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The Brazilian taxation influence on a company's transportation cost

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ABSTRACT
A case study was applied on a multinational company located in Brazil, in the metallurgical industry, which outsources the delivery of its products to customers through a transportation company. The purpose of this paper was to minimize products' distribution costs to this company, observing the different tax structures of the ICMS (Tax on Circulation of Goods and Services), due to the fact state benefits of ICMS could decrease the total cost. Study results suggest that using some DCs may help decrease total distribution cost because of tax impact. It also suggests that the distribution of imported products may be cheaper than the national one, without considering its purchase and manufacturing costs. The proposed approach contributes, to Brazilian companies or multinationals, to evaluate tax incentives as an alternative to reduce logistical costs, relevant given the current context of Brazilian transport.
Keywords: Transportation costs; ICMS tax; Transshipment problem.

A influência tributária brasileira no custo de transporte de uma empresa

RESUMO
Foi realizado um estudo de caso sobre uma empresa multinacional localizada no Brasil, da indústria metalúrgica, que terceiriza a entrega de seus produtos aos clientes por meio de uma empresa de transporte rodoviário. O objetivo deste trabalho foi minimizar os custos de distribuição de produtos para essa empresa, observando as diferentes estruturas tributárias do ICMS (Imposto sobre Circulação de Mercadorias e Serviços), devido ao fato que os benefícios estaduais do ICMS poderiam diminuir o custo total. Os resultados do estudo sugerem que o uso de alguns CDs pode ajudar a diminuir o custo total de distribuição devido ao impacto tributário. Também sugere que a distribuição de produtos importados pode ser mais barata que a nacional, sem considerar os custos de compra e fabricação. A abordagem proposta contribui para que as empresas, brasileiras ou multinacionais, avaliem os incentivos fiscais como uma alternativa para redução dos custos logísticos, relevante dado o contexto atual do transporte brasileiro.
Palavras-chave: Custo de transporte, ICMS, Problema de transbordo.

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1 Introdução

In Brazil, there is a tax called ICMS (tax on the movement of goods and services), instituted by the Brazilian Federal Constitution, that implies on interstate exchanges of goods and transportation service. Although its general rule is within a Federal Law (Peres & Mariano, 2009), its competence was given to the 27 Brazilian states, hence each state has internally its own specifications.

According to this literature review, on the topic of optimizing logistics networks considering the ICMS tax, this issue was first addressed by Yoshizaki (2002), suggesting tax costs should be considered to support logistic decisions. Moreover, some authors have done some variations of this problem (Pantalena, 2004; Nazário, 2002; Junqueira & Morabito, 2006; Silva, 2007; Carraro, 2009; Queiroz, 2011; Hamad & Gualda, 2014). Furthermore, there are international articles about this matter as in Avittathur, Shah & Gupta (2005). Their work showed a tax called Central Sales Tax (CST) that also implies on transportation service among states, with its specificities, though.

Although much have been studied about the distribution network decision, this literature review pointed out that none of those studies yet demonstrated how much this important Brazilian tax can influence the imported product transportation costs, since the changes in ICMS tax on January 2013.

The costs complexity and diversity of freight and taxes, required to make a distribution of products between Brazilian states, show the necessity of a method that allows minimize costs choosing if some distribution centers (DCs) are going to be used or not. Specially with the changes of price of freight established by government in 2018 that raised the cost of transportation for all the companies.

This research has done a case study about a multinational company from the water supply industry. Its factory is located at the State of Rio de Janeiro and the company also has DCs in others Brazilian states. This company employs more than 1300 employees and has private and public clients around the world. It produces its main product and sells for government through bidding and deliveries through an outsourced company for highway transportation.

Therefore, the objective of this paper is to minimize products' distribution costs for a multinational company located in Brazil, observing the different ICMS tax structures. To achieve this objective, a transshipment problem was modeled, a variation of the transportation problem in linear programming, given its usability to solve this type of problem when there are constraints on supply and demand.

The article contains seven sections: (1) this section introduces the problem; (2) the second section briefly discusses the selected applications of linear programming technique within the Brazilian transportation context; (3) the third section establishes the fundamentals of linear programming used in this case study; (4) the fourth section explain the research method; (5) the fifth section presents a case study and discusses the research results; and (6) the last section presents the conclusions and the suggestions for future research.

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2 The Brazilian Taxation

The Brazilian legislation says that the ICMS tax is upon interstate exchanges of goods and services, including foreign trade, when there is a transaction between companies. The Brazilian Federal Constitution granted to Senate the responsibility to determine rates of interstates taxes. Furthermore, the state gives tax subsidies as credits for companies which concur and meets the prerequisites. In this case study, will be used the calculation result of both rates as a final State tax rate. In table 1 is presented the rates of the ICMS tax.

As it can be seen in table 1, there is a difference between the Federal rates and what really happens when a company sells from each state. However, it is not the objective of this paper to describe this difference or try to discuss the reasons behind it. So, for this study, it will be considered for calculation only the rates from state, since it will be the final ICMS cost for the company.

Table 1 - The Federal and State rates of the ICMS tax

		Federal		State	
Origin	**Destination**	**Taxpayer**	**Non-taxpayer**	**Taxpayer**	**Non-taxpayer**
RJ	PE, PB, RN, PI, BA, SE	7%	19%	7%	19%
PB	PE, RN, PI, BA, SE	12%	17%	1%	17%
PE	PB, RN, PI, BA, SE	12%	17%	7,6%	12,9%
RJ	All imported goods sent to another state	4%	19%	4%	19%
PB		4%	17%	1%	17%
PE		4%	17%	2,1%	8,1%

Source: Adapted from Pernambuco State law 11.675 by 1999, Paraíba Decree 23.210 by 2002 and Federal rules by CONFAZ (2017).

For example, the case of Pernambuco, which in its operations of exit from the establishment to another state with material of imported origin, is used the rate of 4%. In the company with the benefit, the transaction will, in fact, be equivalent to 2.10% (ICMS of the general law of 4% highlighted in the sales tax invoice minus one credit / discount of 47.5% over the 4% under Law 11.675 / 1999).

For a sale within Pernambuco, with the benefit, where the internal ICMS is 18%, the company effectively has an ICMS of 10% (ICMS of the general law of 18% of sales within PE, less a credit of 8% defined in Decree 21.959 / 1999 granting the benefit). Before 2016, the local ICMS rate within PE was 17%, thus the effective value of ICMS was 9% (17% minus 8%).

In Paraíba, sales within the state itself, which, as a rule, have an ICMS rate of 18%, highlighted in an invoice, allow the beneficiary company to pay only 4% ICMS tax on total sales, to the public (credit is the ICMS value posted on the branch's entry operations and will be used to deduct ICMS from outflows). Before 2016, the local ICMS rate within PB was 17%, thus the effective value of ICMS was 3%. And in sales out of state (PB) the rate of the law is 12% or 7%, but the actual collection will be 1% of ICMS highlighted in the sale.

In 2016, there were changes in the difference of rates selling to another state, under the ICMS with the publication of Constitutional Amendment No. 87 of 2015, specifically for sales to non-taxpayers, that is, final consumers of the merchandise sold. As each Brazilian state

Avaliado pelo sistema double blind review
Editor: Marcelo G. Amaral

has the competence to legislate on ICMS independently of each other, each one has adjusted its internal laws to disregard companies that construct the condition of taxpayers of the ICMS, as well as public agencies, making them final consumers for ICMS purposes. This change (BRASIL, 2015) created a more equitable financial distribution among the states, with the purpose of eliminating or reducing the inequalities of collection in the coffers of the same, passing to the consumer state (companies that buy in that state) a larger share in the collection of ICMS.

As shown in the introduction section, Avittathur *et. al.* (2005) showed India has a tax called CST that implies on interstate exchanges of goods, as in Brazil, with its specificities, though. Indian companies avoid paying this tax by creating DCs located in states where sales occur, even if logistics costs increase as a result of storage. Therefore, in some cases, these sales are made to reduce CST tax, despite of a greater distance. So an Indian company needs to find out where to locate their DCs.

Yoshizaki (2002) studied opportunities decrease total cost for establishments which avoid pay the ICMS tax and different sizes of DCs. Pantalena (2004) and Silva (2007) studied a case trade-off between logistics and ICMS tax for clients that absorbs the cost from a company and therefore capable of generating situations of a different type of credit in certain states. Carraro (2009) observed, beyond the taxation logistical aspects, one more variable cost in decision making, which is the environmental issue through carbon emissions. Junqueira and Morabito (2006) studied the ICMS effect on agricultural production planning and distribution, as in Queiroz (2011) and Hamad and Gualda (2014), analyzing the different inventory policies and models of localization where there is the ICMS cost or not.

Alves (2018) analyzed a transference operation between four plants (states of RJ, MG, PB and PE) about metallurgical goods and evaluated it costs: including IVA tax, freight, inventory and expedition. The study concludes that there is no rule about the main cost in this type of operation, sometimes can be the tax, in others the transportation cost is the main one.

3 Linear Programming

Taha (2006) described in his book that the transportation problem is a special type of linear programming about sending a product from origins to destinations. Its objective is to determine the distribution which minimize the total cost and, at the same time, satisfy boundaries about offer and demand. The transshipment problem can be understood as a transportation problem with intermediary units between the factory and the client, known as DCs.

The notations used in the model for this case study are as follows:

Parameters and subscripts

I = {i|i = 1,...,m}, set of origins;

J = {j|j = 1,...,n}, set of destinations;

m the quantity of origin.

n the quantity of destination.

10.20401/rasi.5.3.285

Avaliado pelo sistema double blind review
Editor: Marcelo G. Amaral

c_{ij} the transportation unitary cost from origin (source) i to the destination (target) j. The total cost c is the sum of freight and the ICMS tax costs, but when it is about a transport to the DCs, the ICMS tax is equal to zero. It is assumed that there is no uncertainty about the costs, hence each c_{ij} is a constant;

f_i the origins' offer.

d_j the destination's demand.

b_j the DC's capacity.

Decision variables

x_{ij} the quantity transported from origin i to the destination j.

Linear objective function formulation:

The quantity transported from each origin i to the destination j should be multiplied to each transportation costs applied, reaching a sum of the least total cost possible.

$$MinimizeZ = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij} \quad (1)$$

Subject to:

The sum of the quantity transported from each origin i to the destination j should be less or equal to the amount of that origin's offer;

$$\sum_{j=1}^{6} x_{ij} \leq f_i \quad (2)$$

The sum of the quantity received in each destination j from origin i should be equal to the amount of that destination's demand.

$$\sum_{i=1}^{6} x_{ij} = d_j \quad (3)$$

The sum of the quantity received in each DC j from the origin i should be less or equal to the amount of that DC's capacity.

$$\sum_{i=1}^{6} x_{ij} \leq b_j \quad (4)$$

The sum of the quantity transported from each DC i to the destination j should be equal to the amount received from in each origin i.

$$\sum_{i=1}^{6} x_{ij} - \sum_{j=1}^{6} x_{ij} = 0 \quad (5)$$

The quantity transported cannot be negative.

$$x_{ij} \geq 0 \quad (6)$$

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Editor: Marcelo G. Amaral

4 Research method

First, it was made a literature review, using Web of Science interface. Afterwards, the review included some Brazilian journals about ICMS tax within transportation costs context: *The Journal of Transport Literature*, *Produção*, *Gestão & Produção* and *Transportes*. Last, also was found some dissertations about this subject. This review pointed out that none of those studies yet demonstrated how much this important Brazilian tax can influence the imported product transportation costs, since the changes in ICMS tax on January 2013.

Based on that, this applied research chose a qualitative approach, employing a research strategy of single case study, defined when dealing with a contemporary phenomenon that does not require control over behavioral events (Yin, 2011). Its level of analysis was the organizational one and the unit of analysis was the company from the metallurgical industry (Vieira, 2006).

It was also an exploratory study, emerged from a real company demand. The data was gathered by interviewing a financial manager from the company for the problem solving. Therefore, the sample used in this study wasn't probabilistic, hence the results cannot be generalized, at first.

Then it was used a model with linear programming about a transshipment problem, generating three scenarios:

- Scenario 1: deliveries without any DC used as transshipment;
- Scenario 2: deliveries with a possibility to use one DC as transshipment;
- Scenario 3: deliveries with a possibility to use two DCs as transshipment;
- All of the three scenarios may transport national or imported products.

The intention was to verify if transshipment could help decrease the total cost. The presupposition was that despite of a greater distance, increasing freight cost, the state benefits for ICMS tax could decrease total cost.

The complement Solver from Microsoft Excel software was used to generate the results used in this study.

5 Case study

The company studied has its factory located at the state of Rio de Janeiro (RJ) and its DCs in the states of Pernambuco (PE) e Paraíba (PB). Notwithstanding produces only at RJ, it also may import products from two different locations: RJ and PE. This company has two different types of clients: taxpayer; and non-taxpayer, which increases the ICMS tax rate for the company. At state of Rio Grande do Norte (RN) there are two clients, one is taxpayer and another isn't. States of Piauí (PI) and Bahia (BA) has one taxpayer client each and the state of Sergipe (SE) has a non-taxpayer client. All states can be seen at figure 1.

Avaliado pelo sistema double blind review
Editor: Marcelo G. Amaral

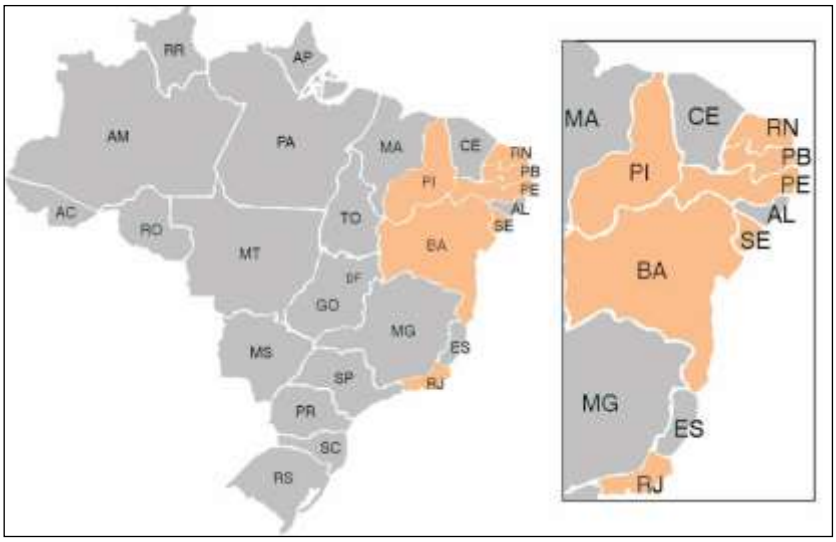

Fig. 1 Map of Brazil, highlighting the states used for distribution in this case study

The company produces or imports its products and hires an outsourced company for interstate highway transportation. Then, when the company sells, the ICMS tax is applied. So the DC is only needed when the ICMS tax cost is lower than the amount of freight and ICMS costs from a direct sell.

E.g.:

- Selling from RJ to RN, the total cost is equal to $1,070,000 composed by freight ($1,000,000) and 7% of ICMS tax ($70,000);
- Selling from PB as a DC (RJ x PB x RN), the total cost is equal to $1,020,000 composed by freight ($1,010,000) and 1% of ICMS tax = ($10,000).

In the last example, the freight is higher than the first one, because of a greater distance, however, it has the lowest ICMS tax, generating a total cost reduction of $50,000.

Nonetheless the company also has constraints about production, quantity that may import, attend exactly the client's demand and not exceed DCs capacity. For that reason, it is necessary to use linear programming to model this problem.

For this problem some assumptions are presented next:

- It will be considered only finished products to be transported to the final client, so does not include the manufacturing costs or the chain link referring to the suppliers of the imported product.
- The factory and the DCs do not have any costs of storage.
- There is only one type of product: in tons, national or imported.
- The company says there is no difference between national and imported products, even regarding level of service.
- The company also says RJ sends only national products to PE, since PE can also import.
- The same origin can supply different destinations.
- The same destination may be supplied by different origins.
- It will be considered just the private clients, since public clients can only receive from one origin.

10.20401/rasi.5.3.285

Avaliado pelo sistema double blind review
Editor: Marcelo G. Amaral

For this study was elaborated a network and presented at figure 2 for better understanding.

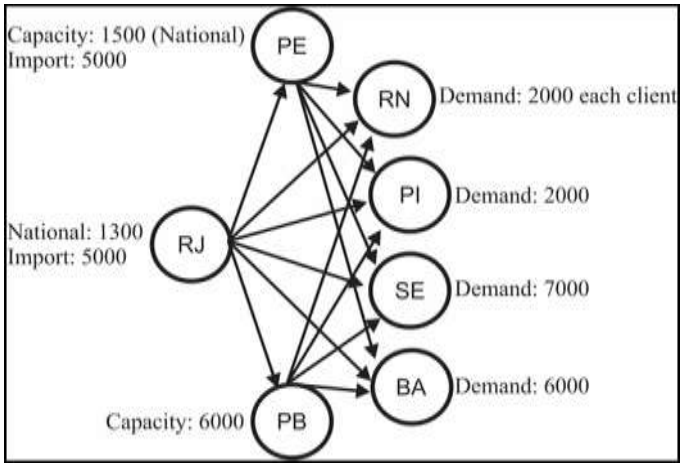

Fig. 2 Network for outflow of pipelines from southeast to northeast Brazil

As it can be seen at Figure 2, PE has the capacity of only 1500 tons of national product, it happens because the PE imported inventory is located at the port of PE, it is not necessary use the transshipment inventory for selling import product from PE.

PB can store the amount of 6000 tons from RJ or PE, independent if it is national or import since there are no difference for the transshipment through PB.

The model adept to this problem is in the section 9 - Appendix, at table 5 for better understanding.

To formulate the linear objective function, it was used the equation 1.

Subject to:

Constraints about origins' offer, using the equation 2:

$$\sum_{j=1}^{6} x_{ij} \leq f_i \text{ (for i = 1,4,5)}$$

Constraints about destinations' demand, using the equation 3:

$$\sum_{i=1}^{6} x_{ij} = d_j \text{ (for j = 3,4,5,6,7)}$$

Constraints about DCs' capacity, using the equation 4:

$$\sum_{i=1}^{6} x_{ij} \leq b_j \text{ (for i = 1,3; j = 1)}$$

$$\sum_{i=1}^{6} x_{ij} \leq b_j \text{ (for i = 1,2,4,5; j = 2)}$$

Constraints about each DC transshipment sending the same quantity that it receives, using the equation 5:

Avaliado pelo sistema double blind review
Editor: Marcelo G. Amaral

$$\sum_{i=1}^{6} x_{ij}\,(fori = 2) - \sum_{j=1}^{6} x_{ij}\,(fori = 1,3 \wedge forj = 1) = 0$$

$$\sum_{i=1}^{6} x_{ij}\,(fori = 3) - \sum_{j=1}^{6} x_{ij}\,(fori = 1,2 \wedge forj = 2) = 0$$

$$\sum_{i=1}^{6} x_{ij}\,(fori = 6) - \sum_{j=1}^{6} x_{ij}\,(fori = 4,5 \wedge forj = 2) = 0$$

Constraint about positive quantity transported, using the equation 6:

$x_{ij} \geq 0$ (for i = 1,2,3,4,5,6; j = 1,2,3,4,5,6,7)

The results for the three scenarios are as presented in Table 2, 3 and 4.

Table 2 - Scenario 1 - Deliveries without any DC used as transshipment

	Origin	Destination	Quantity (ton)	Costs (R$/ton)	Total Costs
National	**RJ**	**BA**	5000	537,75	2.688.750
	RJ	**SE**	4000	1.088,05	4.352.200
Imported	**RJ**	**RN**	2000	583,37	1.166.740
	RJ	**PI**	2000	573,80	1.147.600
	RJ	**BA**	1000	439,37	439.370
	PE	**RN**	2000	448,00	896.000
	PE	**SE**	3000	464,08	1.392.240
TOTAL					**R$ 12,082,900.00**

As it can be seen at Table 2, sales were made direct from RJ, without making any transfer to DC. This has resulted in the highest Total Cost Scenario. It is worth noting that PE was used only for shipment of Imported.

Table 3 - Scenario 2 - Deliveries with a possibility to use one DC as transshipment

	Origin	Destination	Quantity (ton)	Costs (R$/ton)	Total Costs
National	**RJ**	**PE**	1500	389,10	583.650
	RJ	**BA**	5000	537,75	2.688.750
	RJ	**SE**	2500	1088,05	2.720.125
	PE	**RN**	1500	590,58	885.870
Imported	**RJ**	**RN**	2000	583,37	1.166.740
	RJ	**PI**	2000	573,80	1.147.600
	RJ	**BA**	1000	439,37	439.370
	PE	**RN**	500	448,00	224.000
	PE	**SE**	4500	464,08	2.088.360
				TOTAL	**R$ 11,944,465.00**

Comparing the results between Scenario 1 and 2, we have that the Total Cost of sales for RN was 39% higher when PE was used for Nationals, while Total Cost of sales for SE was 19% lower. The cost of sales for PI and BA remained unchanged. This shows that the use of only one DC should be evaluated depending on the conditions of the sale, as it is not always more advantageous to use the transfer for tax purposes.

Table 4 - Scenario 3 - Deliveries with a possibility to use two DC as transshipment

	Origin	Destination	Quantity (ton)	Costs (R$/ton)	Total Costs
National	**RJ**	**PB**	6000	385,98	2.315.880
	RJ	**BA**	3000	537,75	1.613.250
	PB	**RN**	2000	259,73	519.460
	PB	**SE**	4000	287,60	1.150.400
Imported	**RJ**	**PI**	2000	573,80	1.147.600
	RJ	**BA**	3000	439,37	1.318.110
	PE	**RN**	2000	196,32	392.640
	PE	**SE**	3000	464,08	1.392.240
				TOTAL	**R$ 9,849,580.00**

Comparing now the results of Scenario 3 with the other scenarios, we have that the Total Cost of sales to RN were 18% lower in relation to S1 and 41% lower in relation to S2. For SE, the cost reduction was 29% in relation to S1 and 15% in comparison with S2. The cost of sales to Bahia also suffered a reduction of 6% compared to both past scenarios. The cost for PI remains unchanged. These results demonstrate that the use of a more complex Distribution Network assists in the reduction of operation costs, considering both ICMS and Freight.

The difference, between scenario 1 (table 2) and scenario 3 (table 4), is a R$ 2.233.320,00 total cost reduce. It happens mainly because of state of PB benefits for the ICMS tax. As can been seen at scenario 2 (table 3), the difference is lower because state of PE's capacity for transshipment.

In all the 3 scenarios was used the RJ and PE's imported maximum capacity before it uses the factory's capacity to offer from RJ. So changes for ICMS tax upon imported products made them cheaper to transport in this particular case.

Further changes can be helpful for decrease even more the total cost.

- Invest in expand the transshipment capacity, enlarging the DC's inventory;
- Build more DCs;
- Negotiate freight rates with outsourced companies or consider the possibility to buy the company's own transportation vehicles.

6 Concluding remarks

The objective of this paper was to minimize products' distribution costs for a multinational company located in Brazil, observing the different ICMS tax structures.

The study results suggest, despite of a greater distance increases freight cost, using some DCs may help decrease total distribution cost, because of ICMS tax impact. It also suggests that the distribution of imported products is cheaper than the nationals, without consider its purchase and fabrication costs.

The proposed approach contributes, to Brazilian companies or multinationals, to evaluate tax incentives as an alternative to reduce logistical costs, relevant given the current context of Brazilian transport.

It is important to note that this research took into account changes in ICMS tax rates on January 2013. For that reason, it can be a helpful guide for companies know they can use its benefit and also be careful about any future changes.

As a limitation, in this study it was assumed that national and imported products have the same cost because the company didn't provide the data, stated as a security matter. For that reason, it is suggested for future research look for new variables, new cases considering other locations (e.g. Brazilian south and north), evaluate the impact of possible new freight spread sheet made by the Brazilian government, exchange rate and consider build others DCs.

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