

RESEARCH PAPER

Reverse logistics performance measures: a survey of Brazilian companies

Gisele de Lorena Diniz Chaves¹, Naiara Tomazelli Giuriatto¹, Karine Araujo Ferreira²

¹Federal University of Espírito Santo – UFES, Department of Engineering and Technology, São Matheus, ES, Brazil.

²Federal University of Ouro Preto – UFOP, Department of Production Engineering – DEPRO, Ouro Preto, MG, Brazil.

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ABSTRACT

Goal: The purpose of this research was to determine the most frequently used performance measures for the evaluation of reverse logistics in Brazilian companies. Furthermore, we sought to verify whether a correlation exists between certain performance measure dimensions (cost, asset management, customer service, and productivity), company size (micro, small, medium, and large), and their sectors of the economy.

Design / Methodology / Approach: A survey of 125 Brazilian companies from different industrial sectors was conducted. Hypothesis testing allows carrying out inferences about population parameters, and the results indicate the acceptance or rejection of the hypothesis formulated.

Results: This study presents a list of measures for the assessment of reverse logistics in different industrial segments, evidencing the major performance measures used. According to statistical analysis, large-sized companies are those that most frequently adopt performance measures to assess reverse logistics in Brazil. However, no correlation was verified between the performance measure dimensions evaluated and the sectors of the economy.

Limitations of the investigation: This study could not conclude about the maturity level of performance measurement in the investigated companies. The results presented are the first step towards reverse logistics performance measurement and more complementary studies are necessary.

Practical implications: This paper presents a list of performance measures for reverse logistics assessment. This information could support decision making as it provides a possibility of analyzing the choice of the best measures.

Originality / Value: The main contribution of this paper is related to the scarcity of reverse logistics metrics in the literature. As an exploratory study, it could be used to improve the reverse logistics performance measurement studies and practice.

Keywords: Performance Measures; Reverse Logistics Metrics; Survey.

1 INTRODUCTION

Reverse Logistics has acquired increasing importance among scholars and supply chain professionals due to the fact it is one of the instruments used to promote sustainability and also due to its strategic role in many economic sectors (Ho et al., 2012; Lopes et al., 2014). Reverse logistics networks have been implemented in various fields of applications as manufacturing industry, electrical and electronics industry, automobile industry, and other

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industries (Sheriff et al., 2012). Thus, it has become essential for organizations in general owing to growing environmental concerns, legislation, corporate social responsibility, economic factors and sustainable competitiveness (Agrawal et al., 2016; Ravi and Shankar, 2012), mainly with this contribution to circular economy (Guarnieri et al., 2020; Bernon et al., 2018). Although many companies recognize the importance of reverse flow, most of them have difficulties or show an unwillingness to adopt performance measures or to evaluate their performance. Thus, it is difficult to measure the outcome or the impact of product and/or material return, and therefore reverse flow has become one of the major concerns to businesses in several countries today (Bouzon et al., 2016; Lopes et al., 2014; Rogers and Tibben-Lembke, 1999).

Hernández et al. (2010) highlighted that although not exerting a quantitative impact, reverse logistics policies and practices strongly and positively affect corporate performance indicators, which are closely associated with the corporate sustainability concept. Therefore, it is necessary to find methods and tools that enable the evaluation of such influence.

Measuring the performance of the activities that control product return and managing reverse flow is of great importance and relevance to ensure a more effective reverse logistics performance and cost reduction. Performance measurement is of great importance for the success of logistics and reverse logistics in any organization since it is an essential pillar for strategic logistics planning, and it helps to monitor and evaluate its implementation, providing the information needed for its management (Oliveira and Proença, 2019; Barbosa and Musetti, 2011; Frota Neto et al., 2008). According to Han and Cueto (2016), the process of measuring returns formalization performance is aimed at improving reverse logistics quality and identifying potential problem areas.

The literature highlights the savings and benefits related to good management and to the measurement of the reverse logistics results such as company image enhancement, customer satisfaction improvement, cleanliness in distribution channels, profit margin protection, cost reduction, value recapture and asset recovery, reuse of materials in manufacturing, reduction of environmental burden of the final disposal, proper disposal of products and gaining new customers and suppliers (Bai and Sarkis, 2013; Genchev et al., 2011; Lambert et al., 2011; Muniz Junior et al., 2017; Rogers and Tibben-Lembke, 1999). Besides, reverse logistics is gaining importance as government policies and legislation change. According to Jayant et al. (2014), especially in Europe, manufacturers have been forced to take responsibility for taking back and properly recycling or – if recycling is not possible – disposing of their spent products from customer markets.

Accordingly, this study aimed to identify the performance measures frequently used to evaluate reverse logistics in Brazilian companies from different sectors. Furthermore, the correlation between certain performance measure dimensions (cost, asset management, customer service, and productivity), company size and their sectors will also be investigated. To meet the objectives of the present study, a quantitative approach was adopted in the form of a survey conducted in 125 companies from different industrial sectors located in all regions of Brazil.

The use of reverse logistics metrics is almost absent from the literature on reverse logistics (Fernandes et al., 2018). Although several models, frameworks, and logistics performance measures have been developed over the years, most of them do not address specific measures to reverse logistics and many companies are concerned only with the forward flow, failing to properly monitor the reverse flow of products, services, and information. Cazeri et al. (2017) identified that one gap related to Green Supply Chain Management (GSCM) is the performance measures and its integration with existing quality methods.

The choice of performance measures depends on the complexity of the process evaluated, and its importance is determined by the goals established by the company and expectations about their adoption and managerial use of these data (Schmitt, 2002). Thus, the diagnosis of the current state of performance evaluation practices adopted by companies,

especially major systems and performance measures, is the first step to adapt and adjust the performance assessment process of reverse logistics in enterprises.

Hazen et al. (2015) have used goal-setting theory and knowledge-based view to conceptualize a model that examines transactions from the perspective of both the supplier (inbound reverse logistics) and customer (outbound reverse logistics) in a business to business context revealing how actors occupying different supply chain positions manage reverse logistics processes. However, these authors analyzed North American companies and the literature regarding the development of reverse logistics metrics in Brazilian companies is scarce.

Nevertheless, the implementation of reverse logistics in Brazil has increased because the international pressure on environmental issues and sustainable development has led to regulations to mandate and systematize solid waste management (Chaves et al., 2014). Enacted in 2010, law N° 12.305, concerning the Brazilian Solid Waste Policy (BSWP), includes some innovative instruments for developing countries such as shared responsibility throughout the product life cycle, social inclusion of waste pickers, and the definition and implementation of reverse logistics (Campos, 2014; Jabbour et al., 2014). The sectoral agreement is the legal instrument that enables the shared responsibility in Brazil, establishing collection goals for different wastes in which reverse logistics network are critical (Guarnieri et al., 2020).

This study was divided into 5 sections. Following this introduction, section 2 presents a summary of the literature review on reverse logistics, performance measurement, and reverse logistics measures. Section 3 addresses the research methods. Section 4 presents the hypotheses tested and analyzes the main results obtained. Finally, section 5 presents the final considerations.

2 LITERATURE REVIEW

In this section, we present the literature review conducted, highlighting the following issues: reverse logistics, performance measurement, and reverse logistics measures.

2.1 Reverse Logistics

Reverse logistics can revert flows from the point of consumption to the point of origin to recovery value or proper disposal. Due to the growing concern about environmental issues, reverse logistics has become one of the most important concerns for many industries nowadays (Bai and Sarkis, 2013; Ho et al., 2012).

It can be defined as part of business logistics that is responsible for planning, managing, and controlling the flow of products, materials and products' packaging, and their corresponding logistics information through the reverse distribution channels, adding economic, legal, and logistics value and improving corporate image among other things (Council of Supply Chain Management Professionals, 2013; Leite, 2009; Rogers and Tibben-Lembke, 1999). This new configuration supports the idea that the end of the production process and the responsibility of the organization, does not end in delivering the product to the consumer (Gómez and Machado, 2015).

According to Agrawal et al. (2016), reverse logistics activities involve the collection of returned products, inspection and sorting out into different categories, and their disposition for reuse, repair, remanufacturing, or recycling. Complementary, forward and reverse logistics form the closed-loop supply chain network (Govindan et al., 2015).

This process can be divided into two categories: post-sale and post-consumption reverse logistics. The first one can be understood as the area of reverse logistics that deals with the planning, control, and allocation of goods that had little or no use and return to the distribution chain for several reasons: warranty returns and related warranty claims, goods damaged during transportation, excess inventory, and past expiration dates among others. On the other hand, post-consumption reverse logistics deals with assets at the end of their useful life, potentially reusable assets, and industrial waste (Leite, 2009).

Reverse logistics activities are more complex than those in traditional supply chain operations; therefore, organizations need flexibility to deal with operational issues (Prakash and Barua, 2016). To understand the management of reverse flows, Lambert et al. (2011) introduced the following seven key elements: the coordinating system, gatekeeping, collection, sorting, treatment, information system, and disposal system. The relationship between these elements is presented in Figure 1.

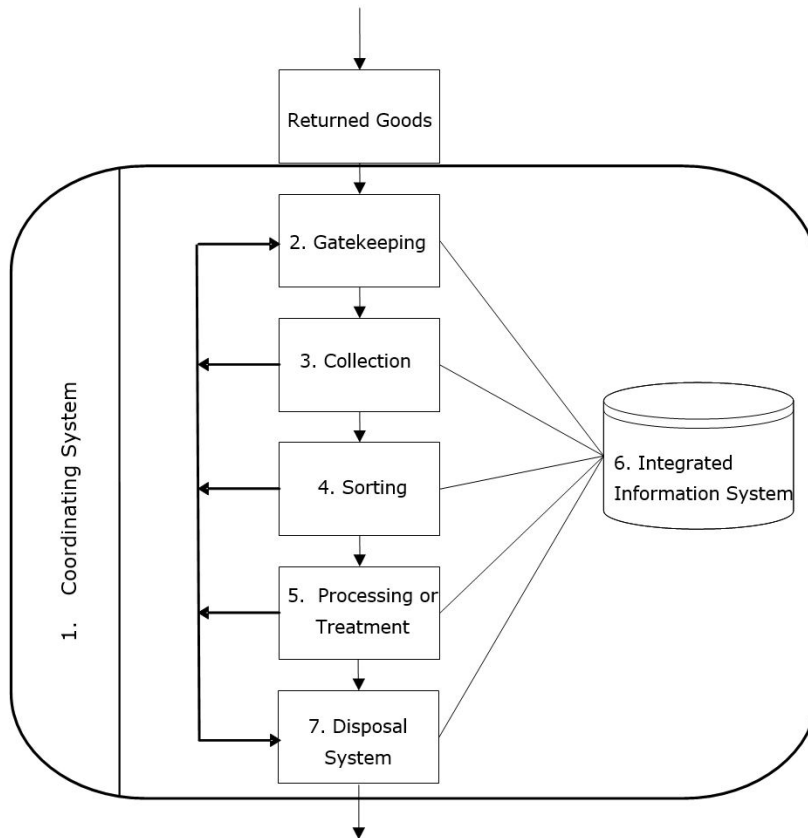


Figure 1 - Reverse Logistics System Elements. Source: Lambert et al. (2011)

A process mapping can ensure continuous improvement of the coordinating system, the first key element for the management of reverse flows. This is the most important key element of the system since it is responsible for the system’s overall management and performance. The second reverse logistics management element is gatekeeping. This process starts when a product is returned by the customer. Thus, the company should screen the products entering the return stream according to their functionality and determine the flow to be followed. This is one of the most important elements in some reverse logistics systems according to Bai and Sarkis (2013), Creutz and Larsson (2012), Lambert et al. (2011).

The next key element is the collection, which involves two activities: collect the returned goods and transport them, which depend on some factors such as product complexity and reason for return among others (Ait-Kaid et al., 2012; Lambert et al., 2011). When companies receive the returns, they must have well-trained personnel and formal processes to quickly respond to how recover more value from returned products. Also, there should be formal contracts (returns allowance, agreed negotiation rules, etc.) among these collecting participant organizations (Han and Cueto, 2016).

The sorting or classification of returned products is the fourth key element. This task involves cross-checking the item returned with the return authorization granted during gatekeeping. The company must determine the criteria to accept to exchange products and determine what products to stock. Furthermore, it is important to assign pre-disposition codes

to the processed return to enable fast and accurate determination of reuse and recycling options (Genchev et al., 2011).

The treatment or processing, the fifth key element, involves activities such as return to the manufacturer/supplier, return to stock, refurbish, repair, resale, balance inventory in the supply chain, refer to customer service, donate, recycle, reject, and liquidate (Genchev et al., 2011).

As shown in Figure 1, the information system, the sixth element, interacts with all other elements since it should manage information about the inventory, production, planning, and customer satisfaction improvements for the other elements. Finally, the seventh key element is the disposal system. It requires that all information about every product be traceable in the system, and the decisions are related to the value of the returned product and its transport (Lambert et al., 2011; Ait-Kaid et al., 2012). According to Hazen (2011), the factors identified as affecting the disposition decision are profit maximization, strategy, market conditions, supply chain infrastructure, and environmental conditions.

After these steps, the customer feedback process can take place, which includes credit authorization and solving customer problems. This is a very important process because mismanagement and lack of control can lead to loss of customers and competitiveness. Since one of the essential management tools involves the evaluation of activities, the next section discusses performance measurement and reverse logistics measures.

2.2 Performance measurement and reverse logistics measures

Reverse logistics has been widely considered to deal with environmental issues and minimize economic, financial, health, legal, and social-related problems (Ho et al., 2012). The organizational integration that is achieved through reverse logistics' rearrangement initiatives increases knowledge and predictability and improves the competitiveness of companies in the market (Abraham, 2011). Studies seeking to understand the characteristics of reverse logistics and to evaluate the results obtained with reverse logistics practices should be a priority when researching on this topic (Fernandes et al., 2018).

Measurement is an inherent necessity in any activity planning and monitoring process. If properly managed, reverse logistics can create value for the company (Hernández et al., 2010). According to Barbosa and Musetti (2011), there is no single definition of performance measurement, which makes the literature on the topic varied and abundant. An interesting definition was provided by Neely et al. (2005), who define performance measurement as the process to quantify the efficiency and effectiveness of actions. These authors added that performance measure is a metric used for quantification.

In the last decades, a large number of studies have been published on performance measurement and the development of frameworks and models, especially logistics excellence models (Global Logistics Research Team, 1995; Fawcett and Clinton, 1996; Bowersox and Closs, 1997; Bowersox et al., 1999; Lapide, 2006). Among these models is the World Class Logistics (WCL), proposed by The Global Logistics Research Team at Michigan State University (Global Logistics Research Team, 1995), which addresses the basic factors to achieve best practices in logistics resulting in attaining the status of a leading company, including performance measurement as one way to achieve excellence.

A performance measurement system should consider that the measurement can be performed on activities and processes, and it can be internal and external. Concerning performance metrics, the WCL model highlights that the performance measures used by world-class companies revolve around 4 dimensions: (1) costs, (2) customer service and quality; (3) productivity, and (4) asset management (Global Logistics Research Team, 1995). Accordingly, in addition to being gathered into categories, these performance measures are allocated at levels: strategic, tactical, and operational. The objective of the strategic level is to align the strategic objectives of reverse logistics systems with the company's mission, taking the financial constraints into account. The tactical level seeks to support the mapping process. Finally, the reverse logistics operational level develops the mapping system and the work instructions for a specific process. With this alignment with the organizational levels, the

operating companies can improve reverse logistics system operation, ensuring greater coordination (Lambert et al., 2011).

In the present study, a comprehensive literature review on performance measurements to evaluate reverse logistics was carried out. In addition to the study conducted by Chaves et al. (2011), who grouped the performance measures for the adoption of reverse logistics up to the year of 2010, other studies were reviewed, such as Genchev et al. (2011); Lambert et al. (2011); Shaik and Abdul-Kader (2012) and Skapa and Klapalová (2010). These measures were grouped under the WCL dimensions and the strategic, tactical, and operational levels, as shown in Table 1.

Table 1 - Performance Measurement for Reverse Logistics Evaluation

LEVEL	COST
Strategic	Total reverse logistics costs; Activity-based costing ABC; reverse logistics profitability; cost of variations in the reverse logistics budget; annual sales of returned products with the use of reverse logistics; net reverse logistics profit versus productivity index of reverse logistics activities; Rate of return on reverse logistics investment; Financial investment in reverse logistics.
Tactical	Return prevention cost; internal failure cost; external failure cost; costs associated with returned goods; costs associated with the failure of service; costs associated with logistics performance gaps; litigation costs; inventory level costs (manufacturers); costs associated with management and planning; warranty costs; costs associated with the receipt and storage of returned products.
Operational	Return processing costs; failure recovery costs; transport costs; inventory movement costs; packaging costs; reverse logistics administrative costs; order processing costs; labor costs; defective or damaged products' costs; costs associated with inspection of returned products; costs of materials used in repair operations.
LEVEL	ASSET MANAGEMENT
Tactical	Inventory obsolescence; inventory level; inventory turnover
Operational	Effective inventory management; the number of days of inventory on hand; inventory amount
LEVEL	CUSTOMER SERVICE
Strategic	On-time delivery; consumer satisfaction; service quality
Tactical	Damage; delivery reliability; information system supporting reverse logistics; shipping and delivery quality; screening procedures for returned products; return reasons; type of products returned.
Operational	Percentage of order backlogs; return volume; reverse logistics cycle time; complaints (absence or presence); Waste generation rate; quantity/volume of recyclable materials resulting from the manufacturing process that are disposed of; number of defective products; return processing speed; dock-to-stock cycle time; quality of document delivery service; recovery efficiency rate.
LEVEL	PRODUCTIVITY
Strategic	Process technology and innovation capacity; adjustment capability (flexibility)
Tactical	Network capacity; Transport capacity; Forecasting method accuracy
Operational	Material reuse; workforce productivity in the transport involved in reverse logistics activities; energy use; diagnostic accuracy.
LEVEL	OTHERS
Strategic	Legal compliance; cost-benefit ratio; population increase versus amount of recyclable waste; level of agents' satisfaction with the recycling program initiatives; corporate image; level of satisfaction of other supply chain participants with the company environmental actions; alliance between reverse logistics team members; value of local currency; global environmental compliance; technology and information capability; product life-cycle; and government satisfaction.
Tactical	Tightening and innovation in reverse logistics; Safety (rate of accidents involving equipment, products, and employees); employment rate; degree of influence of recycling programs on the agents regarding the application of the knowledge acquired outside the sphere of universities; degree of influence of recycling programs on the agents in terms of changes of behavior toward environmental issues; ability to find alternative sources of materials; and management of initiatives and employees' reverse logistics competencies

Table 1 shows that from all the performance measures (86) found in the literature, around 35% correspond to the cost dimension, 25% to the customer service dimension, 7% to the asset management dimension, and 11% to the productivity dimension. These findings corroborate those of Beamon (1999), Cuthbertson and Piotrowicz (2008), and Toni and Tonchia (2001), who reported that many companies still use traditional logistics performance measurement systems with an emphasis on the adoption of quantitative performance measures, focusing mainly on the economic and cost dimensions. The low rate of adoption of qualitative measures may be justified because these dimensions are more subjective and therefore more difficult to be evaluated and interpreted. However, non-financial controls do not limit the importance of quantitative measurements in cost dimension: companies use qualitative measures to give support to decision-making related to those quantitative and, as a result of good management of these economical elements, they can achieve good financial results.

It is noteworthy that these values represent the number of measures in each dimension, but the importance or relevance of the identified measures was not analyzed. It is important to note that 22% of the measures identified in the literature correspond to the dimension classified as 'Other'. In this category, the measures that were not included in the dimensions defined in the WCL model were also considered because they were regarded as relevant. Among them are global environmental compliance, government satisfaction, technology and information capability, product life-cycle, employment rate, ability to find alternative sources of materials, management initiatives, and employees' reverse logistics competencies. These measures show the inter-functional nature of reverse logistics and go beyond the boundaries of companies in terms of their interaction with legal, political, technological, economic, and social aspects.

Miranda and Silva (2002) state that every company, regardless of its size, has a performance measurement system, even if it is rudimentary. However, it is easier for large-sized companies to incorporate measures to assess performance in its strategic plan due to the existing human resources and capital (Barnes et al., 1998). In addition to the companies' size, each industry sector presents peculiar characteristics and may consider the use of a certain set of performance measures more important than others. Sectors that rely more on inventory may consider more important to adopt measures to evaluate inventory management, for example.

Fernandes et al. (2018) identified the main methods and measures used to assess reverse logistics performance through a systematic literature review.

However, the field research focused on identifying, among those found in the literature, the measures that are or have the potential to be adopted in practice and the existence of measures other than those reported in the literature. The existence of a correlation between certain reverse logistics performance measure dimensions and company size and their sectors of the economy was also investigated based on the following hypotheses:

Hypothesis 1: There is a relationship between the reverse logistics dimensions (cost, asset management, customer service, and productivity) and the size of a company.

Hypothesis 2: There is a relationship between the use of performance measures and sectors of the economy.

3 RESEARCH METHOD

A descriptive study with a quantitative approach was carried out in the form of a survey conducted in all regions of Brazil by administering questionnaires prepared using Google Docs to employees of companies in those regions. Initially, associations and federations that include companies working with reverse logistics were contacted and invited to participate, but since the response rate was low, different approaches were adopted. Thus, the questionnaire access link was made available on LinkedIn, through which a high response rate was achieved since it is a professional social network focused on business interactions and relationships.

The study sample comprised the following business sectors: agriculture; livestock; forestry; extractive industries; processing industries, production and distribution of electricity, gas, and water; construction; trade; repair of motor vehicles, personal and household goods;

accommodation and food services; transport. A total of 125 companies/professionals participated during the eight months of research: storage and communications; financial intermediation; real estate, renting and leasing services and other business activities; education; health and social services; and other collective, social, and personal services.

Data analysis was divided into two parts. The first one, descriptive analysis, involves general characteristics of the participating companies such as performance measurement systems adopted to evaluate the reverse logistics and the identification of performance measures adopted. The second included the statistical tests used to confirm the hypotheses suggested in this study.

Hypothesis testing allows carrying out inferences about population parameters, and the results indicate the acceptance or rejection of the hypothesis formulated; null hypothesis (H_0) is the hypothesis to be tested, and the alternative hypothesis (H_1) is the hypothesis that will be considered acceptable if the H_0 is rejected. In this study, two hypotheses were formulated to verify the relationship between dependent and independent variables, i.e., between the following performance measure dimensions: company size and sectors of the economy. In other words, to determine whether any performance measurement dimension is used more or less intensely according to the size of the company and industry sector.

The chi-square test of homogeneity (Tabachnick et al., 2001) was conducted to verify whether the cost of the dimensions asset management, customer service, and productivity were influenced by company size and the sectors of the economy. If the existence of a relationship between these variables was confirmed, the two-sample test for proportions was carried out to identify the most statistically significant company size and industry sector. All tests were carried out using $\alpha = 5\%$.

To verify whether the data supported the assumptions made, the two-sample test for proportions was used since it is an appropriate test to determine the frequency (counts) of items with the same characteristics (Bussab and Morettin, 2013).

The *Action*, a Microsoft Excel® statistical supplement, was used to support the statistical analysis. This free software, developed using the R platform, is a specialized program for statistical analysis of data matrices. It generates tabulated reports, charts, and plots of distributions, which are commonly used in descriptive statistics to describe or measure the association between variables.

4 RESULTS

This section presents the results of the survey conducted highlighting: the characterization of the participating companies/professionals; reverse logistics and performance measurement in these companies; the performance measures adopted to evaluate reverse logistics in these companies; and the hypothesis testing results.

4.1 Characterization of the companies participating in the research

The participating companies belong to various industry sectors: electrical & electronics; scrap tires; lighting & bulb; pharmaceuticals; lubricating oil packaging; PET and glass containers; steel packaging; and pesticide containers. In addition to the industry sector, the service sector was also significantly involved through contacts with the majority of these companies.

Eighty-one percent of the companies participating in the present study are located in the Southeast region (the most developed region in the country, including the highest number of industries), 11% in the South, 4% in the Midwest, 3% in the Northeast, and 1% in the North regions, as shown in Chart 1. Chart 2 (based on data obtained from the Brazilian Institute of Tributary Planning - census conducted by Amaral et al., 2012) shows the distribution of Brazilian companies by regions in 2012.

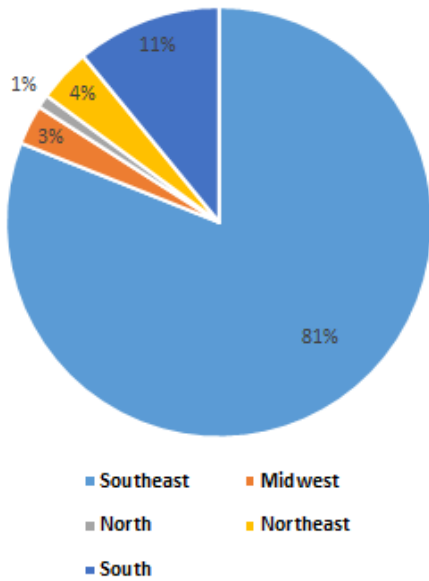


Chart 1 - Distribution of the Brazilian companies surveyed by regions

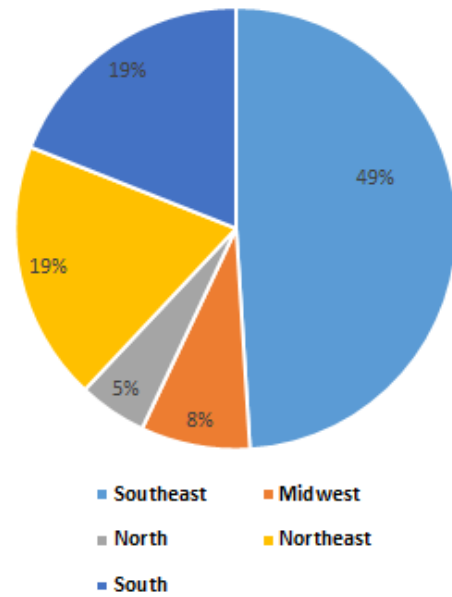


Chart 2 - Distribution of Brazilian companies by region

The comparison between the national distribution and the study sample indicates that the sample is composed of a higher percentage of Southeastern companies.

Concerning their size, it was found that most companies (57% of the companies) are large (based on the following classification: more than 500 employees for industries and more than 100 employees for service and trade), 17% of the companies are small, 15% are considered micro-enterprises, and 11% are medium-sized enterprises (Sistema de Apoio às Micro e Pequenas Empresas, 2015).

Chart 3 and Chart 4 show (based on data obtained from Amaral et al., 2012) that although most companies in Brazil (77.2%) are considered as micro-sized enterprises, 57% of the responses were received from large companies. This was possible since companies of this size have a more effective reverse logistics, and this information is effectively provided to different hierarchical levels. Chart 3 illustrates the size of the companies involved in the present study, and Graph 4 shows the distribution of Brazilian companies according to the same criteria.

It is noteworthy that the professionals working in the micro-sized companies often carry out activities in various areas. Thus, the professionals responsible for reverse logistics in these companies may not have the appropriate training or enough knowledge to work in this specific area.

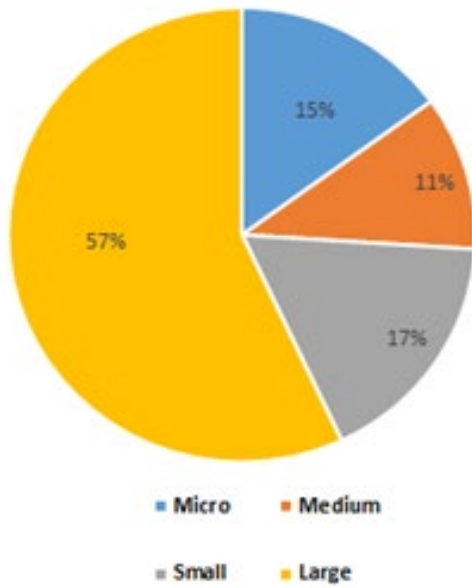


Chart 3 - Proportion of surveyed companies according to size

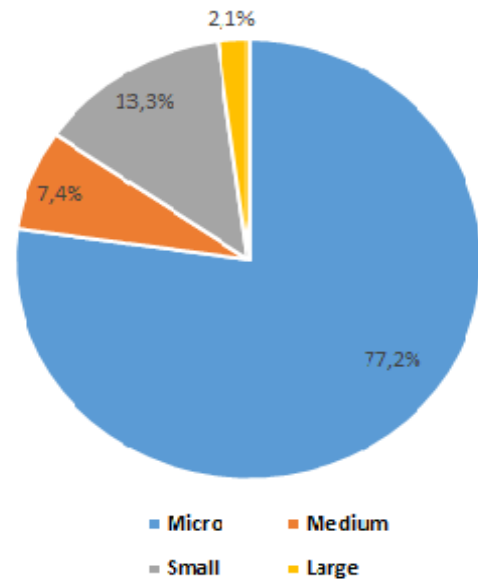


Chart 4 - Proportion of Brazilian companies according to size

In addition to the sector to which these companies belong to another important point to be discussed concerns the sector of activity of the participating companies. The respondent companies belong to the following sectors: transport and storage (32%), manufacturing industries (21%), trade, vehicle repair, personal and household goods (12%), other community, social and personal services (11%), and other sectors (24%) It was observed that most respondent companies belonged to transport, storage, and manufacturing sectors because these sectors are more likely to adopt reverse logistics.

4.2 Adoption of reverse logistics and performance measurement

Regarding the use of reverse logistics performance measures, none of the companies seems to use a structured performance measurement system that includes reverse logistics. However, it is important to mention that in most cases these companies evaluate their reverse logistics using performance indicators.

Analyzing the processes involved in reverse logistics, it was observed that the most common processes used by the participating companies according to the order or number of citations are: resale; recycling; repair; reprocessing; disposal of waste at landfill sites; others; incineration; remanufacturing; and disposal of waste at dumpsites.

Brito (2004) argues that greater economic return is achieved with higher levels of recovery, which is obtained through direct recovery, that is, resale, reuse, and redistribution. However, the recovery option depends on the returned product or material and the product condition (damaged, defective, at the end of life, among others). The results obtained show that most companies use resale, recycling, and repair as processes associated with their reverse logistics operations. These results indicate that these companies, in general, adopt this strategy for economic recovery. However, recycling is a process used less frequently because of its lower economic return compared to that of the other activities, which is due to lack of technology and resources in Brazilian companies, rendering it unfeasible to use expensive processes such as remanufacturing more frequently.

Another important finding was that 17 companies dispose of their waste in dumps, which, although being the least often adopted approach, it is a prohibited activity in Brazil. It is

important to note that although the law N° 12.305/2010, which concerns the Brazilian Solid Waste Policy (BSWP), had established the end of the waste disposal at dump sites by the year 2014, this practice still occurs in Brazil (Campos, 2014; Chaves et al., 2014).

A total of 53% of these processes are outsourced. Moreover, as for the quality of reverse logistics systems used by these companies, most of them consider their reverse logistics activities as having good level quality. This result demonstrates that even not having a standard reverse logistics system implemented, as discussed above, reverse logistics performance in companies cannot be considered low if taken as an average result; although only 11% is considered excellent. This classification results from factors that hinder the implementation or operation of reverse logistics. Govindan et al. (2015) point out the difficulties encountered by enterprises such as the lack of appropriate systems for the implementation of reverse logistics activities and little importance given to reverse logistics when compared to other issues or strategies in the company. Furthermore, Bouzon et al. (2016) compiled a list of the most common reverse logistics barriers in Brazilian organizations based on a systematic literature review, and a priority ranking list of reverse logistics barriers encountered by the electrical-electronic industry sector in Brazil. According to the authors, the "Economic related issues" category of barriers seems to be the priority. The financial burden of taxes and the uncertainty related to economic issues appear to be major obstacles to reverse logistics implementation. The Governance and supply chain related issues category were classified as priority level 2, followed by the technology and infrastructure related issues category. The Knowledge related issues category ranked fourth receiving less than half of the priority given to the first ranked category (Economic). Finally, the Policy (P) and Marketing and competitors categories were ranked fifth and sixth priorities, respectively.

4.3 Adoption of performance measures for reverse logistics

According to the responses obtained, it was possible to draw up a table presenting the use of performance measures (%) for each dimension of the WCL previously identified in the literature (costs, asset management, customer service, and productivity) and verified in practice. These results are shown in Table 2.

Table 2 - Reverse logistics (RL) performance measures for the Costs dimension

Performance Measures - Costs	Used (%)	Not used (%)
Total cost of reverse logistics	65	35
ABC costs	57	43
RL profitability	53	47
Cost of variations in the reverse logistics budget	50	50
Annual sales of returned products with the use of reverse logistics	48	52
Net reverse logistics profit versus Productivity index of reverse logistics activities	45	55
Rate of return on reverse logistics investment	44	56
Financial investment in reverse logistics	44	56
Return prevention cost	44	56
Internal failure cost	43	57
External failure cost	43	57
Costs associated with returned goods	42	58
Costs associated with failure of service	42	58
Costs associated with logistics performance gaps	41	59
Litigation costs	40	60
Inventory level costs (manufacturers)	40	60
Costs associated with management and planning	38	62
Warranty costs	38	62
Cost associated with receipt and storage of returned products	37	63
Return processing cost	34	66

Table 2 – Continued...

Performance Measures - Costs	Used (%)	Not used (%)
Failure recovery costs	34	66
Transport costs	32	68
Inventory movement costs	31	69
Packaging costs	30	70
LR Administrative costs	26	74
Order processing cost	26	74
Labor costs	24	76
Defective or damaged products' costs	24	76
Costs associated with the inspection of returned products	22	78
Costs of materials used in repair operations	22	78

The most commonly used measures in the cost dimension are the total cost of reverse logistics, ABC costs, and reverse logistics profitability; this dimension is the one that showed the greatest use of performance measures. Although there are different motivations for the adoption of reverse logistics, such as environmental, legal, and corporate image factors, the cost of carrying out activities related to LR is the greatest motivator for its adoption and assessment. It was also observed that the primary concern of enterprises is related to the total cost of LR rather than the cost associated with its elements, i.e., fixed costs, variable costs, administrative costs, operating costs, etc.

The results of the Asset Management dimension are shown in Table 3.

Table 3 - Reverse logistics (RL) performance measures for the Asset Management dimension

Performance measures – asset management	Used (%)	Not used (%)
Inventory obsolescence	54	46
Inventory level	54	46
Inventory turnover	53	47
Inventory management accuracy	50	50
Number of days of inventory on hand	50	50
Inventory amount	41	59

The most commonly used measures were the obsolescence of inventory, inventory levels, and inventory turnover. The Asset Management dimension was also one of the most commonly used dimensions, which contradicts the assertion that non-financial measures are barely evaluated. We believe that this result was obtained because it is expected that activities such as resale, recycling, and re-use have an impact on inventory turnover thus minimizing the impact of the inevitable obsolescence and disposal of products.

Concerning the Customer Service dimension, it was observed that performance measures were also quite commonly used. Table 4 presents the measures for this dimension.

Table 4 - Reverse logistics (RL) performance measures for the Customer Service dimension

Performance Measures – Customer Service	Used (%)	Not used (%)
On-time delivery	60	40
Consumer satisfaction	60	40
Service quality	58	42
Damage	57	43
Delivery reliability	54	46
Information system supporting LR	52	48
Shipping and delivery quality	52	48
Screening procedures for returned products	46	54
Return reasons	44	56
Type of products returned	42	58

Table 4 – Continued...

Percentage of order backlogs	40	60
Return volume	39	61
RL cycle time	38	62
Complaints (absence or presence)	38	62
Waste generation rate	36	64
Quantity/volume of recyclable materials resulting from the manufacturing process that are disposed of	35	65
Number of defective products	33	67
Return processing speed	33	67
Dock-to-stock cycle time	32	68
Quality of document delivery service	26	74
Recovery efficiency rate	26	74

The most commonly used performance measures in this dimension were on-time delivery, customer satisfaction, service quality, damage, and delivery reliability. The adoption of performance measures in this dimension is justified since the previously mentioned LR motivation factors (corporate image, reduced environmental impact, cost reduction, and compliance with legislation) directly impact customer service and such impact should be evaluated.

Table 5 shows the performance measures for the productivity dimension.

Table 5 - Reverse logistics (RL) performance measures for the Productivity dimension

Performance Measures - Productivity	Used (%)	Not used (%)
Process technology and innovation capacity	47	53
Adjustment capability (flexibility)	36	64
Network capacity	30	70
Transport capacity	30	70
Forecasting method accuracy	29	71
Material reuse	27	73
Workforce productivity in the reverse logistics transport activities	26	74
Energy use	23	77
Diagnostic accuracy	21	79

It was observed that this dimension was the least commonly adopted in comparison to the others. The most commonly adopted measures were process technology and innovation capacity and adjustment capability (flexibility). These measures reflect the need for flexibility and the use of technologies and the need to restructure business processes to ensure effective adoption of reverse logistics processes. We believe that this dimension will only be effectively adopted when reverse logistics is fully implemented in the enterprise environment.

In sum, as seen in Tables 2-5, contrary to what was found in the literature (only financial measures are effectively implemented), non-financial measures were also properly implemented in some dimensions. The following measures are an example of the balance between financial and non-financial measures: inventory obsolescence, inventory level, and inventory turnover (asset management dimension); on-time delivery, customer satisfaction, service quality, damage; and delivery reliability (customer service); process technology and innovation and adjustment capability (productivity).

5 HYPOTHESES TESTING

To verify the existence of a correlation between the use of performance measures dimensions (cost, asset management, customer service, and productivity) and the size of the companies (hypothesis 1) and the sectors of the economy (hypothesis 2), these hypotheses were formulated and tested. Homogeneity tests were carried out to evaluate the correlation between the variables mentioned above. In the cases in which correlation was statistically proven, chi-square tests such as the two-sample test for equality of proportions were

conducted to identify the most significant size (micro, small, medium, and large) and sector of the economy (transport, storage, and communications; manufacturing industries, trade, repair of motor vehicles, personal and household goods, other community, social, and personal services; and others).

Initially, Hypothesis 1, which suggests the existence of dependency relationship between the use of performance measures according to the dimensions adopted (cost, asset management, customer service, and productivity) and company size, was tested. Based on the statistical tests carried out, it was found that there is a significant difference between the dimension productivity and the size of companies. Large-sized companies evaluate productivity more frequently than the small and medium-sized companies since this performance dimension requires a more fully implemented reverse logistics system to be better evaluated. Besides, it is expected that large-sized companies have properly implemented reverse logistics practices and widely share them with their staff, which enables them, even the low hierarchical level employees, to use relevant information to assess this dimension.

As for hypothesis 2, no significant difference was found in the tests. i.e., no market sector influenced these companies in terms of the use of different performance measures.

This result contradicted our expectations. Since each industrial sector has its peculiarities and is likely to consider the use of a set of performance measures more important than some other sets, we expected that different performance measures would be adopted in different sectors. For example, we believed that sectors that depend more on inventory would consider it more important to use measures that evaluate asset management or companies that provide collective, social, and personal services would adopt more measures to assess the customer service dimension. However, this hypothesis was rejected. We supposed that despite the specificities of the different sectors, the companies have recognized the importance of measuring performance in a comprehensive way, measuring the company performance in different dimensions.

6 FINAL CONSIDERATIONS

Reverse logistics brings strategic competitive advantage and helps to minimize the total costs generated by the launch of new products in the market and their reintegration into the value chain. Thus, given the importance of reverse logistics, managing its performance is also a way to ensure the competitive advantages it can bring. This study identified the most frequently used performance measures for the evaluation of reverse logistics in Brazilian companies belonging to different sectors. As none of the companies investigated adopted a structured system for the evaluation of reverse logistics, Brazilian companies can considerably improve it in terms of awareness, structure, and adoption. These companies evaluate reverse logistics mainly using performance measures on an isolate evaluation.

In this analysis, it was identified that financial performance measures are the most prevalent in the investigated companies, thus fitting the application of a greater number of non-financial measures, such as productivity measures, which had less application in the studied companies. Cazeri et al. (2017) and Abdala et al. (2018) highlight the importance of measuring other dimensions of reverse logistics, in addition to the financial one.

It is important to point out that these results were obtained from a survey that covered different industry sectors from diverse regions of the country. Thus, seasonal or production area surveys should be carried out to produce targeted data, as diverse contexts may result in varying evidence of analysis. Thus, further studies on the topic are necessary, as the existing challenges for small and medium-sized companies in implementing these measures, for example. Another future research is related to the necessity of different performance measures depending on the market sector or the reverse channel. This study could not conclude if companies use the same performance measures if it does no influence on reverse activities or if companies have not achieved a maturity level to improve the measurement process. This field of research requires more complementary studies to advance theoretical contributions but also to improve and increase the use of this activity in practice.

Another challenge in reverse logistics adoption in Brazil was verified, for example, it was observed that 17 companies dispose of their waste in dumpsites, which, in Brazil, it is prohibited by law. These challenges and others identified in the present study can also be seen as opportunities for further research and applications of reverse logistics in Brazil. For example, it was verified that the most commonly adopted reverse logistics processes in Brazil are resale, recycle, and repair, and that companies have the opportunity to adopt other reverse logistics activities.

Is important to notice that resale and reuse options are mostly used for post-sale channel when recycling and reprocessing are more common in post-consumption. However, this was not verified in this research, as it involved a comprehensive understanding of these concepts. So, it is not possible to relate any process to each return channel. Also, it is important to define specific metrics to use on post-sale and post-consumption channels due to the different objectives and incentives in each one.

This study presents two main contributions to academia and operations management. The first is to present the current situation of companies concerning the adoption of reverse logistics. Large-sized companies are those that most frequently adopt performance measures to assess reverse logistics in Brazil. However, no correlation was verified between the performance measure dimensions evaluated and the sectors of the economy.

The second contribution is to present a general systematization of performance measures to evaluate reverse logistics, as well as an analysis of the adoption of these measures in the investigated companies, thus making it possible to verify which ones are most adopted by these companies and which ones still have the potential for greater adoption. It is worth mentioning that before choosing performance measures for the evaluation of reverse logistics, the company should clearly define the purpose of adopting reverse logistics (legal, environmental, economic, social, or others). The choice of the most adequate performance measures to evaluate reverse logistics depends on what the company intends to measure.

Moreover, one of the most difficult tasks regarding returns management is to develop awareness among senior managers of the importance of formalized reverse logistics, and obtain support from them with additional support by cross-functional teams. Managers should come to realize that formalized handling of reverse logistics could bring social and economic benefits. In this sense, the performance measurement of reverse logistics can be an important tool as a motivation to apply them and to induce more sustainable behavior within the supply chain.

Another important issue is related to sectoral agreements, that establish specific process to wastes with greater pollutant impact due to the dangerous materials (like Electro Electronics) or due to the volume generated (like packaging). However, as the time that this study was conducted, not all sectoral agreements were approved, and to avoid restricting the research, the measures were not related to specific requirements established by each sectoral agreement. It could be addressed by future studies.

Finally, it is important to highlight that although these companies are concerned about implementing more efficient logistics processes in the distribution of their products through a direct channel, they should express the same level of concern about the goods distributed through the reverse channel. This study presented a list of measures for this assessment in different industrial segments, which is an initial step towards reverse logistics performance measurement. This research field has still a long pathway to improve reverse logistics.

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