

EFFECTS OF COVID-19 ON WATERWAY TRANSPORT COST STRUCTURE: A MULTIVARIATE ANALYSIS IN AMAZONIA

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ABSTRACT

Amazon region has a specific transportation reality in comparison with other Brazilian regions. One of peculiar features in the region is the waterway transport of people and goods, in association with a high level of disperse population far apart and the lack of social and physical infrastructure, which make costs essential factors to sustainability of service. In this work, a multivariate analysis using ABC method and tendency function to activity costs behavior, inherent to the waterway transport cost structure, was carried out, given the pandemic situation. Data were collected in the last years, before and in the current COVID-19 pandemic phase, to be used to assess changes in interdependence between total cost and activity costs; in order to subsidize the strategic planes of sector recovery. The study was undertaken in a case of a long-distance crossing at a company in Belem, Brazil and, on results, revealed effects on waterway transport cost structure, in which the reduction of trips affected in reducing fuel consumption costs, maintenance and operational factors above 50%. However, fixed labor and administrative costs had a greater share in total costs, even with the 10% drop in costs of support activities, on average, considered as fixed costs; not being offset by the drop in revenue due to reduced trips. In fact, the effects were proved, mainly, in primary activities. In addition, the need for partnerships between competing companies was evidenced, mainly, for secondary activities, in which several costs could be shared in infrastructure and labor on land. Moreover, in port and on maintenance, as well as on economies of scale, companies could have in acquiring of resources in greater quantity, as in the case of fuel.

Keywords: COVID-19, waterway transport, costs, multivariate analysis, Amazonia.

1 INTRODUCTION

In Brazil, inland water transport, actually, is responsible for more than 25 million tons of cargo [1]. There is a consensus in technical reports of literature review, an estimative of 13,000 km of waterways, with a potential for 28,000 km, considering engineering interventions in some parts of the rivers. In Amazonia, it is located the largest waterway corridor of the country – composed by Solimoes and Amazonas rivers – in terms of transported volume and distance covered. Regarding passenger demand, there is an estimate in five million passengers per year, on the main waterway transport service in Amazonia [2].

At the core of economic development in region, in recent decades, the emergence of mining, agricultural and industrial hubs have brought an increase in the harvest, thereby increasing the demand for waterway transport, requiring more adequate and safer transport. Regarding the routes, the use of mixed vessels for the transportation has been growing, since they are the ones that suit the operational conditions to the Amazonas River tributaries. In addition to passengers, the most diverse kinds of products, such as food, beverages, clothing, appliances, electronics and regional products are carried. With the intense movement of people and goods, with little control, cost management is a challenge and crucial for sustainability of business [3].

Waterway transport in Amazonia has importance of social nature, reaching several places that have no other transport option to get around [4]. The greatest difficulty for passenger



transport is a regular and fast shipping that meets appropriate standards of service. The trips, in many services, are planned according to the interest of the ship owner, as he or she only takes trips if there is demand, which makes the trip profitable. Most of services are still served by outdated technology vessels and, in many cases, built in wood or steel, aged over decades.

Without government action, through subsidies and grants, it is impossible for companies to invest in modern technologies, to serve more places where there is a low-income population and to foster the economy. Vessels often have problems related to comfort, hygiene and safety. One of the companies' arguments for low quality of services is the low-value tariffs, due to low purchasing power of passengers. Moreover, due to regional conditions, waterway transport is often used to supply the main economic centers, as well as, allowing access to the most distant locations [5].

The companies of passenger waterway transportation operate under public concessions being, in the interstate and international sphere, the activities and sales prices regulated by the National Agency of Water Transportation (ANTAQ) and, in the state sphere, the Service Regulation Agencies of each State. Thus, such companies can have little influence on tariff and, on revenue as well. Furthermore, due to the requirement of Brazilian Navy, they also have crew scale restrictions that affect the desired results, and business sustainability, too.

In the Amazonia region, companies of passenger waterway transportation, although performing their activities through public concessions, are not exempt from the current market difficulties. This fact can be verified through the existing competition between the activity of waterway passenger transportation and other modes. For example, air transportation for longer distances, a modality that is practicing prices closer and closer to the fares charged in waterway transport and, in some cases, with road connections, transport carried out with a private vehicle in shorter stretches of trips, due to the opening new roads.

Regarding the challenges for which the companies need to pay attention and draw strategies: ensuring the conquest and permanence of new customers; expanding the area of operation, achieving the best quality of services; maintaining the satisfaction of its employees and, economically, managing its resources. The level of information available to managers is important for organizations to be able to define the right strategies on the proper time. The new operational environment, which is based on information, requires companies to have an adequate supervising tool to control and measure performance.

Despite all older challenges, the water transport has been suffering consequences from COVID-19: with services outage, whether passengers or cargo. In Brazil, the fast rise of virus, made it necessary to nonessential trades closing, isolation from crowded cities and the closure of other relevant institutions, such as schools, for example [6]. Thus, the pandemic cannot be considered only as a public health crisis in the worldwide, but also as an economic and social crisis, since most of human behavior dynamics has been affected. Including, issues related to transport, the use of modes and the transport logistics itself [7].

Studies involving the new coronavirus pandemic are still an ambiguous scenario where the actual overall effects of COVID-19 on economy, in society and even on transport, are not yet fully known or predictable. In fact, the transport has been directly affected, requiring studies to predict or to estimate the effects, in order to reorganize the service and make decisions on investments. In the Amazon, particularly, given the importance of waterway transport, and its coverage throughout the region, the economic situation has worsened, which makes it necessary studies of costs in the waterway transport value chain, specially, the costs drivers.

In this context, this work proposed to identify the value chain and analyze the costs of passenger waterway transport, based on strategic cost management, with a typical case of crossing made by a company from Belem city to Marajo Island. As a main hypothesis, it was



assumed that a strategic vision of the value chain might bring sustainability to the business in water transportation companies, i.e., it may constitute as a reference for future and more sophisticated applied works of optimizing the resources involved and supporting the decision-making. It was undertaken a tendency analysis in the cost structure of service, before and in the current COVID-19 pandemic, to verify changes or not in cost drives, and the level of relevance.

2 METHODOLOGY

This work had exploratory and empirical feature of passenger waterway transport and it was divided into three purposes: to identify cost structure of waterway transport service, and its activities; to undertake a survey about these costs; and to analyze the tendency between total costs and individual costs of activities before and in the current pandemic. The methodology was centered on ABC method and, in the case study, the use of tendency function by ordinary least squares, available on Microsoft® Excel® 2019, to analyze the cost structure.

2.1 Cost structure of waterway transport service

At first, a literature review was undertaken, based in strategic cost management, with cost structure framework of value chain and all activities. This analysis considers a broader context, where strategic elements become more aware, explicit and formal [8]. Thus, it goes beyond the scope of cost analysis, which addresses financial aspects for decision-making. In this domain, this analysis conducted to cost allocations that are difficult to measure which affect cost accounting, requiring alternative forms of evaluation. There are several studies with the purpose to identify more specific decision criteria, to be applied in empirical research into managerial accounting [9], [10]. In transport services, there are some recent studies, mainly in logistics [11].

The development of cost analysis models with a strategic management vision has as theoretical reference from Cooper and Kaplan, with the activity-based costing method [12], representing a rupture with traditional costing systems and adapting management accounting to a new situation in terms of markets and industries. The activity-based costing (ABC) method considers that to produce a product or service it is necessary to perform certain activities that, in turn, to spend resources. Thus, this costing system allocates resources for the established activities on value chain, followed by the allocation of costs from such activities on the cost objects, thereby the cost drivers [13].

Cost drivers are crucial elements for this approach because they demonstrate and quantify the cause-effect relationship between resource use, activity performance and cost objects [14]. The information extracted from the ABC method allows to identify activities that add value and those that do not, the latter being able to be reduced or eliminated without compromising the value created for customers.

As this was an exploratory and empirical study of passenger waterway transport, it was divided into two phases:

2.2 Definition of value chain elements

A document analysis was carried out for the general characterization of company and the service, and data for cost structure was obtained to identify the value chain of service and the resources employed. At this stage, empirical observations of service were made, notes were taken of the activities developed in various sectors and interviews were conducted at

company. It was also possible to identify the cost drivers of activities and the value chain structure.

A reasonable level of aggregation was also sought, considering the difficulties that defining each activity would bring to the information system. At this stage, interviews were conducted with the company's employees, since the experience acquired could provide estimatives of resources consumption by different activities, as well as to establish the cause-effect relationship between the resources consumption and their activities. Finally, defined the activities, the resources that each activity consumed were allocated to them.

The ABC methodology seeks to answer: Which activities are being executed by the organization? How much does it costs to be executed? How much of each activity is needed for services, considered as cost objects? In short, in ABC the cost of service results from the sum of direct costs and the cost of all the activities needed to produce a service [15], as presented in Fig. 1.

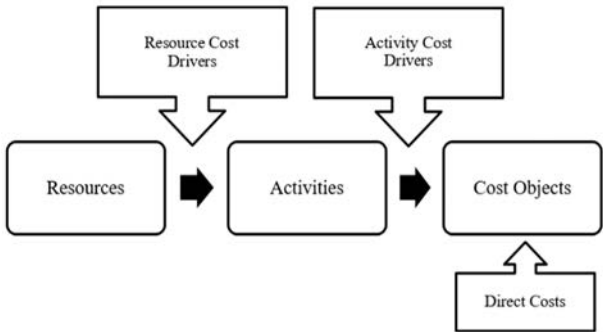


Figure 1: Activity-based costing method assumptions [16].

Fig. 1 indicates that ABC is a method with three main steps: the first, in which the costs of resources consumed are allocated to the various activities of company. In this step, resource drivers are used to distribute the costs consumed over more than one activity. Second, the activities costs are allocated to the cost objects based on their consumption of the former. This allocation is done using activities cost drivers. Finally, direct costs are added to the cost objects, having the total cost of service.

3 THE CASE STUDY

The case study started from value chain recognition of service, with identification of resources and activities, to analysis of pandemic effects on cost structure by COVID-19. The research does not intend to discuss the strategic cost management approach instead, it is focused on use it, analyzing the operational conditions.

3.1 Case: Belem–Camara crossing, in Brazil – context and ABC method application

Belem–Camara crossing has the following basic operational features: daily frequency of the service for passengers, authorized by Para Service Regulation Agency: ARCON. The trips departs from Belem waterway terminal (at Port of Belem) to Marajo Island (at Port of Camara). See Fig. 2 for a map that shows the waterway route. The crossing is 30 nautical miles long with two equipments: ship for 600 passengers and boat for 137 passengers. There is a competitor with similar equipment and, another one with a ferryboat.



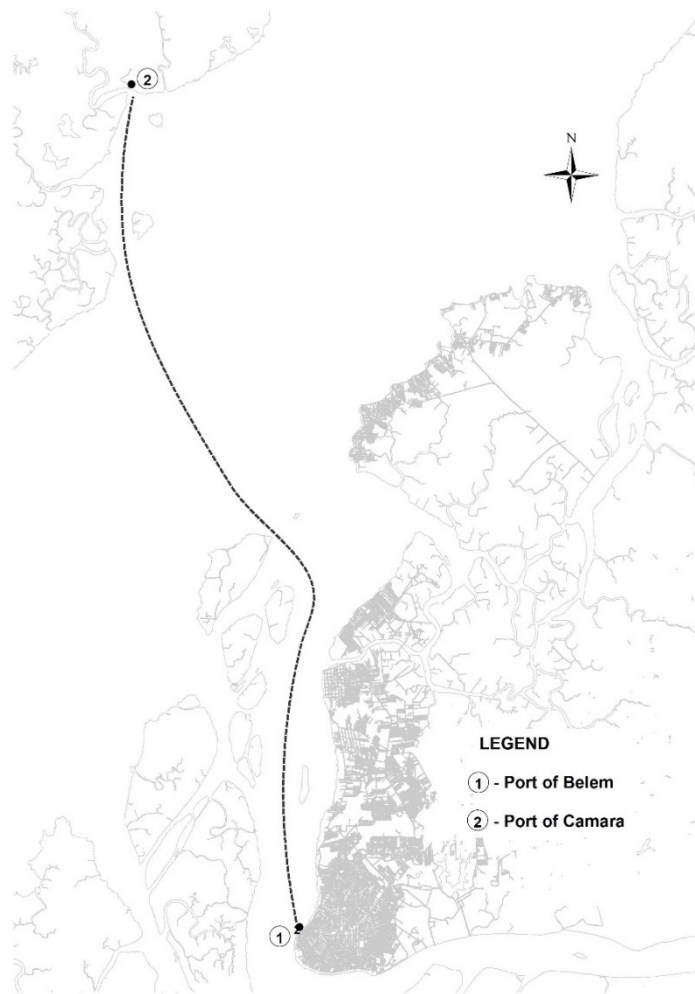


Figure 2: Belem–Camara waterway route. (*Source: Authors.*)

In an interview with the company's board, the main challenges were identified:

- The out-of-date Belem–Camara crossing tariff, in the last 20 years, and without perspective of adjustment by the regulatory agency;
- The high seasonality rate of service, where only in two months of year can one actually have the capacity of service filled;
- The large number of competitors equipments;
- Shortage of skilled labor;
- Conflicts of operational nature and financial adjustment with competing companies; and
- Inefficiencies resulting from low management capacity.

3.1.1 Cost structure: activities and resources

In this step, cost objects were identified: the crossing and its trips, existing equipment, if passengers and/or cargo. In sequence, the elements of the value chain – the activities – were identified (see Table 1). Activities were classified as primary operational or supplementary (linked directly to the cost object, i.e., Belem–Camara route) and secondary activities; identified as variables costs and fixes costs, according to direct dependence on whether or not there are trips.

Table 1: Activities and related resources: cost structure. (*Source: Authors.*)

1. Primary activities				
1.1. Operational		Direct costs	Indirect costs	Costs
1	Administrative support at the port	Wages with charges	-	Variables
2	Ticket Sales (ticket manufacture/ refund/ distribution and card costs)	Ticket office salary/programs and systems/box office rental/ticket printing	ARCON rates and income tax	
3	Release of the fleet and crew (equipment preparation and crew scale)	Dispatcher	Shipping fee Mooring fee	
4	Fleet maintenance (personnel/ storage and equipment)	Mechanical (with charges)/ spares parts	-	
5	Equipment operation (inputs and crew)	Fuel/lubricant/wage/boat rental	OAF/Gratification/ Infringement minutes/ Naval engineering service/Vessel inspection/Registration	
6	Equipment operation (depreciation)	5% p.a. of the market value of the equipment	-	
1.2 Marketing and Sales				
1	Advertising	Annual amount	-	Fixes
2. Support activities				
1	Maintenance of the company headquarters	Port infrastructure expenses	Administrative taxes/ FAO	
2	Administrative activities	Lawyer/Administrative staff	PCMSO, administrative taxes/digital certificate, trademarks and patents	
3	Accounting and finance services	Accounting advice	Accounting fine	
4	Other activities	Board payment	Company advertising, bank/loan charges/ employer's union monthly fee	

3.1.2 Cost drivers for each activity and financial statements

Revenues and costs by activities for 2017, 2018, 2019 and 2020 from service were determined. See in Table 2, revenues and costs total per/year. Revenues and costs were consolidated from gathering information by activity of cost object, i.e., Belem–Camara route. In turn, resources were allocated in activities according to their nature, namely human resources, infrastructure, equipment, and miscellaneous resources. The human resources encompassing the operation's employees and the administration's employees (surveillance,

cleaning, electricity, maintenance at headquarters and administrative services) were classified into operational and administrative labor.

Table 2: Company financial statements in 2017, 2018, 2019 and 2020, US\$. (*Source: Authors.*)

Data	2017	2018	2019	2020
Total revenues	1,157,970.31	1,102,103.96	1,108,597.06	750,455.95
Total costs	1,220,290.34	1,308,634.83	1,194,522.79	771,090.21

Infrastructure costs include expenses with the company headquarters (warehouse, water, energy, indirect taxes, etc.), the ticket sales counters and the port infrastructure for crossing, being public authorities responsible for passenger terminal. The resources are related to the equipment used at crossing, as well as computers, printers and other. Finally, in other activities, there are resources such as software and contract services, as well as occasional costs with service providers. The analysis of documents (particularly, financial information), on-site observations, and the interviews that were performed, allowed the identification of the most relevant costs and respective cost drivers, with fuel consumption as resource cost driver and nautical miles as activity cost driver.

Once the activities were defined, annual activity costs of crossing were allocated, as shown in Table 3. It is important to point out that transport service operational activity requires much fuel and labor. Consequently, costs directly associated with resources and activities from cost drivers are more representative in cost structure of service, as example, 1.1.5 activity. Activities as 1.1.2 and 1.1.3 already depend on whether or not there are trips and, for this reason, the number of trips heavily influences them. Therefore, the study was focused on changes in primary activities costs, however, being aware of supplementary and secondary activity costs made it possible to analyze the importance of these cost elements in the value chain and their representativeness in total cost of service.

Table 3: Activities costs per/year, US\$. (*Source: Authors.*)

Activities	2017	2018	2019	2020
1.1.1	78,635.54	70,478.22	76,136.60	60,112.71
1.1.2	72,554.65	74,232.43	72,554.65	11,004.28
1.1.3	20,287.77	20,863.31	20,287.77	8,606.92
1.1.4	112,043.31	114,596.08	112,043.31	126,093.74
1.1.5	675,771.17	766,025.06	650,488.55	324,222.99
1.1.6	71,942.45	68,345.32	64,928.06	51,942.80
1.2.1	4,654.68	2,955.40	4,745.32	2,232.13
2.1	91,074.88	94,456.17	91,074.88	91,170.75
2.2	52,874.34	52,249.98	48,789.01	50,894.77
2.3	1,589.93	1,589.93	1,589.93	1,589.93
2.4	112,394.01	112,778.19	118,402.70	108,921.58

3.2 Predicting 2020: actual costs and cost tendencies

Data analysis from Table 3, applying the tendency function by ordinary least squares, using Microsoft® Excel® 2019, presented the cost values estimated for 2020. Table 4 presents the

actual costs and the estimative of costs, without the current pandemic, following the tendency based on data of previous years.

Table 4: Comparing costs per/year, US\$ in 2020.

Activities	2020, actual costs (in the current pandemic)	2020, estimated costs (without current pandemic)	%
1.1.1	60,112.71	76,332.92	-26.98
1.1.2	11,004.28	73,113.91	-2.97
1.1.3	8,606.92	20,479.62	-137.94
1.1.4	126,093.74	112,894.23	10.47
1.1.5	324,222.99	710,069.57	-119.01
1.1.6	51,942.80	71,912.47	-38.45
1.2.1	2,232.13	4,073.15	-82.48
2.1	91,170.75	92,201.98	-1.13
2.2	50,894.77	53,347.11	-4.82
2.3	1,589.93	1,589.93	0.00
2.4	108,921.58	111,520.62	-2.39

4 DISCUSSION

ABC method was suitable for the analysis. It was possible identify the cost structure of service, presented in Table 1. Cost structure represents the service value chain, divided in primary activities, supplementary and support activities. On cost structure was allocated all cost, qualifying them in direct and indirect costs and, furthermore, in variables and fixes costs. This perspective is useful to evaluate changes in value chain cost structure of activities and resources costs, quite appropriate for the objective of this work.

- COVID-19 pandemic caused a Belem–Camara complete stoppage and, afterwards, in operation under restrictions, for months in 2020, greatly affected passenger transport service and the worsening of financial situation. In results, the following stood out:
- A financial instability of operation, resulting from competition and management difficulties, presenting in annual deficit for consecutive years (Table 2) and worsening in 2020. COVID-19 pandemic only worsened what was already bad. Note that compared with preceding years (2017, 2018 and 2019) 2020 reduced by nearly 40% the revenue, on average. Although, costs have also decreased, they have remained even greater than revenue. Applying the trend function, a revenue projection obtained, based on the last years, was US\$ 1,147,577.07. Instead, it was only 750,455.95 of actual revenue in 2020 (in Table 2). The tendency of total cost projection was US\$ 1,240,033.10, instead of US\$ 771,090.21 in 2020 actual costs. On average, 53% and 63% decrease in revenue and cost, respectively, between 2020 and previous years.
- Fuel consumption and labor are the cost drivers of resources, influenced by number of trips, i.e., by nautical miles, cost driver of activities. In Table 3 presents 1.1.3, 1.1.5 and 1.2.1, the most relevant activities influenced by trips. These activities are employed heavily in operation and suffered a drop 137.94%, 119.01% and 82.48%, respectively, with the stoppage in 2020, as they are directly related to tickets sales (Table 4).
- The fleet maintenance activity is the second most important activity in the company's costs, but with stoppage, little was done. Likewise, no investment on fleet renewal, which reflected in 38.45% in 1.1.6 activity from Table 4.

- Support Activities were little affected by pandemic, as seen in Table 3. Administrative activities, other activities consist of many costs that need to appreciate by company, the most, indirect costs of service production on land. COVID-19 merely changed support activities, comparing with previous costs, as seen in Table 3 from 2.1 to 2.4.

At last, primary activities cost of Belem–Camara crossing are driven by nautical miles, in turn, has as critical activities the trips and their costs (direct operational costs), as well fleet maintenance. Such activities were the most affected by COVID-19, on above 50% (Table 3). On the other hand, support activities remained next to tendency curve of data from previous years, which company should be seen it as a possibility of decrease total cost, reducing total of support activities, at least, to match up the reduction of revenue.

5 CONCLUSION

The experience in this work pointed out the managerial accounting approach emerges as an important source of information, with elements that translate the organization's performance, seeking information in financial accounting and production records. Strategic Cost Management, as one of the instruments addressed by managerial accounting, enables identify superior strategies that can produce a competitive advantage. Faced on cost structure of a service, as in the case studied, was possible identify main activities and their cost drivers, thereby makes it possible to establish performance strategies on activities searching for better results.

The use of ABC methodology proved to be useful for the understanding of Belem–Camara crossing, through cost structure, which made it possible to identify the main activities and their costs and the relevance of cost drivers in total cost, as well as, where to make adjustments for get better financial results. The effects of COVID-19 pandemic were evidenced, mainly in primary activities, related to trips. Moreover, reducing support activities, maybe withdraw costs or collaborating be a way of reducing costs.

Indeed, several costs can be reduced if the infrastructure and on land labor (port and maintenance) are shared. Furthermore, there are economies of scale to be explored in acquisition of resources, particularly, fuel. Although, to do so, the business environment would have to be improved, making it more professional and establishing a relationship of greater trust and collaboration among operational partners. Finally, it is noteworthy that, results obtained are subject to similar conditions of study case. They may vary, depending on service and location. However, in Amazonia, and even in other parts of the world, the analysis may be applicable on several known situations.

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