GESTÃO & PRODUÇÃO

ISSN 0104-530X (Print)
ISSN 1806-9649 (Online)

ORIGINAL ARTICLE

Measuring costs in a containerized cargo export chain: analysis from the perspective of an exporting company

Mensuração de custos em uma cadeia de exportação de carga conteinerizada: análise a partir da perspectiva de uma empresa exportadora

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How to cite: Delfim, L. M., Gadelha, C. A. P., Silva, J. F., & Leite, M. S. A. (2023). Measuring costs in a containerized cargo export chain: analysis from the perspective of an exporting company. *Gestão & Produção*, 30, e12422. https://doi.org/10.1590/1806-9649-2023v30e12422

Abstract: To perform better cost management in a supply chain, it must reduce or eliminate activities that do not add value to the product or export process. Thus, this paper aims to measure the costs of a containerized cargo export process using a combination of the Supply Chain Operation Reference Framework and activity-based costing, from the perspective of an exporting company. A qualitative approach is used to identify the processes and activities that generate costs in a containerized cargo export chain and a quantitative approach is used to measure these costs, through a combination of the mentioned methods. By applying the proposed methods, it was feasible to calculate the costs of the export chain of ceramic products, while it was possible to identify these costs based on performance indicators and metrics. Thus, this work assists commercial actions, raising the costs of an export chain and trying to fill gaps in the literature.

Keywords: Export; Logistics costs; Supply chain operation reference; Activity-based costing.

Resumo: Para exercer uma melhor gestão de custos em uma cadeia de suprimentos, deve-se reduzir ou eliminar atividades que não agreguem valor ao produto ou processo de exportação. Desse modo, este trabalho possui como objetivo mensurar os custos de um processo de exportação de cargas em contêineres utilizando a combinação do *Supply Chain Operation Reference Framework* e o custeio baseado em atividades, a partir da perspectiva de uma empresa exportadora. Utiliza-se uma abordagem qualitativa para identificar os processos e atividades que geram custos em uma cadeia de exportação de carga conteinerizada e uma abordagem quantitativa para mensurar esses custos, por meio da combinação dos métodos mencionados. Ao aplicar os métodos propostos, foi viável realizar o cálculo dos custos da cadeia de exportação de produtos cerâmicos, ao mesmo tempo em que foi possível identificar esses custos com base em indicadores e métricas de desempenho. Assim, esse trabalho auxilia as ações comerciais, levantando os custos de uma cadeia de exportação e tentando preencher lacunas na literatura.

Palavras-chave: Exportação; Custos logísticos; Supply chain operation reference; Custeio baseado em atividades.

Received Aug. 25, 2023 - Accepted Aug. 29, 2023
Financial support: None.Financial support: None.

1 Introduction

Countries that reach an adequate level of logistical development and eliminate trade barriers between themselves will be able to position themselves competitively in international markets. According to Martí et al. (2017), the globalization process has intensified international competition, with supply chain efficiency playing a central role. Therefore, reducing commercial costs is essential to promote the internationalization of production.

The logistics costs sector is gaining prominence, as presented by ILOS (ILOS - Especialistas em Logística e Supply Chain, 2017): logistics costs correspond to 12% of Brazilian GDP. According to the National Confederation of Industry (Confederação Nacional da Indústria, 2022), compared to 18 other countries, such as China, Russia, India, and South Africa, Brazil occupies the 15th position in terms of infrastructure and logistics, revealing low competitiveness in this aspect. As Péra et al. (2019) highlight, the Brazilian transport system has a series of bottlenecks, increasing transport costs and decreasing profits, for example, at ports, trucks and ships can face long queues, leading to long waiting times. Therefore, measuring these costs is of fundamental importance for companies and the economy of a country.

Logistics costs are all transportation costs, customs, taxes, fees, tariffs, insurance, currency conversion, packaging, handling, and payment fees, in other words, the costs of getting a product from its origin to the buyer (González-Ramírez et al., 2020). Engblom et al. (2012) mention that logistics costs encompass a variety of components in the literature, such as transportation, storage, inventory maintenance, and logistics administration.

An important sector to measure these costs is a product chain, which can be exported or imported. Hintsa et al. (2009) state that increased logistics integration and cost efficiency have made maritime operations an essential part of global supply chain management. This logistics value chain integration has evolved through numerous collaborative alliances and acquisitions, making integrated carriers strong players in global supply chain management players.

To carry out this research, the activity-based costing (ABC) method was applied to the studied export chain. This method demonstrates managerial value, as it allows the analysis of a system's processes/activities, allowing the identification of opportunities to improve processes and reduce costs. According to Duran & Afonso (2020), the allocation of logistics costs is imprecise due to the complexity of logistics processes, but using an activity-based costing system results in more accurate information.

An important logistics tool that helps in the application of the ABC method is the Supply Chain Operations Reference (SCOR), a supply chain management analysis method, based on what was proposed by APICS (Association Supply Chain Management, 2017), which can be used to map, evaluate, and improve supply chain operations. In general, the use of the SCOR reference model represents an important step toward systematizing, integrating, reporting, and managing key processes throughout a supply chain (Machado, 2013).

The objective of this study is to measure the costs involved in the export process of containerized cargo, using the combination of SCOR and ABC methods, from the perspective of an exporting company. To this end, the research proposes to map the export processes and activities of the studied cargo, identify the cost items and resources consumed by the activities in the export process, determine the costs of the chosen link using the ABC method, and calculate the costs of the supply chain. export with the combination of ABC and SCOR methods.

2 Literature review

2.1 Logistics costs

Logistics activities encompass the planning, implementation, and control of direct and reverse flows, storage of goods, services, and information between the point of departure and the point of origin to satisfy customer requirements (Hwang et al., 2017). In this context, researchers have presented the need for manufacturing companies to manage their supply chains more efficiently. For example, when surveying 50 professionals who work in logistics systems in Brazilian companies, Martins et al. (2020) identified that, among 33 performance indicators, the mapping of operational logistics costs is in third place among the most relevant for management. As a result, measuring and managing these logistics costs has become increasingly urgent.

Some companies choose to outsource their logistics activities to reduce their costs, this makes sense in some cases since there is a connection between outsourcing and logistics costs. Companies with a high level of outsourcing generally experience lower levels of logistics costs compared to those with a low or no level of outsourcing (Solakivi et al., 2013).

Organizations that do not list logistics among their main activities are adversely affected by the lack of knowledge in logistics processes and the systemic control of logistics costs (Škerlič et al., 2016). When analyzing the structure of logistics costs in various industries in economically developed countries, it is observed that the largest portion is made up of inventory management costs (20-40%), followed by transportation costs (15-35%) and administrative and managerial costs (9-14%) (Kovrizhnykh & Nechaeva, 2016).

In the article presented by Škerlič & Muha's (2016), the authors divided logistics costs into the following components: transportation, storage, storage, administration, packaging, and indirect logistics costs. Havenga & Simpson (2018), consider that logistics costs are the sum of transportation costs, storage and port handling, management and administration of costs and profits, and, finally, inventory maintenance costs.

In international e-commerce, it is noteworthy that logistics costs are high due to customs processes, inspections, different taxes, as well as customs clearance and insurance costs (Yuan, 2023). Although most authors share similar definitions of logistics costs, there are several differences in research when analyzing these types of costs. To address this issue, an analysis of the costs considered as logistical is presented in Table 1.

Based on Table 1, five types of costs are highlighted: transportation (100%), storage (86%) purchase/sale, handling, and management administration costs with 57% frequency. In addition to these costs, there are those of inventory (43%) and packaging (35%). There are also the costs of waste (21%), insurance (21%), capital cost (14%), and transport restrictions (7%) with less convergence, having been mentioned only by some of the authors studied.

Table 1. Logistics costs.

Authors	Transportation	Storage	Buy / Sell	Handling	Management and Administration	Stock	Packaging	Waste	Safety	Capital cost	Transport restrictions (fines)	Taxes
Pirttilä & Hautaniemi (1995)	X	X	X	X								
Themido et al. (2000)	X		X	X								
Engblom et al. (2012)	X	X			X	X	X					
Solakivi et al. (2013)	X	X			X	X	X					
Somapa et al. (2012)	X	X	X	X	X							
Rantasila & Ojala (2015)	X	X	X			X						
Hansen et al. (2014)	X	X			X		X	X	X	X		
Škerlič et al. (2016)	X	X	X				X			X		
Kovrizhnykh & Nechaeva (2016)	X		X		X							
Jena & Seth, (2016)	X	X		X					X			
Shvartsburg et al. (2017)	X	X	X	X								
Havenga & Simpson (2018)	X	X		X	X	X						
Kucera (2019)	X	X		X	X	X		X	X			
Duran & Afonso (2020)	X	X	X	X	X	X	X	X				
Barbosa et al. (2022)	X	X	X	X							X	
Yuan (2023)	X	X		X	X				X	X		X
Frequency	100%	86%	57%	57%	57%	43%	35%	21%	21%	14%	7%	

Source: Authors.

2.2 SCOR Model

To integrate their processes and evaluate them against other companies, it is recommended that companies identify and analyze performance measures, which can be an effective technique. The SCOR model can describe a complex set of definitions from different sectors, to use the model as support for supply chain improvement projects (Association Supply Chain Management, 2017).

SCOR provides methodology, diagnostics, and benchmarking tools that help organizations make improvements to supply chain processes. The model contains four sections, which are: practices, people, performance, and processes, the last two (performance and processes) are the focus of this work, as it aim to measure the costs related to the activities carried out in the export process.

In the literature, several works are found in which SCOR is applied aiming at the described objectives. Astuti et al. (2018) apply SCOR to detect and analyze risks in a supply chain. Bukhori et al. (2015) use SCOR with other methods to analyze quality problems along the meat supply chain. Furthermore, Huang et al. (2020) use it to study the operational efficiency of the port with ships entering and leaving and the stacking yard.

2.3 Activity-based costing (ABC)

According to Xu et al. (2020), the ABC method is a cost allocation method that distributes indirect costs to product activities, providing a more accurate allocation. This gives the company a clear and detailed understanding of all associated costs, allowing it to make more informed decisions about pricing, budgets, and general business strategies. Among the costing methods in the literature, the ABC method stands out for determining costs in complex processes with many interactions (Bokor & Markovits-Somogyi, 2015). One of the objectives of the ABC method is to obtain information for decision-making, to improve the competitiveness of companies.

Regarding the applicability of this method to measure logistics costs, it is stated by Gui and Na (2019), that the ABC method is considered the most promising for managing maritime logistics costs, as it is used to calculate storage, distribution, and distribution operations. and other costs. Furthermore, the use of the method is related to the vision of the processes, which allows the definition of the activities carried out in the logistics function, leading to a more accurate analysis of costs.

A study that deserves to be highlighted is the work carried out by Schulze et al. (2012), the authors combine the ABC method, applied to map costs in the supply chain, with the SCOR method to identify and analyze the logistics chain. Thus, the authors emphasize that surveying costs between companies along the supply chain can promote strategic decisions.

3 Research methodology

This research is characterized as a case study, adopting a qualitative approach to identify and understand the export process of the focal company of the study. The export chain investigated involved ceramic products, with around 62.8 thousand square meters exported from Brazil to the United States during the last quarter of 2019. The company in focus operates in the tiles, ceramics, porcelain, and cement sectors.

Relevant data was obtained through historical analysis of cost information provided by the focal company, as well as by collecting data from documents. To conduct this case study, the techniques proposed by Marconi & Lakatos (2017) were applied, which include bibliographic research, document analysis, direct observation, and interviews. The steps taken to carry out this study were as follows:

1. Select bibliographic material;
2. Obtain the company's consent and select the export chain;
3. Identify the agents involved in the export process;
4. Map the process according to the SCOR model;
5. Raise resources and activities;
6. Establish cost drivers;
7. Calculate the costs of activities;
8. Calculate the costs of the export chain;
9. Classify costs according to the SCOR model performance metrics.

The first phase of the research consisted of selecting articles to make up the study portfolio. The research base used was Web of Science, due to its extensive database. The keywords used were "logistic" and "cost", followed by a second search with the keywords "port" or "seaport" or "harbor" or "maritime transport" and "cost" or "expense", without period restriction. The initial search resulted in a total of 827 articles. Next, the titles of the articles were read and those that were relevant to the topic in question were selected. Subsequently, a dynamic reading of the articles was carried out, covering the title, abstract, keywords, methodology, and results, to identify affinity with the present research. From this stage, 102 articles were selected for a complete reading, aiming to form a solid basis for the theoretical foundation and also to obtain new ideas that could contribute to the study in question.

Based on the volume of exports in progress, the focal company was selected as the ideal candidate for the research project. After carrying out a detailed presentation of the project addressing the objectives and goals to be achieved, acceptance was obtained from the general director. During this meeting, the export process to be evaluated was also discussed in detail, as well as the various agents involved in transporting the cargo of ceramic products.

To evaluate the cost of the export process, the activity-based costing (ABC) method was adopted, which made it possible to identify and allocate specific costs for each relevant activity in the process. Furthermore, the Supply Chain Operations Reference (SCOR) structure was used to analyze and improve the efficiency of the entire supply chain involved in the export of ceramic products.

To map the activities in the export process, semi-structured interviews were conducted. As a result, 5 main sectors were identified in the export process of the investigated company. The first is the commercial representation sector, responsible for establishing contact with the customer and selling products. Next, we have the export sector, in charge of managing the entire export process. The production planning and control sector (PCP) is responsible for organizing and monitoring the production of products. The purchasing sector receives demands from the PCP and purchases the necessary products and/or services from suppliers. Finally, the shipping sector assumes responsibility for packaging and shipping the products.

Four professionals from the exporting company participated in the research. The first is the sales executive, who reported having held this position for two years. The second is the PCP analyst, who stated he has three years of experience in the company. The third professional questioned is the buyer, who reported having worked in this role for more than two years. Finally, the consignor stated that he had carried out this activity for two years.

The commercial sector and the export sector were presented by the sales executive, as he was responsible for both. In the research, the logistical approach adopted was the SCOR model, which is based on the following main processes: Plan, Supply (Source), Make, Deliver, Return, and Enable. These internal processes establish relationships with both the company's suppliers and customers.

After applying the SCOR model to map the process, the ABC costing methodology was used to calculate process costs. Initially, the resources and activities of the process were identified based on the mapping carried out.

Then, in the ABC application stage, the studied processes were delimited, which encompass the purchasing, production, packaging, and shipping activities carried out by the focal company. In this context, specific cost drivers were determined for each of these activities, to identify more precisely how costs were related to each process. Subsequently, using the established cost drivers, calculations were carried out to determine the cost per square meter (m^2) of the load in question within the processes analyzed by ABC. This approach allowed for a more precise allocation of costs related to the purchase of materials, the production of ceramic products, their appropriate packaging, and their shipping.

Subsequently, the calculation of costs throughout the export chain was completed, covering everything from purchasing and production planning to product packaging.

During this process, logistical costs were properly segregated within the export chain, allowing an analysis of the results obtained.

4 Results

4.1 Characterization of the company and the export process

The company studied operates in the field of ceramic production, having been on the market for over 30 years, and is one of the leaders in the country in this field, with a manufacturing capacity of four million m^2/month. The cargo studied was exported to the United States, a market seen by the company as promising for consolidating the brand in the country, with the importer being the third largest chain in the segment in the USA.

The production system has a linear layout, making it a discrete and repetitive process. The products exported to the client in the USA were two ceramic pieces: Oregon Gray and Oregon Off White, both measuring 34 x 34 centimeters. The total quantity produced by Oregon Gray is 33,058.40 m^2, while that of Oregon Off White is 29,747.20 m^2, totaling 62,805.60 m^2. This production corresponds to 10.35% of the monthly production of the studied plant, which was 606,817.3913 m^2 per month. Its export process can be seen in Figure 1, detailing the negotiation of the product until its delivery to the end customer.

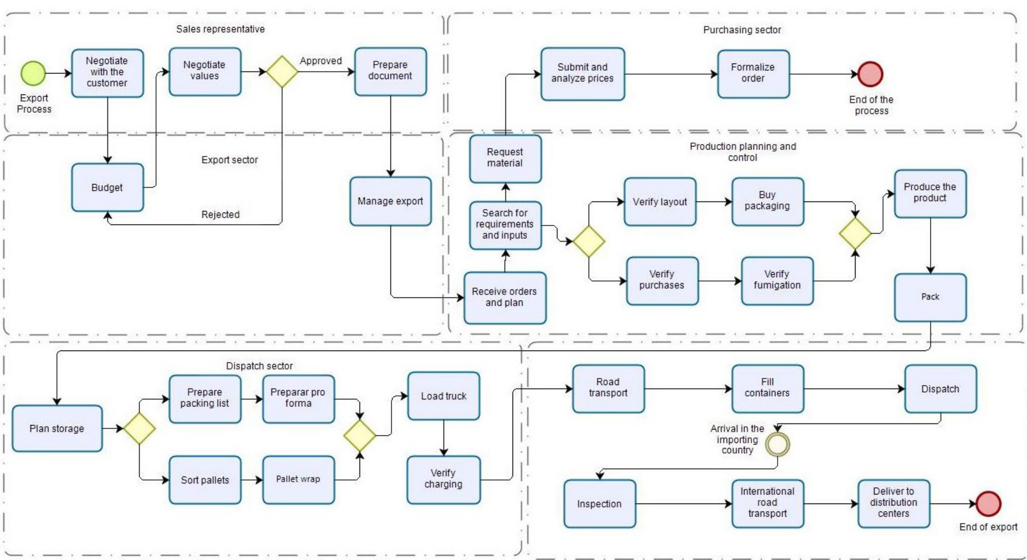

Figure 1. Export chain. Source: Authors.

The export process begins with negotiations conducted by the company's export team with the customer. During this transaction, a quote and a sales order are made, which are analyzed by the customer. After approval of the budget and agreement with the terms, the exporting company involves production planning and control, together with the purchasing sector, to carry out activities that range from issuing the raw material purchase order to receiving the material and product production.

The products are then manufactured, also involving the packaging and shipping sectors. With proper planning and ship scheduling, the products are transported to the vessel, which takes them to the international port. At the port, the international customs broker takes action to guarantee the delivery of the product through an international carrier to the importing company's distribution centers.

4.2 Activity mapping

From the observation and description of the production process mentioned above, it was possible to identify and define the activities carried out by the company. As a result, ceramic production processes were categorized into four macro processes and thirty activities, which are detailed in Chart 1.

Chart 1. Mapping of activities.

Management Processes	Activities	Description
Planning (PCP) and buying	1. Receive orders and plan production	The PCP sector receives the customer's order and plans the month's production.
	2. Calculate the amount of raw materials required	The PCP sector, based on monthly production and customer orders, calculates the raw materials to be purchased.
	3. Request raw materials in the Purchasing system	The order for raw materials is made by the PCP through the company's system for the purchasing sector.
	4. Present and analyze supplier prices	The purchasing department receives the order from the PCP and sends it to the supplier for pricing.
	5. Formalize the purchase order	Formalize the purchase order, with quotations and approvals, and send it to the supplier.
Producing	6. Receive orders	Inspect the raw material received.
	7. Check invoice and material	The person responsible for each sector checks the invoice and the material received.
	8. Store material	After verification, the raw material is stored.
	9. Load the tractor with material	The first step in production is to load the tractor (loader) with the basic raw material, which is dough.
	10. Weigh material	The tractor loaded with the MP takes it from storage to the scale machine, where the MP is weighed.
	11. Grind material	After weighing, the MP is transported to the mill, where the mass is ground, generating the so-called ceramic slip.
	12. Dry ceramics using the Atomizer	The ceramic slip is taken to the atomizer, which, through drying, generates atomized powder.
	13. Pressing Atomized Powder	The atomized powder is taken to pressing, forming the "bisque", the pressing forms the ceramic.
	14. Dry ceramics	For the ceramic to gain more resistance, it is taken by conveyor belts to the second dryer.
	15. Glaze ceramics	After leaving the dryer, the ceramic is glazed, gaining a smooth, crystalline coating and engobe is applied, which is a layer of clay that allows the color to change.
	16. Print on ceramics	The ceramics enter the HD machine and digital printing on the piece is carried out, this activity is the only one that differentiates the products of this export.
	17. Burn bisque	After digital printing, the ceramic is taken to the industrial oven, in which the "Bisque firing" generates the last step to form the piece.
	18. Classify ceramics	The ceramics are taken to the surface, monitoring and classifying the products.

Chart 1. Continued...

Management Processes	Activities	Description
	19. Print the barcode	When leaving the surface, the barcode is printed on the side of the part, this is an exclusive requirement for the export process to the USA.
	20. Calibrate ceramics	Each ceramic is measured and separated according to the measurements.
Packing	21. Group the pieces	After calibration, the packaging machines group 14 ceramics into a single box.
	22. Packing boxes on the palletizer	The pallet machine receives the boxes from the packaging machine and packs them automatically.
	23. Control Quality	The quality inspector visually analyzes the quality of ceramics, packaging, and pallets.
	24. Store Product	Once the pallet is properly loaded, it is taken to storage using forklifts.
Shipping	25. Plan Storage	This activity precedes the previous one, the warehouseman and the forklift operator, depending on the day's production, plan how and where the pallets will be stored.
	26. Issue documents	The shipper is responsible for preparing the proforma, separating each proforma by shipment, and making it using different colored papers.
	27. Sort pallets	Depending on the day's load, the pallet load is separated for wrapping.
	28. Wrap pallets	Each pallet is taken to a wrapping machine, where the operator wraps the pallet with insulation paper to protect the load.
	29. Load truck	With the pallet wrapped, the forklift operator takes the load to the truck, and the truck is loaded.
	30. Check the loaded batch and issue the invoice	With the truck properly loaded, the logistics assistant carries out the first check of invoices, packing lists, and proformas.

Source: Authors.

Activities begin from the moment the order arrives at the PCP and purchasing department, where purchasing and production control is carried out until the product is delivered to the carrier, which is the moment at which the cargo becomes the responsibility of the carrier itself. With the costs collected and the activities mapped, the next step in the method is to distribute the costs to the activities.

4.3 Application of the ABC method

The application of the ABC method aims to identify process costs, followed by the identification of unit costs per m^2 of products and, finally, the measurement of process and chain logistics costs, which can be useful for improvements by company managers.

Company data regarding selected export cargo costs was collected. Using the costs referring to the period between January 2019 and January 2020 of the company studied. Therefore, as the load studied represented, on average, 10.35% of the company's monthly production, this percentage was used for appropriate allocations, being corroborated by the company's managers. The costs related to the processes and loads studied in the company were identified during the monthly period. It is important to highlight that only costs directly linked to the export process were considered. In this way, any costs that were not linked to this process were identified and excluded from the analysis.

Total costs were R$220,204.09 and were distributed among activities using the ABC method. To arrive at these costs, calculations were carried out taking into account the allocation of people and machines involved in the processes. Some costs, such as depreciation and labor, were considered based on the average monthly cost, taking into account only the 10.35% corresponding to the load studied. Furthermore, costs related to resources such as electricity and water were also considered in proportion to the load.

In addition to the costs mentioned above, some raw material costs were directly allocated to products. The inputs used in the production of both products have different individual costs: the dough, glaze, and packaging have costs of R$1.91, R$2.11, and R$2.69, respectively. Furthermore, the natural gas used in the production process costs R$3.96 for both products. These costs are per m^2 of ceramics produced. Consequently, the direct cost of raw materials per m^2 of each piece was R$10.67. The fixed monthly costs were R$220,204.09, which were distributed to the processes and products studied.

4.4 Distribution of costs to activities

To allocate costs to corresponding activities, the monthly resources used by the company and their respective drivers were identified. Table 2 presents the cost items and resource drivers (causes of resource consumption by activities), which were established through research carried out in a detailed study of the company's routine. These drivers were defined to ensure that conclusions related to resource consumption by activity are representative and appropriate.

Table 2. Costs and drivers.

Cost Item	Cost (R$)	Drivers
Electricity	75,397.89	Equipment power in activities
Labor	43,222.95	Hour
Amortization	91.37	Quantity Produced
Cleaning services and supplies	987.42	Quantity Produced
Shipping and Shipping	9,389.18	Quantity Produced
Office Supplies	387.08	Quantity Produced
Donations	836.42	Quantity Produced
Fuels/Lubricants	7,049.88	Quantity Produced
Taxes	3,391.44	Quantity Produced
IPTU / TCR	2,165.35	Area
Commercial Consultancy	3,137.87	Quantity Produced
Consulting / Input Analysis	132.36	Quantity Produced
Depreciation	7,526.96	Depreciated machine values
Accounting and consulting services	285.16	Quantity Produced
HR and Security Consulting	184.50	Quantity Produced
Legal Advice	1,350.19	Quantity Produced
Property security and insurance services	5,008.53	Area
Business administrative consultancy	540.07	Quantity Produced
Graphic services	135.16	Quantity Produced
Provision for losses in civil cases	1,099.48	Quantity Produced
Forklift expenses	639.73	Used forklifts
Rental/Leasing of machinery and equipment	4,129.69	Used forklifts
IT services and materials	4,079.56	Quantity Produced
Maintenance and conservation of machines, equipment, and buildings	40,753.17	Area
Import/export expenses	2,671.15	Quantity Produced
Water treatment	5,611.52	Amount of water used

Source: Authors.

It is observed that several cost items are related to the quantity produced factors, being distributed equally between the activities. This occurs because these cost items are not directly consumed by a specific activity but rather serve as a support base for all activities. It can also be seen that these items are, for the most part, of low relevance in terms of representation in the process, with the majority of costs distributed based on more precise factors. In total, 83.764% of the costs were distributed with precise drivers, while the other part, 16.236%, was distributed equally across activities.

After allocating costs to activities, it was possible to carry out an important analysis of the costs generated by each of them. At this point, it is possible to identify the activities that add value to the product, those that are necessary even without adding value, and also those that are considered waste, not adding value to the process. Chart 2 presents in detail the costs of each activity, as well as the processes for which they were calculated based on the drivers. It is possible to observe that the majority of costs are associated with the production process, representing 77.08% of total costs. This is in line with the research since these activities are directly related to the production of the product.

Chart 2. Cost of activities.

Management Processes	Activities	Cost (R$)	Cost Per Process (R$)
Planning (PCP) and buying	1. Receive orders and plan production	1,436.01	7,125.94
	2. Calculate the amount of raw materials required	1,436.01	
	3. Request for raw materials in the Purchasing system	1,436.01	
	4. Present and analyze supplier prices	1,408.96	
	5. Formalize the purchase order	1,408.96	
Producing	6. Receive orders	2,689.95	169,730.80
	7. Check invoice and material	1,967.50	
	8. Store material	28,605.33	
	9. Load the tractor with material	8,455.11	
	10. Weigh material	14,351.69	
	11. Grind material	22,447.52	
	12. Dry ceramics using the Atomizer	34,175.37	
	13. Pressing Atomized Powder	21,917.09	
	14. Dry ceramics	3,447.23	
	15. Glaze ceramics	7,322.29	
	16. Print on ceramics	2,978.29	
	17. Burn bisque	12,984.40	
	18. Classify ceramics	3,555.23	
	19. Print the barcode	2,501.70	
	20. Calibrate ceramics	2,332.12	
Packing	21. Group the pieces	3,573.77	25,168.82
	22. Pack boxes on the palletizer	5,995.42	
	23. Control quality	3,663.45	
	24. Store product	11,936.19	
Shipping	25. Plan storage	2,257.13	18,178.53
	26. Issue documents	2,107.70	
	27. Sort pallets	3,847.44	
	28. Wrap pallets	3,312.91	
	29. Load truck	4,362.81	
	30. Check the loaded batch and issue the invoice	2,290.55	

Source: Authors

Chart 2 shows the activities that cause the highest costs are the activities of drying the ceramics through the Atomizer (12), representing 15.52% of the costs, followed by storing material (8) with 12.99% and grinding material (11) with 10.19%. These activities have in common the high consumption of electrical energy by the machines.

With the costs of the activities outlined, the next step was to distribute the costs of the activities to the products studied.

4.5 Distribution of costs to products

In the case studied, the unit cost is calculated per m^2. However, as it is a continuous production process, all products go through the same activities and at equal times, making this distribution equal to the products, as both products consume the activities equally.

The direct costs of the pieces, which are R$10.67 per m^2, and the general production costs (CGP) indicated by the ABC method are diluted by dividing the quantity produced. Thus, the cost per square meter of the Oregon Off White and Oregon Gray products is R$3.51. This value is obtained by dividing the general production costs of the product (R$ 220,204.09) by the total quantity produced (62,805.60 square meters). In this way, the general production costs found by applying the methods (R$ 3.51) are added to the direct costs (R$ 10.67). Thus, the unit cost per m^2 was R$14.18, for both products, since the process is the same.

4.6 Identification of costs throughout the chain

After mapping the processes and activities based on the SCOR model, and applying the activity costing method (ABC), to concisely analyze the data found, the cost indicators and metrics provided by the SCOR performance section were used, which correspond directly to segregated activities and processes. Such indicators and metrics serve to describe process performance and align strategic objectives.

The analysis of the costs found was carried out using the ABC costing method, based on the indicator and corresponding performance metrics, proposed in the SCOR model. Firstly, the costs in the "Plan" processes were surveyed, and are presented in Table 3.

Table 3. Planning costs.

Costs	Value in R$	Related activities
Planning cost	**6,565.14**	**Total**
Cost of supply chain planning	-	Not applicable
Planning cost (Supplying)	2,872.01	2. Calculate the amount of raw materials required
Planning cost (Manufacturing)		3. Request material in the purchasing system
Planning cost (Delivery)	1,436.01	1. Receive orders and plan production
Planning cost (Feedback)	2,257.13	25. Plan storage
Cost of supply chain planning	-	Not applicable

Source: Authors

Based on the "Plan (PCP) and purchase" activities, it was possible to observe the costs related to each area, when focusing on planning. The total costs of planning, supply chain planning, and return process planning are not part of the research scope of this work, therefore, they were not considered for this calculation. The same structure is applied in the supply process, as shown in Table 4, below.

As can be seen in Table 4, the total cost of supplying raw materials to the company is around 36 thousand. Within this total value, the most expensive is the cost of transferring the product, which corresponds to 79.28% of the total cost. This activity is related to the storage of raw materials ("Activity 8: Store material"). Without considering the supply planning costs, which are also very expensive. Following the manufacturing process in Table 5, which is the production of the product.

Table 4. Supply costs.

Costs	Value in R$	Related activities
Supply costs	**36.080.71**	**Total**
Cost to authorize payment from suppliers	1,408.96	4. Present and analyze prices with the Supplier
Cost to receive the products	2,689.95	6. Receive orders
Cost to schedule product delivery	1,408.96	5. Formalize the purchase order
Cost to transfer the product	28,605.33	8. Store material
Cost to verify the product	1,967.50	7. Check invoice and material

Source: Authors.

Table 5. Manufacturing costs.

Cost	Value in R$	Related activities
Manufacturing cost	**831,795.94**	**Total**
Direct material cost	670,159.10	Direct cost (Raw Material)
Indirect costs related to production	130,991.14	Activities 9 to 24 (Produce and Packaging)
Direct labor cost (**CMOD**)	30,645.70	CMOD of activities 9 to 24 (Produce and Packaging)

Source: Authors.

Below, Table 6 shows the costs of the delivery process, which refer to the product shipping stage.

Table 6. Delivery costs.

Costs	Value in R$	Related activities
Shipping costs	**392,146.65**	**Total**
Order management costs	15,921.40	26. Issue documents
		27. Sort pallets
		28. Wrap pallets
		29. Load truck
		30. Check the loaded batch and issue the invoice
Delivery cost	376,225.24	FOB and DDP costs (Freight)

Source: Authors.

Order management costs refer to the shipping process in the industry, such as issuing documents, separating, packaging, and loading the truck with pallets, being less expensive than delivery costs, which are free on board (FOB) and delivered duty paid (DDP). The first concerns national road transport to the port, and the second concerns international sea and road transport.

It is important to note that in the DDP process, the company is responsible for the cargo until it reaches the customer's warehouses and distribution centers. This type of product delivery provides the exporting company with greater bargaining power over freight and, consequently a greater financial return. In the Supply Chain Operations Reference (SCOR) model there are indicators of risk mitigation costs, these processes were not the focus of this work, therefore they are not presented. The total costs in the process from purchase to delivery are presented in Table 7.

Table 7. Total costs.

Costs	Value in R$	Items
The total cost of supply chain management	**1,335,285.77**	Planning cost + supply + manufacturing + delivery + fees
Cost of sold goods	**890,363.19**	Total
Labor costs	43,222.95	Table 5 – Labor
Direct material costs	670,159.10	Table 4
Indirect costs related to production	176,981.14	**CGP** - **CMOD**

Source: Authors.

Table 7 presents a summary of the total costs from the purchase of raw materials, through manufacturing, to the delivery of the product to the customer. The costs of goods sold are highlighted, which are the sum of the costs presented later. This table gives a general sense of the cost of the chain that aims to align with the company's strategy to reduce costs. Table 8, below, reveals a summary of all costs found by the SCOR model, as well as their sum.

Table 8. SCOR costs.

Costs	Value in R$
Planning Cost (Supply)	6,565.14
Supply cost	36,080.71
Manufacturing cost	831,795.94
Delivery cost (with FOB and DDP)	392,146.65
Partial sum	1,266,588.43
Fees	68,697.33
Total	**1,335,285.77**
Another way to calculate:	
Cost of sold goods	890,363.19
Fees	68,697.33
Transport	376,225.24
Total 2	**1,335,285.77**

Source: Authors.

The total cost of supply chain management is described as R$ 1,335,285.77 for this process and the loads studied. This calculation was made by summing all costs along the chain. Its unit cost was R$14.18 per m^2 produced, consistent with the summary shown in Table 9, below.

Table 9. Cost per m^2 of cargo.

Items	Value in R$
Purchasing and planning	0.11
Production + RM	13.37
Packing	0.40
Expedition	0.29
Taxes (m^2)	0.50
Agents Commission (m^2)	0.36
US Commission (m^2)	0.24
FOB (m^2)	0.59
DDP (m^2)	5.40
Total	**21.26**
Production m^2	62,805.60
Total Supply Chain	**R$ 1,335,285.77**

Source: Authors.

The cost of loading through the chain was R$21.26 per m^2. The highest costs come from production, which is the process that adds the most value to the customer. The process also has a DDP cost, but the customer pays the exporting company and, therefore is responsible for all product logistics.

4.7 Measurement of export logistics costs

Once the operation of the company's processes is known, it is possible to identify logistical activities and processes, as well as their costs. At this stage, it is determined which of the activities identified by the ABC method are considered logistical, based on a literature review. Logistics costs are then measured both in the load studied and in the entire chain, using the SCOR model, to assess their representativeness about total costs. This analysis provides important insights into logistics costs and their impact within the general context of the company.

Based on the systematic review carried out, it was possible to identify that the studied chain has the following logistical costs: Transport, Storage, Purchase/Sales, Handling, Management and Administration, and Packaging. These costs are shown below, in Chart 3, identified through ABC activities and related to the costs found in SCOR.

Chart 3. Measuring the costs of logistics activities

Logistics costs	Related activities	Value in R$	Metrics SCOR
Transport	FOB + DDP (Freight)	376,225.24	Delivery or installation costs for the order
Storage	6. Receive orders	2,689.95	Cost to receive the products
	8. Store material	28,605.33	Cost to transfer the product
	24. Store product	1,936.19	Indirect costs related to production
			Direct labor cost
Buy / Sell	2. Calculate the amount of raw materials required	1,436.01	Planning Cost (Supply)
	3. Request raw materials in the purchasing system	1,436.01	Planning Cost (Supply)
Handling	9. Load the tractor with material	8,455.11	Indirect costs related to production
			Direct labor cost
	27. Sort pallets	3,847.44	Order management costs
	29. Load truck	4,362.81	Order management costs
Management and administration	7. Check invoice and material	1,967.50	Cost to verify the product
	25. Plan storage	2,257.13	Planning cost (delivery)
	26. Issue documents	2,107.70	Order management costs
	30. Check the loaded batch and issue an invoice	2,290.55	Order management costs
Packing	22. Packing boxes on the palletizer	5,995.42	Indirect costs related to production
			Direct labor cost
	28. Wrap pallets	3,312.91	Order management costs

Source: Authors.

It is identified that Free on board (FOB) and Delivered at place paid (DPP) freight costs are obtained directly from the chain, representing the costs of transport and services outsourced by the company. On the other hand, all other costs were identified based on logistical activities using the ABC method, being related to the measurement of cost processes using the SCOR model.

The logistical cost items and their respective values identified in the exporting company were as follows: Transport (R$ 376,225.24 represents 28.176%), Storage (R$ 43,231.47 represents 3.238%), Purchase/Sale (R$ 2,872.01 represents 0.215%), Handling (R$ 16,665.36 represents 1.248%), Management and Administration (R$ 8,622.87 corresponding to 0.646%) and Packaging (R$ 9,308.32 corresponding to 0.697%). The total value of logistics costs is R$456,925.27, which represents 34.22% of the total value of the company's logistics costs.

5 Conclusion

By reviewing the literature related to the topics covered, it was possible to identify existing gaps, especially when it comes to the combination of SCOR and ABC methods.

There is a notable lack of studies that explore this combination and the application of these methods in case studies. This research plays a fundamental role in filling this gap, by measuring the costs involved in an export chain. In this way, it directly contributes to the expansion of knowledge in this specific area.

Organizations are undergoing major transformations with the exponential growth of new technologies and need to gain value to remain competitive in this panorama. The SCOR and ABC methods have been presented as effective ways of mapping processes and supply chains and understanding the source of costs. In this environment, companies need to recognize not only their production costs but also the costs involved in the supply chain in their export process.

This article sought to measure the costs of an export process for a containerized cargo originating in Brazil and destined for the United States using the combination of SCOR and ABC methods, from the perspective of an exporting company. The study was successful in measuring the total costs of the process, as well as the costs per square meter of the load. Furthermore, logistical costs related to the export chain were also evaluated. This analysis provides important information for the exporting company in terms of decision-making and improving operational efficiency.

The results obtained in this study highlighted the main logistical cost items with the greatest participation in the analyzed export process. Transport was identified as the main cost item, representing 28.176% of total logistics costs. Next, storage had a share of 3.238%. Logistics costs totaled 34.22% of the export process studied. This information is valuable for managers, as it allows them to visualize the influence of each expense on the company's and supply chain's activities and processes.

It is recommended that managers analyze these expenses carefully, looking for opportunities to reduce them and improve the level of service. Proper production planning can help identify and eliminate unnecessary items, resulting in cost reduction. Furthermore, it is important to highlight that a good relationship with cargo agents and ship owners can play a fundamental role in reducing transportation costs, which is the main cost involved. These measures will allow managers to optimize available resources, improve operational efficiency, and provide even greater value to customers.

This study represents the first step towards future research aimed at improving cost management throughout the supply chain, through the elimination or reduction of activities that do not add value. In future work, it is suggested that in-depth studies be carried out on the import and export processes, covering the entire logistics chain. It is important to direct attention to the agents involved in the transportation process since this is one of the main logistical costs that a company can face. Furthermore, it would be relevant to consider production planning and control, seeking efficient synchronization of capacity and demand throughout the chain. This additional research can provide a comprehensive and in-depth view of the topic, contributing to operational efficiency and supporting strategic decision-making.

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Leonardo Melo Delfim, Caio de Araújo Pereira Gadelha, Jonas Figuerêdo Silva and Maria Silene Alexandre Leite worked on the conceptualization and theoretical-methodological approach. The theoretical review was conducted by Leonardo Melo Delfim, Caio de Araújo Pereira Gadelha and Jonas Figuerêdo Silva. Data collection was coordinated by Caio de Araújo Pereira Gadelha. Leonardo Melo Delfim and Caio de Araújo Pereira were involved in the data analysis. All the authors participated in the writing and final revision of the manuscript.