive cost characteristics; however, they perceive reliability and travel time characteristics differently. The value of time for RJ was R$ / t. h 7.43 and for RS of R$ / t. h 2.49.

RESUMO

O presente artigo analisa a estrutura de decisão dos usuários embarcadores de transporte de carga de dois estados brasileiros: Rio Grande do Sul (RS) e Rio de Janeiro (RJ). Modelos de escolha discreta são estimados para analisar a escolha modal de embarcadores de carga a partir de dados de Preferência Declarada. Os resultados evidenciam e quantificam o impacto nas preferências das empresas embarcadoras de carga de minimizar tempos, custos e atraso nos envios de mercadoria. Adicionalmente, é quantificado o impacto de características de confiabilidade, disponibilidade do modo e tipo de serviço na escolha modal. Os resultados mostram a complementariedade dos dados de RJ e RS na estimação dos modelos. Características de custo são percebidas de forma similar por embarcadores de carga de ambos os estados, entretanto características de confiabilidade e de tempo de viagem mostraram ser percebidas de forma diferente. O valor do tempo estimado para RJ foi de R$/t. h 7,43 e para RS de R$/t. h 2,49.

1. INTRODUCTION

Interest in cargo transport studies has grown in recent years due to its importance in the economy and its effect on the environment (Brooks and Trifts, 2008; Wang et al., 2013; Tapia *et al.*, 2018; Tapia *et al.*, 2020). In Brazil, the road mode's predominance characterizes cargo transportation, which corresponds to 61% of the country's total cargo transportation (CNT, 2019). Road transport's predominance generates many negative externalities, such as congestion, air pollution, and accidents, besides the loss of competitiveness of the economy (Bontekoning, 2004).

The imbalance between the different modes of transport in Brazil and its impact on the country's economy suggests the need to promote alternative transport modes. The planning of a more efficient and sustainable transport system is underway through studies that seek to promote the rationalization of transport flows between different modes. So, encouraging intermodality (Larranaga *et al*., 2016; Behrends, 2017).

Studies on the choice of the mode of cargo transportation are being developed in several countries. Some studies use Stated Preference (SP) data (Beuthe and Bouffioux, 2008; Chiara *et al*., 2008; Danielis and Marcucci, 2007; de Jong *et al*., 2014; Feo-Valero *et al*., 2011; Feo *et al*., 2011; Nugroho *et al*., 2016). Others employ Revealed Preference data (RP) (Jiang *et al*., 1999; Ravibabu, 2013) or mixed data, combining RP and SP data (Vellay and de Jong, 2003; Kim *et al*., 2014; Tapia *et al*., 2018). The restrictions on obtaining company data and the lack of published data on freight transport make studies in this area less common than in passenger transport, especially the acquisition of RP data (Tavasszy and de Jong, 2014; Konstantinus *et al*., 2020). Some of these studies report time values for freight transport (Fowkes *et al*., 1991). In Brazil, the contribution is even smaller, with almost no reference values for cargo transportation.

The value of time (VOT) for freight transport is a critical component of the Cost-Benefit Analysis of transport projects and policies. VOT measures allow converting a unitary transport time (for example, an hour) into a monetary value. Many cost-benefit analyses report that time savings represent most of the benefits of transportation projects (Konishi *et al*., 2014).

In this context, due to the importance of cargo transportation in the competitiveness of the Brazilian economy, this study aims to contribute to this field; analyzing cargo transportation shippers' decision structure from two Brazilian states, Rio de Janeiro (RJ) and Rio Grande do Sul (RS), and determining the value of travel time. Thus, this study proposes three objectives: (i) to identify the preferences of cargo shippers regarding the attributes of the cargo transport service in RJ and RS; (ii) analyze the combination of both data sets, looking for models that more adequately represent the decisions concerning cargo transportation in Brazil and (iii) determine and compare the time values for RJ and RS. The combination of data from both regions is expected to obtain more accurate estimators.

For that, we estimated discrete choice models from SP data from the states of RJ and RS. RJ data came from a stated preference survey conducted with cargo shippers in this region. The SP data were the same used in a previous study developed by Larranaga *et al.* (2016), which uses an SP survey conducted in the state. Section 4 presents the description of both surveys. The combination of data from both states and comparing the results obtained allowed a better understanding and analysis of cargo transportation in Brazil.

The structure of the paper is as follows. The second section summarizes some studies on the value of time in cargo transportation. The third section presents the method adopted. The fourth section describes the cargo transport system's current situation in RJ and RS states, explains the data and the experimental design. The fifth section shows the estimated models for the two states, discussing the results. The sixth section presents the main conclusions.

2. VALUE OF TIME IN FREIGHT TRANSPORT

The value of time (VOT) in cargo transportation usually refers to a monetary value that decision-makers (for example, carriers and shippers) are willing to pay to decrease transportation time when moving cargo from source to destination. This value's knowledge allows policymakers to conduct cost-benefit analyses of infrastructure projects and service improvements and forecast traffic demand (de Jong, 2008; Feo *et al.*, 2011). Table 1 summarizes the values found in the literature.

Table 1 – Revision of VOT in freight transport (dollar per ton and hour)

Study	*Region*	*Mode*	*VOT (2015 $/t.h)*
Guan and Kazuo (2000)	Japan	Highway, Railroad, Waterway and Air	2.263–7.052
Bergkvist and Westin (2001)	Switzerland	Highway	0.016–0.450
de Jong et al. (2001)	France	Highway	6.343–13.828
Shinghal and Fowkes (2002)	India	Highway and Railroad	0.028–0.261
Train and Wilson (2008)	Switzerland	Highway, Railway and Waterway	0.038–0.071
Fries et al. (2009)	Spain	Highway and waterway	0.272–0.867
García and Feo (2009)	Denmark and Sweden	Highway, Railway and Waterway	2.143
Rich et al. (2008)	South Korea	Railroad	0.016–1.054
Kang et al. (2010)	Switzerland	Highway and Railroad	2.336–2.767
Masiero and Hensher (2010)	Spain	Highway and Railroad	1.306–3.843
Feo et al. (2011)	Australia	Railroad	0.646–1.217
Masiero and Hensher (2011)	China	Highway and Railroad	0.640–9.701
Brooks et al. (2012)	New Zealand	Highway, Railroad and Waterway	1.167–1.265
Tao et al. (2016)	Japan	Highway, Railroad, Waterway and Air	0.296
Kim et al. (2017)	Switzerland	Highway	0.131–4.668
Stinson et al. (2017)	India	Highway and Railroad	2.234
Tao et al. (2017)	USA	Highway and Waterway	0.296

Most of the reported studies were carried out in the United States and European countries, with few studies in developing countries, especially in the Brazilian context. The time values depend on the context analyzed, as they vary with the type of product transported, worth of service attributes, sizes, costs, and transport times. Thus, obtaining time values for each country/region is essential to conduct adequate analyses.

3. METHOD

Discrete choice models were estimated to analyze the modal choice of cargo shippers from SP data. The econometric models proposed are based on a behavioral approach, using disaggregated demand models (Ben-Akiva and Lerman, 1985; Domencich and McFadden, 1975; McFadden, 1974), combining data from two SP surveys conducted in the Brazilian states of RS and RJ. The joint estimation of both databases was performed using a simultaneous estimation process, initially introduced by Ben-Akiva and Morikawa (1990) and developed by Bradley and Daly (1994).

The joint estimation's purpose was to take advantage of both data sources' complementarity, enriching the estimation. From an econometric point of view, the joint estimation's fundamental difference is the inclusion of the difference in scale between both sources, specifying error terms with different variance for each one. Thus, considering ε the stochastic error of the SP data from RJ and η the corresponding to the RS data, it is possible to express the difference of variance through Equation (1) (Ortuzar and Willumnsen, 2011):

$$\sigma_\varepsilon^2 = \mu^2 . \sigma_\eta^2 \quad (1)$$

being μ an unknown parameter called model scale factor. This consideration determines that the utility functions of alternative j for each of the data sources, according to Equation (2):

$$U_j^{RJ} = V_j^{RJ} + \rightleftarrows \varepsilon_j = \theta . X_j^{RJ} + \alpha . Y_j^{RJ} + \rightleftarrows \varepsilon_j \quad (2)$$
$$\mu U_j^{RS} = \mu(V_j^{RS} + \rightleftarrows \eta_j) = \mu(\theta . X_j^{RS} + \omega . Z_j^{RS} + \eta_j)$$

θ, α, ω, and μ are the parameters to be estimated. X_j^{RJ} and X_j^{RS} are common attributes of alternative j for RJ and RS data, respectively; While Y_j^{RJ} and Z_j^{RS} are unusual attributes of alternative j for each data set.

The parameters common to both data sources were determined based on the procedure proposed by Louviere *et al.* (2000). Initially, multinomial logit models (MNL) were estimated separately for the SP responses from Rio de Janeiro, and Rio Grande do Sul, allowing each one to have its own parameters (i.e., intercepts and coefficients) and error variability. Subsequently, the estimated parameters for both responses were graphically represented (θR^J and θRS) to see whether they differ only by a multiplicative scalar, equal to the line's slope for the pairs of values coefficients, or not. Both responses were combined in a third step, assuming equal systematic utility, but different error variability, estimating MNL models for the combined data set (Rio de Janeiro and Rio Grande do Sul). The assumption of the equality of parameters adopted was verified with the likelihood ratio test (Ben-Akiva and Lerman, 1985) by Equation (3):

$$LR = -2 * [(L_{RJ/RS}) - (L_{RJ} + L_{RS})] \quad (3)$$

$L_{RJ/RS}$ is the maximum likelihood value corresponding to the combined data set, L_{RJ} corresponds to data from Rio de Janeiro, and L_{RS} to those in Rio Grande do Sul. This statistical test is asymptotically distributed chi-square with $(K + 1)$ degrees of freedom, with K being the number of parameters common to both sets of data. The result indicates whether the hypothesis of equality of parameters is verified or not. Thus, if the LR was greater than the critical value of χ_k^2 for the required level of confidence (95%), the test was rejected. The attribute common to both data sets was removed from the set of common attributes X. This was specified with a different parameter in each data set. The procedure was repeated for those parameters that could be considered common to both sets (those closest to the straight line), and the equality was verified through the likelihood ratio test. The model parameters were obtained by maximizing the likelihood function, in this non-linear case, due to the inclusion of the scale factor μ multiplying the rest of the parameters in the RS utility function, using the Biogeme software (Bierlaire, 2003).

After determining the parameters common to both data sources and defining the MNL model's structure with combined data, we added the heterogeneity of the attributes measured in the sample and we included it in the mixed logit model estimation. Initially, multinomial logit models were estimated for each data set and for combined RJ and RS data. The MNL model (McFadden, 1974) is one of the discrete choice simpler models and the most used. MNL assumes that the utility function's random term is identically and independently distributed according to a Gumbel distribution (Type I Extreme Value). This assumption for the distribution of errors is quite simplistic since it depends on the hypothesis of independence and homoscedasticity of errors (Ben-Akiva *et al*., 2003). Equation 4 shows the MNL probability:

$$P_{jq} = \frac{e^{\lambda V_{jq}}}{\sum_{\forall i \in A(q)} e^{\lambda V_{jq}}} \quad (4)$$

To overcome the limitations of the MNL, we tested more flexible structures: random parameters logit models ($ML - RC$) and mixed logit error components models ($ML - EC$). The former takes the population's heterogeneity into account, assuming the parameters vary from one individual to another following a probabilistic distribution. The tested distributions were normal, lognormal, and triangular. When maximizing the sample's likelihood, the estimation process determines the estimators of the parameters that define this distribution such as mean and variance. The second model ($ML - EC$) included the panel effect (correlation between data of the same individual), adding a term representing this effect.

The estimated parameters were used to calculate travel time's subjective value (VOT) for Rio de Janeiro and Rio Grande do Sul, representing the cargo shippers' willingness to pay for reducing travel time by one unit. The calculation was performed considering the marginal rate of substitution between travel time and cost, according to Equation (5) (Ortúzar and Willumsen, 2011):

$$VOT = \frac{\partial V_i / \partial Time_i}{\partial V_i / \partial Cost_i} \quad (4)$$

When specifying a linear utility function such as Equation (2), Equation (4) is reduced to the quotient between the time parameter and the cost parameter.

4. DATA

4.1. Freight transport in Rio de Janeiro and Rio Grande do Sul

Rio de Janeiro state (RJ) has a 24,875 km long road network, including paved and unpaved highways. The predominance of road transport marks cargo transportation. The analysis of flows passing through the state shows that general cargo is the type of freight with the largest share, representing 44% of the flow passing through the state of RJ in road mode. The General Cargo category corresponds to seven types of products: (i) Machines, equipment, auto parts, boilers; (ii) Food and beverages; (iii) Shipbuilding, railway, air industry; (iv) Drugs, chemicals, hygiene, and hospital; (v) Plastics and rubber; (vi) Printing industry; and (vii) Others (PELC, 2015a).

RJ has two railway networks: MRS Logística and the Ferrovia Centro-Atlântica (FCA) (Figure 1). In the state, there are two relevant railway corridors i) Minas Gerais (MG) - Rio de Janeiro (RJ) and ii) São Paulo (SP) - Rio de Janeiro (RJ). The first is of great strategic importance, linking the first state to the two main ports in the states of Rio: Itaguaí and Rio de Janeiro. The rail network of this corridor is formed by the MRS network, with 1,013 km. The main products transported are (i) Iron ore, (ii) Cement, (iii) Steel products, (iv) Industrial products, and (v) Minerals. The second corridor is essential due to the integration of the region with the highest industrial concentration in Brazil to the main ports in the RJ state. The Rio de Janeiro - São Paulo corridor's rail network comprises lines from MRS Logística and Rumo (Malha Paulista), totaling 1,010 km. The main products transported in this corridor are (i) Iron Ore, (ii) Coal, and (iii) Industrialized Products. Figure 1 shows the road and railway networks in Rio de Janeiro state (PELC, 2015a).

In Rio Grande do Sul state, one of Brazil's most populous states, the road mode transports 88% of the total cargo (Secretaria da Coordenação e Planejamento, 2020a). In the extreme south of Brazil and in the center of MERCOSUL, the state's geographical location results in a transport network connection both with Brazil and abroad. Thus, in addition to the flows of goods produced and consumed in the state, the vast majority of goods flows between Brazil, Uruguay and Argentina travel through its transport infrastructure (RUMUS, 2015).

The rail network in Rio Grande do Sul state is part of the so-called Southern Regional Network. The company Rumo is currently operating this network. The cargo transfer centers that present the greatest movement are located near the Metropolitan Region of Porto Alegre, and in Passo Fundo, Cruz Alta, Uruguaiana, and Porto do Rio Grande. The main products transported are: fuels, fertilizers, agricultural commodities, bran and vegetable oils; industrialized products for the civil construction and steel industry; forest products, and containers

(Secretaria da Coordenação e Planejamento, 2020b). Figure 2 shows the road and railway networks in Rio Grande do Sul state (Secretaria da Coordenação e Planejamento, 2020b,2020c).

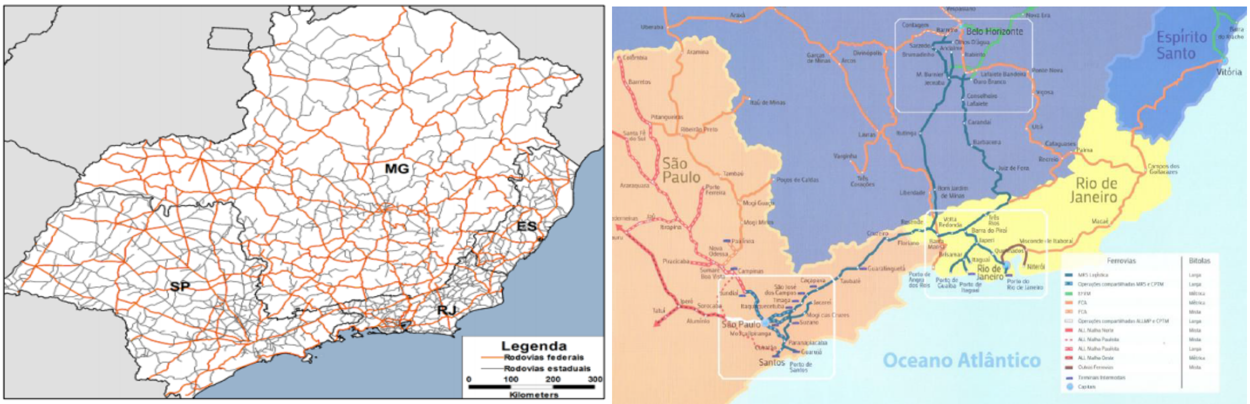

Figure 1. Road network (upper) and railway network (lower) in the State of RJ

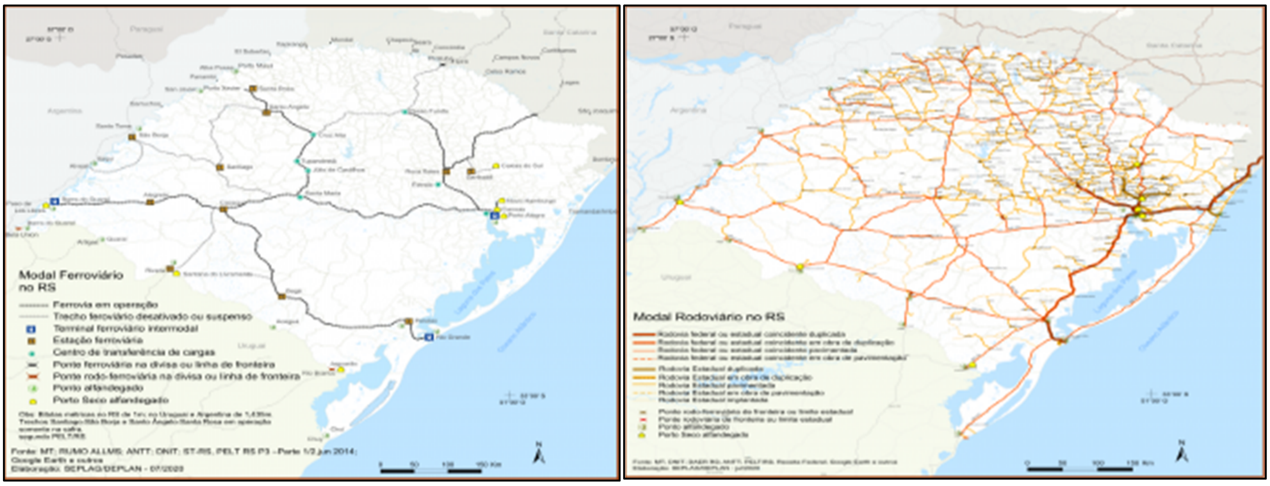

Figure 2. Road network (upper) and railway network (lower) in the state of RS

4.2. Determination of cargo type and sample

The determination of the type of cargo sought to identify the most representative products of each state. In RJ, the General Cargo category products were analyzed: 1) Machines and Equipment; 2) Food and Beverages; 3) Pharmaceuticals, Hygiene, and hospital and 4) Others. These four types of products correspond to about 85% of General Cargo's flow between Rio de Janeiro and São Paulo's states, therefore being selected for the study (PELC, 2015b). Following selections adopted by Masiero and Hensher (2010, 2012); Feo-Valero *et al.* (2016); Fridstrom and Madslien (1995), the survey in Rio sought to interview large companies in the following categories: 1) producers and distributors, and 2) companies in the wholesale sector that operate over long distances. A total of 35 companies received the questionnaires, 26 of which answered the complete questionnaire. The 26 companies are distributed among four sectors of General Cargo: Food and Beverages (11 companies); Pharmaceuticals, hygiene, and hospital (5 companies); Machinery and Equipment (4 companies); and Others (6 companies). Companies were contacted, and online questionnaires were sent between August and September 2016.

In RS, the determination of the type of cargo comprised two stages: shippers and products. Initially, possible shippers were selected, considering the diversity of production chains, type of cargo, volume transported, economic value, and final destination of the shipment (state, national or international). The selection process combined information from two sources: (i) Foreign Trade Information Analysis System (Ministério do Desenvolvimento, Indústria e Comercio Exterior, 2014); and (ii) Large Business Ranking (Amanhã, 2014). The types of products selected were those with high transport density, representing at least 80% of the set of products generated in the state. Besides, we included the most representative products in the state's trade balance and products with low added value but have strategic importance for the state economy. Thus, we selected 22 products, the most important of which were footwear, soy, tobacco, vehicles, frozen meat, chemicals, and leather. A total of 50 companies were interviewed, conducting the survey with logistics managers between January and March 2015.

4.3. Experimental design

4.3.1. Selection of attributes and levels

The selection of attributes rested on a review of the literature of relevant international and national articles on the subject of study (Cullinane and Toy, 2000; Danielis and Marcucci, 2007; Feo *et al.*, 2011; Guy and Urli, 2006; Hoffman, 2000; Malchow and Kanafani, 2001, 2004; Martins *et al.*, 2005; Nir *et al.*, 2003; Novaes *et al.*, 2006; Shinghal and Fowkes, 2002; Tongzon, 2009; Feo-Valero *et al.*, 2016). The mentioned studies consider attributes related to time, cost, reliability, and frequency of the service to characterize the modal alternatives. Additionally, information from surveys with shippers from each state complemented the literature's information to better represent each state's particularities. Thus, the risk of cargo theft for the state of RJ was added and stratified the attribute related to the delivery time for RS.

Thus, the experiment in RJ comprised six attributes: (i) *Cost* (cost in the vehicle, transfer, loading/unloading, storage); (ii) *Total time* (in the vehicle; loading/unloading, transfer, waiting); (iii) *Service* (type of service: door to door or mode to mode), (iv) *Reliability* (deliveries made within the stipulated period), (v) *Availability* (available year-round or between harvests) and (vi) *Risk of Cargo theft*. The alternatives considered were those that represent transportation in the state, and that presents a trade-off between them: (i) Road and (ii) Rail.

In RS, the experiment considered four attributes: (i) *Cost* (cost in the vehicle, transfer, loading/unloading, storage); (ii) *Total time* (in the vehicle; loading/unloading, transfer, waiting); (iii) *Reliability* (% of shipments that meet the delivery deadline) and (iv) *Delay greater than 2 days* (% of shipments that arrive two or more days after the agreed date). The last two attributes, related to the delivery time, were defined to capture the variable's non-linearity. In this case, the alternatives considered to indicate the preference of the surveyed companies were: (i) Road, (ii) Intermodal by rail, (iii) Intermodal by water. The inclusion of the *Time* and *Cost* attributes allows the determination of the transport time value. Table 2 shows the attributes and levels considered in the RJ and RS surveys.

The determination of each level rested on information from each state. In RJ, it was using the information provided by the Rio de Janeiro State Department of Transportation. In RS, it was using information obtained from shipping companies, the study Rumos 2015 (2006), and data from the georeferenced network and processed with a Geographic Information System (GIS). The software adopted for mapping and analyzing GIS data was Transcad (Caliper, 2012).

Table 2 – Attributes and corresponding levels for each mode of transport

State	Attribute	Road	Railway	Waterway
Rio de Janeiro	**Cost** (level of logistical cost).	100 R$/ton	60% or 90% of the values of the road mode	
	Time (hours)	6 hours	20% or 60% longer than the road transport time	
	Service level	Door to Door	Door to Door or Mode to mode	
	Reliability (on time deliveries)	100%	70% or 90% of deliveries made on time	
	Availability	All year	Period between harvests or all year	
	Cargo theft	Probable or unlikely	Unlikely	
Rio Grande do Sul	**Cost** (R$/100)	Current level, + 5%, -5%	Current level, + 5%, -5%	Current level, + 5%, -5%
	Time (hours)	Current level, + 12%, -12%	Current level, + 12%, -12%	Current level, + 12%, -12%
	Reliability (%)	75, 85, 90	75, 85, 90	75, 85, 90
	Delay greater than 2 days (%)	5,10,15	5,10,15	5,10,15

4.3.2. Preparation of the experimental design

The experimental design was structured from orthogonal design for Rio de Janeiro and efficient design for Rio Grande do Sul. In RJ, due to the unavailability of previous information necessary for an efficient design, a fractional factorial design was elaborated, obtaining 16 situations of choice. To reduce possible fatigue effects of the respondents, the design was divided into two questionnaires. The questionnaires were presented sequentially. Each company answered a questionnaire, with 8 choice situations in each one.

First Scenario

The company is sending a shipment of 20 pallets of products over a distance of 350 kilometers. Evaluate the conditions of each travel mode and select which would be the company's choice.

	A) Road	B) Rail
Cost	100 BRL/ton	60 BRL/ton
Time	6 hours	7 hours and 20 minutes
Service	Door to door	Mode to mode
Reliability	100%	70%
Availability	All Year Round	All Year Round
Cargo Theft Risk	Likely	Unlikely
Which option would the company choose?		

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Plano de Logística e Transportes do Rio Grande do Sul PELT - RS

Solicitamos que nos indique qual alternativa preferiria:

Obs: O volume de envio considerado corresponde a 37 toneladas

Situação de escolha 8:

	Apenas rodoviário	Ferroviário mais rodoviário	Hidroviário mais rodoviário e/ou
Custo total da viagem/envio	R$ 1.700	R$ 900	R$ 1.000
Tempo total da viagem (inclui espera e	7 hrs	10 hrs	25 hrs
% de envios que cumprem o prazo de entrega	90%	80%	80%
% dos envios que chegam 2 ou mais dias após	5%	15%	10%
Escolho:	○ A	○ B	○ C

Figure 3. Example of a questionnaire answered by companies in RJ (upper) and RS (lower) (Portuguese)

In RS, the experimental design was structured using an efficient design (Rose and Bliemer, 2009) and implemented in NGene (Choice Metrics, 2013). The efficient design allowed us to generate parameter estimates with standard errors as small as possible. Standard errors were determined using the variance-covariance matrix (CVA), based on the underlying experience and some prior information on parameter estimates. The efficiency measure used was the D-error, which is the determinant of the stroke matrix, for only one individual.

The design's objective is to minimize this efficiency error and obtain a D-optimal design (with the lowest D-error) (Rose and Bliemer, 2009). To personalize the research design, the companies that demand cargo belonging to the sample were grouped into segments according to product and similarities in the shipment characteristics. The companies were stratified into 6 categories, and a design was drawn up for each category. Details on the elaboration of the Rio Grande do Sul design can be found in Larranaga et al. (2016). 18 choice situations were defined to be presented to the companies surveyed. This quantity was determined according to the following criteria: sample size, nature of choice studied, and degrees of freedom (number of choice situations must not be less than the degrees of freedom of the experiment).

The method adopted to indicate the preference of the companies surveyed in both states, concerning the alternatives presented, was the choice method (choice) among the alternatives presented for each state (2 alternatives for RJ and 3 alternatives for RS). Figure 3 shows an example of the questionnaire applied to RJ and RS, respectively.

5. RESULTS AND DISCUSSION

The models were estimated using the Biogeme software (Bierlaire, 2003). Table 3 presents the results of: (i) MNL models estimated for each data set (RJ and RS) separately (Model 1 - MNL) ,and (ii)models estimated for the grouped set of RJ and RS data - the multinomial logit (Model 2-MNL) and the mixed logit of error components that include the panel effect (Model 3 - ML-EC (panel)).

Table 3 – Estimated models

	Model 1 - MNL		Model 2 MNL	Model 3 ML-EC (panel)
	RJ	RS	Combining RJ and RS	Combining RJ and RS
Variable	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
2 days_delay	-	-5.17 (0.00)	-6.14 (0.01)	-7.41 (0.10)
Availability	0.992 (0.03)	-	0.992 (0.03)	1.15 (0.10)
Cost*	-0.044 (0.00)	-0.037 (0.00)	-0.044 (0.00)	-0.053 (0.05)
Reliability RJ	0.035 (0.04)	-	0.035 (0.04)	0.0459 (0.00)
Reliability RS	-	3.02 (0.00)	3.58 (0.01)	6.42 (0.10)
Service	2.07 (0.00)	-	2.07 (0.00)	2.56 (0.00)
Time RJ	-0.30 (0.04)	-	-0.30 (0.04)	-0.394 (0.00)
Time RS	-	-0.025 (0.04)	-0.030 (0.10)	-0.132 (0.09)
Road constant RJ	-0.855 (0.15)	-	-0.856 (0.15)	-1.14 (0.19)
Road constant RS	-	0.659 (0.05)	0.782 (0.08)	0.186 (0.80)
Road constant RS	-	0.442 (0.03)	0.524 (0.07)	0.432 (0.65)
Mu	-	-	0.843 (0.00)	0.838 (0.09)
Sigma_RJ	-	-	-	1.34 (0.00)
Sigma_RS	-	-	-	-3.65 (0.10)
N. Observations	208	1170	1378	1378
Draws	-	-	-	1500
Final log-likelihood	-106.89	1114.15	-1221.55	-1029.30
Pseudo-R2	0.22	0.13	0.14	0.28

* Cost expressed in R$/ton

The following section discusses the results of the estimated models: Model 1 (MNL), Model 2 (MNL), and Models 3 (ML-EC).

5.1. Model 1 and Model 2

Model 1 (MNL) presents the results of the estimated parameters for each data set separately: RJ and RS. Model 2 (MNL) shows the results for the combined data. The specification of model 2 followed the procedure described in section 3: (i) estimation of the model for each data set - RJ and RS (Model 1); (ii) comparative graph of the estimated parameters for each set (RJ vs RS); (iii) estimation of the model with parameters common to both sets - RJ and RS, (iv) test of likelihood ratio. Steps ii), iii) and iv) were repeated for those parameters that could be considered common to both sets. The results of each step are described below.

After estimating Model 1 (Table 2), the possible combination of data was explored. Analyzing the attributes included in each SP survey, it is observed that the attributes *Time*, *Cost,* and *Reliability* were included in both surveys. Thus, these attributes could be considered common to both data sets and represented in the model structure with the same parameter, differing only by a scale factor (as shown in Equation 2). In order to explore this assumption visually, a comparative graph of the parameters estimated in Model 1 (MNL) was performed for each set (RJ vs RS). Figure 4 shows the resulting plot.

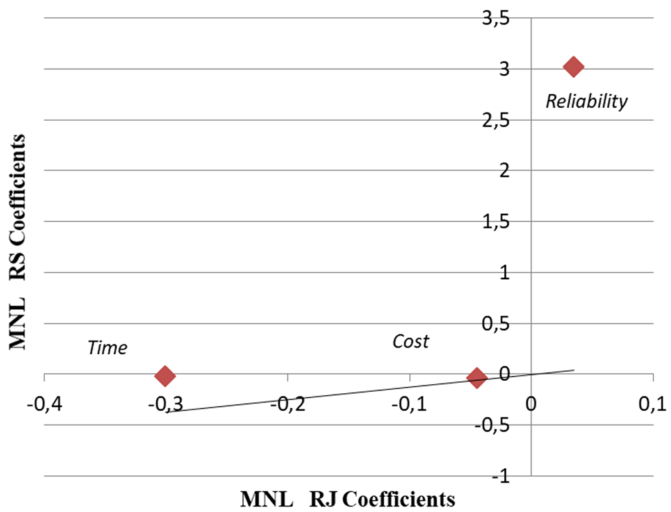

Figure 4. Representation of estimated coefficients for attributes common to RJ and RS

The comparative graph is used to initially identify the parameters common to both data sets (Louviere *et al*., 2000). The graph suggests that the *Time* and *Cost* coefficients could differ only by a multiplicative scale, the relationship between them is close to a linear relationship. However, *Reliability* departs from the point cloud around the straight line, suggesting that this attribute should be considered as a specific parameter for each data set.

From the initial identification of the possible common parameters *Time* and *Cost* (through the graph of Figure 4), a MNL model was estimated for the combined data set (RJ and RS), and the equality of these parameters was verified using the likelihood ratio test (Equation 3). The test value (LR) was higher than the chi-square distribution's critical value (95% confidence interval and 2 degrees of freedom), rejecting the hypothesis of equality of all parameters in both data sets. Thus, the procedure was repeated, considering only *Cost* as a common parameter to RJ and RS, and *Time* as a specific parameter. MNL models were estimated with this new specification and verified statistically through the likelihood ratio test. The obtained LR value was 0.02, less than the distribution's critical value (3.84), not rejecting the hypothesis of equality of the *Cost* parameter. This result means that the scale factor estimate for this parameter is valid, as it was based on the equality of the *Cost* parameter in both data sets, confirming the combination of data from both regions. The *Cost* parameter was then specified in a common way to both regions and *Time* and *Reliability* specific to each one. The results are shown in Table 2: Model 2- MNL.

5.2. Model 3

Model 3 presents the estimation results of a mixed logit error component model, which includes the panel effect (ML-EC (panel)). From the specification of Model 2, the heterogeneity of the attributes measured in the analyzed sample was added and included in the estimation of the mixed logit model of random coefficients. Thus, it was considered that the perceptions of cost, time, reliability, and other characteristics varied between the companies surveyed. The random coefficients models showed the same results as the models of fixed coefficients (Model 2- MNL), indicating homogeneity of companies in the perception of these attributes. Thus, these were not shown in Table 2. Subsequently, the panel effect was added to Model 2, estimating mixed logit error componente model (Model 3 - ML-EC). Model 3 presented a satisfactory fit (Pseudo-R2 = 0.28). The scale factor (Mu) was significantly different from 1 (90% confidence), indicating the difference in scale between the parameters estimated for RJ and RS. The standard deviation of the error components for RJ and RS (Sigma RJ and Sigma RS), which represent the panel effect, was significantly different from 0 (90% confidence), verifying the correlation between responses from the same company.

5.3. Discussion of estimated parameters

The choice of the most suitable model between the MNL (Model 2) and the ML-EC (Model 3) was based on the Likelihood Ratio test (Ben-Akiva and Lerman, 1985), selecting the ML-EC (Model 3). Thus, analyzing Model 3, it is possible to observe that the modal constants were not significantly different from zero for a 95% confidence level. Therefore, it is not possible to compare the propensity to choose between modes. The signals obtained for the parameters are consistent with the microeconomic theory and previous assumptions.

Analysing the estimated coefficients, it is possible to observe that the analyzed variables' coefficients are significantly different from zero (for 90% and 95% confidence). The negative sign of *Cost*, Time_*RJ*, *Time_RS*, *Delay_Major_2* days indicates that the modes' utility decreases with increments in time, cost, and important delays (greater than two days). As expected, companies seek to minimize the times and costs related to cargo transportation, while also reducing shipping delays. The positive sign of the variables *Reliability*, *Availability,* and *Service* indicates that increases in the percentage of shipments that meet the delivery deadline, in the mode's availability throughout the year, and the type of service door to door increase the usefulness of the modes. Companies that demand cargo significantly value compliance with the stipulated deadline and further penalize significant delays, showing this effect on the preferences of the transport mode choice. Contrast to expectations, d, *Cargo Theft Risk* was not significantly different from zero (90% confidence level) across all estimated models.

5.4. Subjective value of travel time

The estimated parameters of the ML-EC model (Model 3) were used to calculate the Subjective Value of Time for RJ and RS, according to Equation 4 presented above. The estimated time value for Rio de Janeiro was R$ / t. h 7.43 (2.23 U$/ t.h) and for Rio Grande do Sul it was R$ / t.h 2.49 (0.75 U$S / t.h) (average price of U$S in 2015). The VOT for RJ was almost 3 times higher than for RS, indicating that RJ shippers are willing to pay for reducing an hour in transportation time by three times that of RS shippers. This result is probably due to the type of cargo carried. In RS, the products transported are mainly commodities, products with less added value than those transported in Rio de Janeiro. The time values obtained are within the range of the research reported in the literature for road and rail modes (Section 2), which vary between 0.016 (U$S/ t.h) (Rich *et al*., 2008, a study in Sweden and Denmark) and 3.843 (U$S/t.h) (Masiero and Hensher, 2010; developed in Switzerland).

6. CONCLUSION

This study analyzed the process of choosing a mode of transport by companies with transport operations in the states of Rio Grande do Sul and Rio de Janeiro, estimating discrete choice models based on stated preference data. The results showed and quantified the impact on cargo shipment companies' preferences to minimize times, costs related to cargo transportation, and delay in shipping goods. Additionally, they showed and quantified the impact that increases in the percentage of shipments that meet the delivery deadline, the mode's availability throughout the year, and the type of door-to-door service increase present in the choice of mode.

The results showed the potential of combining data from Rio de Janeiro, and Rio Grande do Sul. Cost characteristics are perceived similarly by cargo shippers from both states. However, characteristics of reliability and travel time showed to be perceived differently. The models' results imply that the data of both areas can be combined to obtain more accurate estimates. After considering the differences in scale between the databases in both regions, the results show that a proportion of the differences between the model results of both áreas is due to the difference in measurement (measurement scale). So, not due to real differences in perception and decision making. In this way, the combination of both databases allows to maximize the adjustment and improve the parameter estimates.

The transport time parameter was different in both regions, indicating variation in this attribute's perception, resulting in different values of travel time for each area. The subjective values of transport time obtained extend the results reported in other contexts, adapting the values to the Brazilian context. Infrastructure projects often lead to reductions in transportation time. The direct benefits resulting from the reduction in transportation time are reflected in the travel time values, which need to be computed for an adequate analysis of the costs and benefits arising from infrastructure projects.

The time values obtained contribute to the development of reference values for cargo transportation in Brazil. Studies developed in other states will contribute in this regard. Thus, future studies with SP data could be carried out in other regions and combine with revealed preference data representing the choices made by cargo shippers. The indirect benefits of transport time savings, such as opportunities to reorganize the distribution and logistics process, are probably not computed by respondents when choosing the mode of transport presented in the SP study (De Jong, 2001). Future studies could measure these benefits.

The determination of transportation time values for the Brazilian context is a valuable element in elaborating transport policies and cargo transportation planning applications.

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