KEDGE BUSINESS SCHOOL
ILS2016
Information Systems Logistics and Supply Chain
6th International Conference
université de BORDEAUX

Waterways Cargo Transportation: A Comparison between Brazil and the United States

Moacir de Freitas Junior[1,2], Rodrigo Carlo Toloi[1, 3], João Gilberto Mendes dos Reis[1], Oduvaldo Vendrametto[1]

[1] Paulista University, Postgraduate Program of Engineering Production, São Paulo, Brazil
[2] Faculdade de Tecnologia da Zona Sul, São Paulo, Brazil,
[3]Federal Institute of Mato Grosso, Rondonopolis, Brazil,
{bicimo@uol.com.br, toloirodrigo@gmail.com, betomendesreis@msn.com, oduvaldov@uol.com.br}

Abstract. An efficient transport network needs an infrastructure that would be able to provide an optimization in cargo transport, bringing agility and speed. With respect to this, waterways can be considering a solution due to its energy efficiency, greater productivity in relation to the cargo volumes, and low cost per ton. The purpose of this study is compare Brazilian waterways with the American waterways about costs and infrastructure available. To that end we conducted a bibliographical study to collect data and make feasible the comparisons between countries. The results showed that in Brazil, the one cargo tonne transported by one thousand kilometers, cost three times more that in the United States.

Keywords: Infrastructure, transport, waterway, competitiveness.

1 Introduction

Waterways are means of transportation that use water from great lakes and rivers to transport goods and people [1]. It is a mode which increases competitiveness advantages and represent low cost per ton transported. Moreover, its high capacity of transportation, countries with wide territorial dimensions should consider the waterway as an option [1]. However, the use of waterways transportation in the world is small in front of its potentiality.

Fici states that in the world, around 450 thousand km of rivers can be navigable and only 190 thousand km are explored by means of waterways, useful for the transportation is around 2.2 million ton per cargo/year [2]. Besides its low cost of transport and high capacity of transport cargo, the advantages of waterway system in comparison to the other transportation modes include energy efficiency, cargo concentration capacity, infrastructure lifespan, fuel consumption, emission of pollutants, and so on.

The United States considers this potentiality. According to Kruse et al., annually 624 million metric tons of products are transported by American waterways, which corresponds to 14% of all domestic transport and amounts to an average of US$ 70 billion [3]. On the other hand, the waterways are responsible for only 1,95% of all cargo transported by water [4].

The purpose of this study is to compare the Brazilian and American waterway use considering costs and infrastructure. Both countries are larger and plenty of many rivers, but do they use efficiently the waterways available?

This paper is divided in sections and after these introduction is presented the methodology, following by the scenario of Brazilian and American waterways, and a comparison between both countries.

2 Method

This study is an exploratory research that aims to compare the inland waterway network in Brazil and the United States. These countries are the two major grain producers in the world, however, they present significant differences in the logistics systems. Where the USA uses a large inland waterway, for instance, to move grains between growers and ports, while Brazil, despite the size of rivers available, it uses, in general, the roadway transportation to move grains.

We conducted a qualitative study to describe and compare the current situation of inland waterways in both countries. To this end, the research followed the steps:

a) A literature review: which allowed us to identify: (i) volumes and the main transported goods; (ii) advantages and disadvantages of inland waterways; (iii) the main corridors of transportation; and (iv) costs of transport matrix related to GDP.
b) Description of the data: the characteristics of the modes were investigated between the two countries, detailing the use of the inland waterway network and its extension. Moreover, we verified the volume of traffic and types of loads and products.
c) Data Analysis: The comparative use of the waterway between Brazil and the United States were develop taking into account the extension and infrastructure level offered.

3 Brazilian Waterways and American Waterways

With a large coastline, Brazil owns many navigable rivers, however, this has never been the most used cargo transportation mode, where its participation is less than 15% below, in comparison to the maritime transportation [4].
Brazil has 63,000 km of waterways, being that 40,000 and 50,000 km of rivers, lakes and lagoons can be considered potentially navigable, where 29,000 km will have its structure improved according to the National Plan of Logistics and Transport [5].
Brazilian rivers, frequently of great volume, are considered to be an alternative for the reduction of costs in transport, but, not always navigable, because of their unevenness [6]. However, according to the Brazilian Waterways Report produced by the National Waterway Transport Agency, around 13,646 km are effectively used for navigation [7]. The waterway mode in Brazil is not used frequently because Brazil focuses on the road mode most often, as can be seen in Figure 1.

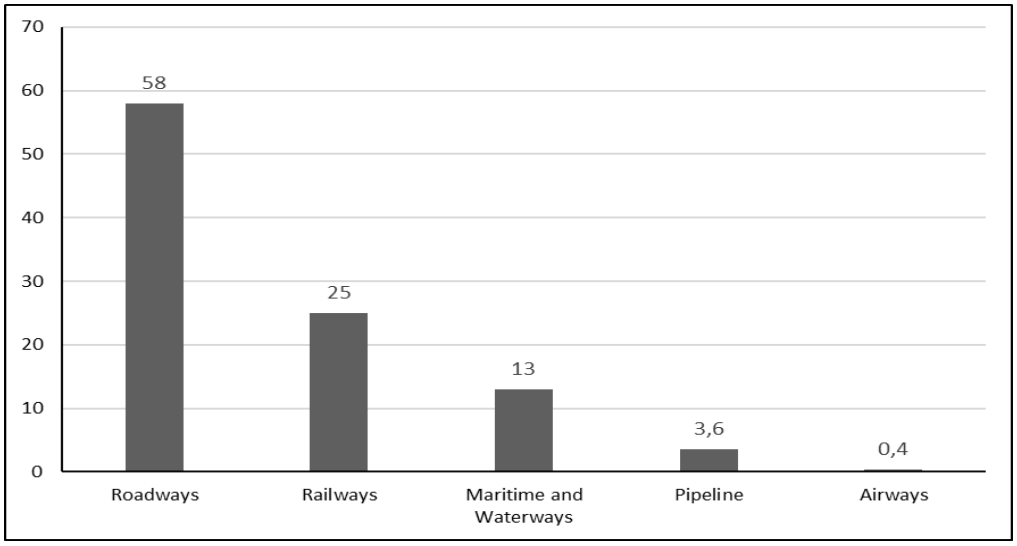

Fig. 1: Matrix of Brazilian Transport. Source: Adapted [4]

The inland navigation transported a total of 28 million metrics tons, having solid bulks as main cargo [8]. Amazon waterways represent, respectively, 61,9% and 35,1% (Table 1)

Inland navigation is considered vital for transporting the wealth of a nation, especially in regions that show a natural hydrographic condition [9]. Table 2 presents the extension of the waterway network currently in operation in the country.

Table 1. Participation in inland navigation by type of cargo and by basin district in the main river basins

District	General cargo free (%)	General cargo in containers (%)	Liquid Bulk (%)	Solid Bulk (%)	Total participation by basin district (%)
Amazon	53,1	72,4	68,2	19,8	35,1
Parana	0,1	--	--	33,5	20,7
Paraguay	--	--	--	31,4	19,4
South	4,9	--	17,6	14,9	13,3
Tocantins-Araguaya	41,9	27,6	14,2	0,5	11,5
Total participation by type of cargo	20,8	0,1	17,2	61,9	100,0

Source: Adapted from [7] and [8]

Table 2. Brazil's Waterways

Waterway	Extension/Km
Tiete-Parana	1,660
Amapa Madeira	4,164
Tapajos	1,046
Capim	372
Tocantins Araguaya	3,040
San Francisco	1,371
Jacui, Tapajos, and Lagoa dos Patos	670
Paraguay	1,323
Total	13,646

According to Valente, the only waterway connecting great economic centers is the Tiete-Parana; hence the operations will always depend on the others modes of cargo, for example, we have the transport of grains from Mato Grosso which are transport by barges to Porto Velho and then transferred to ships at Itacoatiara Port [10].
The waterway cargo transport in Brazil has progressively growning, in 2013 more than 80 million metric tons were transported [7]. The evolution from 2010 to 2013 is shown in Table 3.

Table 3. Waterway transport cargoes in TKU – 2010-2013

Type of navigation	TKU (in billions)							
	2010	%	2011	%	2012	%	2013	%
Inland coasting	24,7	42,6	23,9	23,9	25,0	40,5	24,5	38,0
Inland long journey	18,1	31,2	20,6	33,9	20,1	32,6	21,3	33,1
Inland navigation	15,2	26,2	16,3	26,8	16,6	26,9	18,6	28,9
State	2,3	4,0	2,3	3,8	2,2	3,6	2,5	3,8
Interstate	10,7	18,4	10,9	17,9	11,8	19,2	12,7	19,8
International	2,2	3,9	3,2	5,2	2,5	4,1	3,4	5,3
Total General	57,9	100,0	60,9	100,0	61,7	100,0	64,3	100,0

Source: Adapted [7]

The routes of the main groups of goods emphasize the logistics corridors, which use the waterway mode [11]. Bauxite, for example, uses the corridor Solimoes-Amazonas departing from Oriximiná/PA and Juruti/PA for export or to other Brazilian port installations via coast [7]. Another important waterway corridor is Madeira. A Large part of the soybeans produced in the central western departs from Porto Velho/RO and goes downs Madeira River to Itacoatiara/AM or Santarém/PA, from where it goes on to exportation [7].
In San Simão/GO, there is the Parana-Tiete waterway that link the city to the Pederneiras/SP, where it is transferred to a railway and exported by Santos Port [7]. The World Wide Inland Navigation Network

presents the main products and the respective percentage transported in Brazilian waterway in 2010 (Figure 2).
In 2011, the most transported products were iron ore, soybean, nonmetallic minerals, organic chemical products, semitrailers, fuel and mineral oils and corn, which amounted to 81,3% of all transport in this period [8].
Freitas et al. state that the United States is one of the countries that most use this mode, owning the bigger waterway flow in the world, with approximately 57% of use amounting to 40 thousand km. Mississippi, Missouri, Ohio, Tennessee, Illinois and Arkansas Rivers, besides the lakes, are very well explored in the transport of cargoes because of the potential they represent [12](Figure 3).

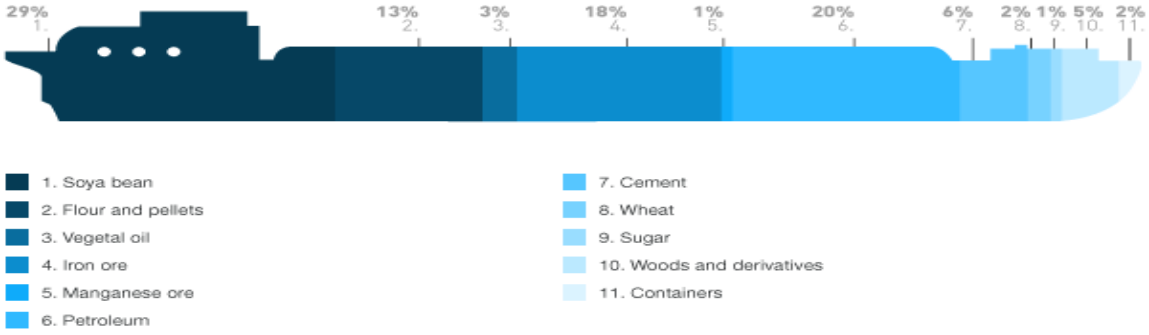

Fig. 2. Types of Cargoes Transported by Waterway. Source: [13]

Fig. 3. Types of cargo transported by American waterways. Source: [13]

Queiroz et al show the importance of the American transport network for it uses 19,210 km of navigable canals with 240 locks, in 38 states, from Canada to the Gulf of Mexico and also from the Atlantic to near the Rocky Mountains as well as the northwest Pacific [14].
The fluvial navigation is widely used in the United States and predominates in the American transport matrix. According to Kruse et al. the country owns 40,230 km of waterways, 19,310 km inland and 20,920 km coastal, owns 400 ports and transport 70 million metric tons of cargo annually, from which

half are grains, soybeans, corn and pet food [3]. Mississippi River alone has 3,730 km and is considered one of the most important rivers for navigation and goods transport, especially agricultural products[3].
Carlini argues with economic benefits of sea transport, American government invested effectively in the infrastructure of the waterway mode in the past few decades where all the involved sectors are supported by federal loan for operational expenses and working capital, in the process [15].
He also states that after the creation, in 1986, of the water resources development Act - WRDA, all expenses for the construction and development of projects in waterways are split: 50% for the federal government and 50% for the users of that system, through the Inland Waterways Fund. Table 4 presents the structure of the American waterways network, and the bigger extensions are the Mississippi, Missouri and Atlantic Intercostal waterways.

Table 4. American Waterways

Waterways	**Extension/Km**
Mississipi	3,730
Missouri	3,767
Ohio	355
Tenessee	1,490
Illinois	493
Arkansas	2,364
Atlantic Intracoastal	4,800
Apalachicola-Chattahoochee	269
Gulf Intracoastal	1,700
Ten**nesse**e-Tombigbee	320
Monong**ah**ela	210
Upper Mississipi	2,000
St.Clair	65
St.Lawrence	1,197
St.Mary	480
Columbia Snake	2,000
TOTAL	25,240

The Atlantic Intercostal waterway, located between the coasts of the Atlantic and the Gulf of the United States, provides a navigable itinerary for the ship, without many risks, being favorable for tourism navigation since it goes past cities like Fort Lauderdale.
The main products transported by American waterways are coal, responsible for 31% of all cargo handling through American waterways, followed by petroleum with 26%, and then, crude material with 15% of the volume transported by the waterway mode [13] (Table 5).

Table 5. Participation in the volume transported by type of cargo

Product	Participation (%)
Coal	31,00
Petroleum and Petroleum products	26,00
Crude Materials	15,00
Food and Pharmaceutical Products	14,00
Chemical Products	9,00
Primary Manufacturing Products	4,00
Manufactured Products	1,00
Total	100,00

Source: Adapted [13]

Kruse et al. point out that this scenario could be better used, having in mind that American waterways do not use their potential fully, and its mass use would result in less environmental impacts [3].

The rivers are a natural path and do not require high construction and maintenance costs. The costs of construction and maintenance of canals are lower when compared to the other modes, and they can even be used for watering, tourism, leisure, and energy production. Table 6 shows the average cost by mode for construction and maintenance.

Table 6. Average Cost of Construction and Maintenance by Modes in US$

Mode	Construction	Maintenance
Waterway	34.000	Low
Rail	1.400.000	High
Road	440.000	High

Source: Adapted [5]

4 Comparisons

4.1 Infrastructure

In this paper, we presented the main characteristics of Brazilian and American waterways. So far, when we compare of the transportation infrastructure between the United States and Brazil, the first is ahead, because Brazil still has the same matrix from the 1980's [5]. Furthermore, the United States has an advantage in relation to the use waterway mode use, and it transport on average eight times more cargo annually than Brazilians. Indeed, the Americans also explore twice more the options of navigable canals. The focus of the use of waterways is related to the commodities transportation, where in the United States main product is coal and in Brazil, soybeans (Table 7).

Table 7. Comparison of Brazilian and American Waterway Network

Item	**Brazil**	**USA**
Main Product Transported in %	Soybean - 29%	Coal - 31%
Network Used in Km	13,646	25,240
Volume Transported in million/tonnes/year	80	624

According to Logistics Institute - ILOS if the Brazilian transport matrix were similar to the American matrix and if the same costs were practiced, Brazil would reduce its expense in US$ 28.711 billion, which represents 37% profit. Table 9 compare transport infrastructure between the United States and Canada with to BRIC countries.

Table 9. Infrastructure of Cargo all over the World

	Brazil	**China**	**India**	**Russia**	**USA**	**Canada**
Area (million Km^2)	8.5[1]	9.6	3	17	9.1	9
Paved Roadway	219	1,576	1,569	776	4,375	416
Railway	29	86	64	87	225	47
Pipeline	19	87	35	260	2,225	100
Waterways	14	110	15	102	41	0.6

Source: Adapted [16]
[1]Thousand of kilometers. Source: Adapted [16]

4.2 Cost

Freitas et al. states that the costs of transport are those which involve transference of goods and raw material from the suppliers to the delivery of the finished product to the final customer [12]. Note that it is represented by the capital (depreciation, financial taxes, return taxes, etc.), operational (maintenance, supervision, staff, lease, insurance, etc.), and other (taxes, tolls, licensing, etc.). Table 10 shows the

comparison of costs among the matrixes of Brazilian and American transport, where the first has a cost three times higher, making the process expensive.

Table 9. Matrix of transport of cargo in Brazil and the USA and their respective costs by mode, in 2012

	Brazil		USA	
	% TKU	**US$/Mil TKU**	**% TKU**	**US$/Mil TKU**
Roadway	67	133	31	310
Railway	18	22	37	29
Waterway	11	30	10	10
Pipeline	3	25	21	9
Airway	0,04	1060	0,30	1,107

Source: Adapted [13]

Brazilian logistics costs are 27% bigger in comparison with the ones in the USA, and this is caused by the matrix of transport, considering that in Brazil roadway mode predominates. At the same time the waterway cost for TKU in Brazil is three times more than in the USA.

5 Conclusion

This study focused on the comparison of the use of the waterway mode between Brazil and the USA. The general result indicated that Logistics is one of the biggest issues to the economic development of Brazil, which, although owning similar geographic dimensions to the ones in the USA, has a different matrix of transport. Brazil focuses on roadway mode for transporting, which represents 60% of all the volume of cargo transported, although it has a very deficient infrastructure where a great part of the roadways are in bad condition and the rate of investment by the public sector is very low.
On the other hand, the USA focuses on the railway mode and constant investment is made by both the private and public sector. In relation to waterway transport, the mode with the best cost/benefits relationship, a great competitiveness advantage is observed for the USA, considering that they use 57% of their waterway potential while Brazil uses only 26%. By the American waterways, 483 million metric tons on average are transported annually whereas ins Brazil, only 25 million tons.
Finally, it is clear that, in Brazil, the investment in infrastructure does not catch up with the advances of the productive sector. The future studies will check alternatives for transferring cargo to the waterway mode.

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