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PERFORMANCE INDICATORS OF REVERSE LOGISTICS SYSTEMS: A PROPOSAL FOR A MODEL APPLIED TO THE BRAZILIAN CONTEXT

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ABSTRACT

Objective: The objective of this study was to propose a generic model of performance indicators (PIs) for Reverse Logistics Systems (RLS), investigating four topics of interest: Quantities of products produced; Estimates of product lifespan; Predilections for disposal/destination of these wastes by consumers; and Quantities of waste returned by the RLS versus environmental requirements of the products.

Theoretical Framework: This topic highlights the presentation of a compilation of RLS PIs extracted from the literature, classified into different categories, containing their respective calculation metrics..

Method: The methodology adopted comprises a combined qualitative/quantitative approach involving bibliographic research and data collection via Survey, targeted at representatives of the nine RLS with national coverage covered in the research.

Results and Discussion: The construction of the results involved the compilation and analysis of feedback from the RLS managers, as well as the topics of interest of the research, revealing categories of PIs not previously used by the referred RLS and culminating in the presentation of the proposal for a model applied to the Brazilian context.

Research Implications: The practical and theoretical implications of the presented proposal foster a more holistic view of the topic, revealing a myriad of possibilities for direction and improvements in this area.

Originality/Value: This study contributed to the literature by expanding the understanding of variables involved in the RL problem. The relevance and value of this research are evidenced by listing different IDs for SLR, thus providing input for direction and development of improvement strategies.

Keywords: Reverse Logistics, Performance Evaluation, Performance Indicators, Reverse Logistics Systems, Generic Model.

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INDICADORES DE DESEMPENHO DE SISTEMAS DE LOGÍSTICA REVERSA: UMA PROPOSTA DE MODELO APLICADO AO CONTEXTO BRASILEIRO

RESUMO

Objetivo: O objetivo deste estudo foi propor um modelo genérico de indicadores de desempenho (IDs) para Sistemas de Logística Reversa (SLR), investigando quatro tópicos de interesse: Quantidades de produtos produzidos; Estimativas de tempo de vida dos produtos; Predileções de descarte/destinação desses resíduos pelos consumidores; e Quantidades de resíduos retornadas pelo SLR *versus* requisições ambientais dos produtos.

Referencial Teórico: Neste tópico, destaca-se a apresentação de um compilado de IDs de SLR extraídos da literatura, classificados em diferentes categorias, contendo suas respectivas métricas de cálculo.

Método: A metodologia adotada compreende uma abordagem combinada quali/quantitativa envolvendo pesquisa bibliográfica e coleta de dados via Survey, direcionada a representantes dos nove SLR com abrangência nacional abordados na pesquisa.

Resultados e Discussão: A construção dos resultados envolveu a compilação e análise dos *feedbacks* das gestoras de SLR, bem como dos tópicos de interesse da pesquisa, revelando categorias de IDs até então não utilizadas pelos referidos SLR e culminando na exposição da proposta de um modelo aplicado ao contexto brasileiro.

Implicações da Pesquisa: As implicações práticas e teóricas da proposição apresentada fomentam um olhar mais holístico sobre a temática, descortinando uma miríade de possibilidades de direcionamentos e melhorias nessa área.

Originalidade/Valor: Este estudo contribuiu para a literatura ao ampliar o entendimento acerca de variáveis envolvidas na problemática da LR. A relevância e o valor desta pesquisa são evidenciados ao se elencar diferentes IDs para SLR, assim fornecendo insumos para direcionamento e desenvolvimento de estratégias de melhoria.

Palavras-chave: Logística Reversa, Avaliação de Desempenho, Indicadores de Desempenho, Sistemas de Logística Reversa, Modelo Genérico.

INDICADORES DE DESEMPEÑO DE LOS SISTEMAS DE LOGÍSTICA INVERSA: UNA PROPUESTA DE MODELO APLICADO AL CONTEXTO BRASILEÑO

RESUMEN

Objetivo: El objetivo de este estudio fue proponer un modelo genérico de indicadores de desempeño (IDs) para Sistemas de Logística Inversa (SLI), investigando cuatro temas de interés: Cantidades de productos producidos; Estimaciones de vida útil del producto; Predicciones sobre la eliminación/destino de estos residuos por parte de los consumidores; y Cantidades de residuos devueltos por SLI frente a los requisitos ambientales de los productos.

Marco Teórico: Este tema destaca la presentación de una compilación de IDs SLI extraídos de la literatura, clasificados en diferentes categorías, conteniendo sus respectivas métricas de cálculo.

Método: La metodología adoptada comprende un enfoque combinado cualitativo/cuantitativo que involucra investigación bibliográfica y recolección de datos mediante encuesta, dirigida a representantes de las nueve SLI de cobertura nacional cubiertas en la investigación.

Resultados y Discusión: La construcción de los resultados implicó la recopilación y análisis de feedback de los gestores de los SLR, así como temas de interés para la investigación, revelando categorías de IDs no previamente utilizadas por los citados SLIs y culminando con la presentación de la propuesta de un modelo aplicado al contexto brasileño.

Implicaciones de la investigación: Las implicaciones prácticas y teóricas de la propuesta presentada fomentan una visión más holística del tema, revelando una miríada de posibilidades de orientación y mejoras en esta área.

Originalidad/Valor: Este estudio contribuyó a la literatura al ampliar la comprensión de las variables involucradas en el problema RL. La relevancia y el valor de esta investigación se resaltan al enumerar diferentes identificaciones para SLI, proporcionando así información para orientar y desarrollar estrategias de mejora.

Palabras clave: Logística Inversa, Evaluación del Desempeño, Indicadores de Desempeño, Sistemas de Logística Inversa, Modelo Genérico.

1 INTRODUCTION

The management scope within an organization that is responsible for the supply chain, providing resources and subsidies is called Logistics. The current characteristics accepted by institutions, as well as the needs established by the market, have led to new activities and functions for logistics (Silva *et al.* , 2015). One of these recent tasks is called reverse logistics (RL). RL is based on the idea of planning, implementing and inspecting finished products, in process or materials within a scheduled flow, from consumption to the point of origin, through reverse means, aiming to add value to the product or its correct destination (Costa *et al.* , 2014).

The topic began to be examined in the United States and in parallel in Europe at the end of the 1970s (Guarnieri, 2016). Agrawal *et al.* (2015) specify that various researchers over time derived different meanings for LR, presented in Table 1.

Table 1

Meanings derived over time.

Authors	Year	Description
Murphy and Poist	1989	They introduced the concept of reverse flow of materials.
Carter and Ellram	1998	They added the term environment.
Rogers and Tibben-Lembke	1999	A path establishing the abstraction of Reverse Logistics, externalizing the idea of planning, implementing and controlling efficiency, the true costs of the raw material course and adding value to the product.

Source: Adapted from Agrawal *et al.* (2015).

In Brazil, in the late 1990s, actions related to waste separation and reverse logistics emerged (Guarnieri, 2016). With the intensification of waste in urban centers and the beginning of the use of disposable packaging and products, social awareness of ecosystem preservation increased (Mendonça *et al.* , 2017).

Only in 2010, in response to the forecast of unbridled consumption and reuse of solid waste, the PNRS, transcribed as the National Solid Waste Policy, was established, granted by Law No. 12,305/2010, reflecting the encouragement of shared management of the waste generated (Brazil, 2010). The PNRS is likely a tactic implemented in the European Union,

proposing to add efficiency and effectiveness in waste management, expanding recycling throughout Europe and the benefits of moving natural resources within the economy (Kim *et al.* , 2018).

In Brazil, considering nine Systems with national coverage, some of them having collected: from 1999 onwards, 4.2 million tons of unusable tires (Abrelpe, 2017); from 2002 to 2019, 521,991 tons of empty pesticide packaging (inpEV, 2019); in 2010, 36% of the total volume of Used or Contaminated Lubricating Oil was collected (MMA, 2011a); from the implementation of the SLR, 8 million batteries were collected (MMA, 2011b); 4,742 tons of plastic packaging for lubricating oils (Abrelpe, 2017); 13,969 tons per day of packaging in general (Abrelpe, 2017); and 256,941 tons of medicines (Abrelpe, 2017).

In this context, the question arises as to whether these SLRs are considering performance foundation that measure ecosystem demands involving, integrating or correlating the following items: Quantities of products produced; Lifespan estimates; Consumers' preferences for disposal and/or destination of the same; Quantities returned by the System *versus* environmental requests for the products subject to the System.

Therefore, this article aims to propose a generic model of performance indicators that is more appropriate to the Brazilian context, aiming to achieve, through the specific objectives of prospecting SLR performance indicators applied in Brazil and worldwide, as well as proposing a list of indicators for application by managers of nine SLRs - with national scope - taking into account the involvement/integration/correlation of the aforementioned items.

2 LITERATURE REVIEW

2.1 REVERSE LOGISTICS SYSTEMS

A system can be correlated as the sum of organized elements that present a relationship between themselves, generating a process. A process is defined as an operation that admits an input, incorporates value and generates an output to obtain concrete results (Harrington, 1993). Following the idea of a system, a Logistics System is formed by basic constituents, encompassing the processes of planning, storage of raw materials, flow control, operationalization of in-process products, finished products, money and information, from origin to destination, in an economical, efficient and effective manner, meeting the needs and priorities of customers (Novaes, 2003).

The reverse logistics system aims to direct the final destination of solid waste to those

involved in the product's trajectory, such as national companies and consumers (Nascimento & Lima, 2018). There are two subsections of reverse distribution channels: post-consumer and post-sale reverse logistics. Post-consumer is conceived of inputs used and subsequently discarded. In contrast, post-sale deals with products that have not been used or are barely used, due to expiration, return, defect or other similar situations (Santos & Marchesini, 2018).

The SLRs emphasize that the waste needs to be linked to its origin of production or commercialization, specifying that there is some way of reusing it as a method of applying post-consumption responsibility, inferring such attention from the entry of the polluter-pays concept, which guides the PNRS (Nascimento & Lima, 2018).

In Brazil, considering nine actions with national scope, the following segments will be addressed: Pesticide packaging; Unusable tires; Used or contaminated lubricating oil; Batteries; Polymeric packaging of lubricating oils; Sodium and mercury vapor fluorescent lamps and mixed light; Packaging in general; Electronic products and their components and Medicines.

2.1.1 Reverse Logistics Systems entering the Brazilian level

2.1.1.1 Waste tires

The specification of tires as new, post-consumer, repaired and unusable, which also classifies and describes the correct final destination, is substantiated by CONAMA Resolution No. 416/09. The responsibility is directed to the producers and importers of new tires with a unit value greater than 2 kg, where they are compelled to collect and dispose of the waste at the end of their useful life (Conama, 2009).

According to ANIP, a national oil industry institution, in 2010, 67.3 million tires were produced, of which 18.1 million were exported and 23.9 million were imported (Lagarinhos & Tenório, 2013).

The efficiency of SLR insertion is an important tool for the problem of unusable tires, as it results in the reduction of waste through the capture, conduction and environmentally assertive disposal of this material (Pedram *et al.* , 2017). Considering the base year of 2016, the evidence in the Tire Report shows that national tire manufacturers allocated approximately 457,533 tons in an environmentally appropriate manner (Anip, 2019).

2.1.1.2 Pesticide packaging

Specific provisions for pesticide wrappers are cited in the "Pesticide Law", law no. 7,802, dated 11/07/1989, as well as subsequent modifications, so it is necessary to understand the purpose of the Law (Silva *et al.* , 2017).

Empty agrochemical packaging causes harm to animal and plant health. In the past, packaging was not disposed of correctly; one way was to bury it. Thus, contamination with agrochemical residues in groundwater and soil was observed, causing people to harm the packaging, rather than degrading it (Ferreira *et al.* , 2017).

In Brazil, the institute that operates by conducting empty packaging, portrayed by inpEV, reports that 94% of the plastic wrappers of pesticides sold were destined for the institute and also returned by farmers 44.5 tons of this waste in 2017 (Inpev, 2019).

2.1.1.3 Used or contaminated lubricating oil – OLUC

All persons, whether natural or legal, according to articles 2 and 5 of the Resolution issued by CONAMA, in full National Environmental Council, ordinance no. 362/2005, which handles the OLUC in its prerogatives, are stewards of the waste generated, such as: lubricating filters and components such as the OLUC (Machado *et al.* , 2019).

The Lubricants Bulletin, provided by the national agency with oversight over oil, natural gas and biofuels, shows that although the legislation denoted existed in Brazil, in May 2017, the amount of oil collected represented 39.20% of the oil sold (ANP, 2017).

2.1.1.4 Batteries and batteries

Defined, the battery, according to CONAMA Resolution No. 401: 2008, as electrochemical generators of electrical energy, translating into chemical energy; they can be classified as: non-rechargeable or rechargeable (Quintana & Benetti, 2016). Batteries are considered rechargeable storage devices or a group of batteries, either in series or in parallel (Moretti *et al.* , 2011).

The chemical elements attached to the batteries indicate the possibility of contaminating the soil, thus, the water table can also be contaminated, depending on the quantity of chemical components, they can cause diseases in the nervous system, cancer, kidneys and other diseases (Carvalho *et al.* , 2016).

2.1.1.5 Plastic packaging for lubricating oils

December 19, 2012, related to plastic packaging for lubricating oils, the sectoral agreement that imposed the SLR was signed. Thus, in article 33, the parties cited in Law 12,305/2010 are responsible for implementing and practicing the LR (Silva *et al.* , 2018b).

In 2016, the Jogue Limpo program correctly disposed of around 92 million of these plastic wrappers, recovering 4,500 tons of plastic containers out of the 4,590 tons collected (Abrelpe, 2017).

2.1.1.6 Sodium-mercury vapor and mixed-light fluorescent lamps

The introduction of this System was developed by the National Information System (SINIR), which was implemented through regulations recognized as the Sectoral Agreement (AS), which aims to dispose of waste from these components environmentally and coherently with the PNRS (Sinir, 2016).

Just one fluorescent lamp does not constitute a significant difference in harming the ecosystem, however, the increase in the use of fluorescent lamps is noticeable. In Brazil, 206 million units of these lamps were quantified (Cestari & Martins, 2015). Thus, the problem presented becomes worrying.

2.1.1.7 Packaging in general

The Packaging agreement commits to the PNRS requirements by expanding selective collection, increasing the recovery rate, and allocating a large part of the collected waste to the collectors' cooperative (Sinir, 2015).

The AS allocates a large part of the processed materials to institutions which, when considered coupled with investment in these organizations, result in a virtuous cycle of packaging for commercialization and income generation (Demajorovic & Massote, 2017).

Companies have increased their interest in the LR of their own packaging, in an attempt to reestablish such economic value and improve their image and relationship with their customers through strategic action planning (Silva & Leite, 2012).

2.1.1.8 Electronic products and their components

At the same time, companies and the Brazilian government are taking action to reduce the consequences of environmental impacts. In this sense, the PNRS assigns responsibility to distributors, manufacturers, traders and importers of electronic products to implement post-consumer SLR (Oliveira *et al.* , 2016).

According to the Ministry of the Environment, inoperative electronic products in the country's homes reach 500 million. The National Association for Electronic Recycling also reported that around one million tons of this waste is not disposed of correctly (Gama *et al.* , 2016). Waste Electrical and Electronic Equipment (WEEE) has accumulated to 1.5 million tons, and its components are not recycled (PSP, 2014).

2.1.1.9 Medications

Post-expiration, contaminated, prevented from circulation or unused medicines are considered waste linked to health services and may pose potential threats to the environment and public health. Therefore, for correct disposal, pharmaceutical waste is classified as B.2 in “Special Waste” and must comply with NBR 12.809/1993, which addresses actions on this waste (Silva *et al.* , 2017).

In 2014, industry data showed that less than 1% of shipped products were returned due to expiration. In conclusion, a large part of pharmaceutical waste was disposed of incorrectly, where consumers were not aware of the return of these inputs to the respective manufacturer (Bueno *et al.* , 2017).

Considering the problems caused by the erroneous disposal of pharmaceuticals, such as the contamination of water and soil and, consequently, the poisoning of people and animals, the issue must be treated with considerable environmental and social relevance (Soares *et al.* , 2018).

2.2 PERFORMANCE EVALUATION

Performance verification and measurement are described in the literature as the procedure for sizing an activity, such as measurement consisting of the estimation method and evaluation is the action of propagating performance (Neely & Gregory, 1995). Kaplan and Norton (1997) abstract that a performance evaluation system demonstrates that financial and

non-financial metrics must incorporate the information system for employees of all classes of the organization.

For Fonseca and Rozenfeld (2012), the concepts involving performance evaluation have numerous meanings, resulting in the existence of several research segments with different views and definitions, making the literature related to the topic comprehensive and diversified.

Performance evaluation is important in companies due to the assumption of creating management mechanisms to measure expectations on certain points, that is, how the company is behaving in the circumstances measured, influencing the determination of the value to the organization, which is generated by productive competence (Magarão & Cuvillier, 2014). Souza (2002) concludes that evaluations are essential for organizations and, through feedback processes, reviewing work methods and planning. This allows the institution to renew itself, oxygenating it and treating it with the capacity to resist turbulent and changing environments.

2.2.1 Performance evaluation entering Reverse Logistics

Neely and Gregory (1995) translate that performance evaluation is a way for the institution to evaluate, within reverse logistics, efficiency and effectiveness, that is, the evaluation encompasses the broad characteristic of improving discernment about a dynamic system, instructing those responsible to improve the entity's LR (Fernandes *et al.* , 2018).

Incorporated into the institution, as a possibility, through reverse logistics, some values such as: logistical, environmental, economic, social, image, among others (Guarnieri *et al.* , 2006). Therefore, monitoring this development, achieving competitive implications, assimilating losses, reducing costs and improving processes are some reasons injected for investment in performance evaluation (Shaik & Abdul-Kader, 2011).

Any evaluation system needs to have in its structure the performance indicators that integrate the different procedures, forming a basis for decision-making (Neto *et al.* , 2017).

2.3 PERFORMANCE INDICATORS

Due to their purpose, indicators, through data collection and management of this data (applying procedures and metrics), must show information on a given topic. The performance metrics apparatus is implemented through indicators that measure logistics (Chaves *et al.* , 2008).

Performance indicators (PI) provide the opportunity to supervise processes and, through

evaluation, recognize weak aspects of the process where managers can intervene by implementing an improvement with the parameters determined by the business tactic used. They are necessary for an institution to achieve its mission (Ceni *et al.* , 2016).

Kaplan and Norton (1992) corroborate that performance measurements provided by indicators need to scrutinize information and compare it, substantiated by goals or in comparison with the market. Anthony and Govindarajan (2002) cover the use of parameters, which should not only pay attention to the financial references that present the consequences of the decisions taken, but also view non-financial parameters, which are formidable metrics of future performance.

2.3.1 Performance indicators within Reverse Logistics

Reverse chain mechanisms aim to build measures to contemplate evaluation and comparison of effects, through established models. The possibility of benefit in metrics of repeatability of verifications lies in the applicability of indicators to the sieve of the performance of SLR (Xavier & Corrêa, 2013). According to Hernández *et al.* (2011), currently understanding the consequences of LR in companies, and then pointing out management indicators to measure it, is among one of the main tasks of company management.

IDs influence the advancement of environmental and RL practices (Esteves, 2017). There are multiple reasons for these. In Reverse Logistics, the behavior of government and society, ecosystem laws, cost containment, technologies, among others, create a group of complex and integrated elements to be evaluated by institutions (Hernández *et al.* , 2011).

Regarding active guardianship indicators, RL practices are interconnected with the percentage of returned or replaced inputs. In the customer section, reverse logistics is correlated with 'delivery quality' through the intervention of indicators interrelated with the entirety of the merchandise and packaging. In the cost theme, there are indicators of costs of returned, exchanged and damaged products (Chaves et al., 2008). Indicators of any specificity are essential for measuring the performance of the various RL systems, and their prioritization is presented as a consequence of specific goals (Hernández *et al.* , 2011).

Considering the factors demonstrated, through this investigation, performance indicators substantiated with LR and metrified according to Table 2 were investigated in the literary context. Each indicator has its composition formed by letters (example: a, ai , A) - with their specifications shown in Table 3 -, numbers and mathematical methods such as: multiplication, division, addition and summation.

Table 2

Performance Indicators found in the literature.

Indicator Application	Indicator Name	Composition of the Indicator*	Author
Return Indicators *versus* Sales			
After-Sales	% return *versus* total sales	a/ b . 100	Chaves *et al.* (2008); Silva *et al.* (2018a)
	% return on total sales per salesperson	a/ c . 100	
	% of turnover *versus* total sales	d/ b . 100	
	% of turnover versus total sales/seller	d/ c . 100	
	% of exchange versus total sales by product type	a/ and . 100	
Return Reason Indicators			
After-Sales	% reduction in product return costs	Not considered by the authors	
	% reduction in product switching costs		
After-Sales/Post-Consumption	Cost of material return *versus* logistics delivery cost		
Return Quantity Indicators			
Post-Consumption	% of quantity returned *versus* quantity sold	a/ b . 100	
After-Sales/Post-Consumption	% recycled materials, units	f/ g . 100	Chaves *et al.* (2011)
	% recycled materials, in $	v/ u . 100	
	% of returned materials recovered, in units	h/ g . 100	
	% of returned materials reused, in dollars	v/ g . 100	
Cost Indicators			
After-Sales/Post-Consumption	Value per fines	Σ j	Chaves *et al.* (2011); Sellitto and Mendes (2006)
	Cost of returning the main product, per unit	k/l	
	% share of returns (based on the cost of the main product)	[(k+ l)/ k] .100	
	Reversal logistics costs	(m+n+o+p) . and	Chaves *et al.* (2011); Lacerda (2003)
	Cost of preventing return	(o+p) . and	
	Internal cost of failure	[Σ(q)] . r	
	External costs of failure	Σ(s)	
	Return processing cost	(n+t)	Chaves *et al.* (2011); Lacerda (2003); Kruger *et al.* (2018)
	Cost incurred rectified in repairing faults	Not considered by the authors	Chaves *et al.* (2011)
	Distribution freight cost	(z/ai) . 100	IMAM (2003); Zago *et al.* (2008)
	Cost for maintaining stock	bi/ci	Chaves *et al.* (2011); Lacerda (2003); Kussano and Batalha (2012)
	Cost within the administrative reverse logistics	of	Chaves *et al.* (2011); Lacerda (2003)
	Order processing cost	hey/fi	Chaves *et al.* (2011); Lacerda (2003); Angelo (2005)
	Labor cost	gi	Chaves *et al.* (2011); Lacerda (2003)
	Cost of goods returned	hi . ji	Chaves *et al.* (2011); Lacerda (2003);

	Cost of spoiled products	hi . ji	Kussano and Batalha (2012)
	Cost of service failures in their provision	read /(mi . s)	Chaves *et al.* (2011); Lacerda (2003); Angelo (2005)
	Cost of logistics failures	no	Chaves *et al.* (2011); Lacerda (2003); Freires (2000)
	Cost of repairs and processes	Not considered by the authors	Chaves *et al.* (2011); Lacerda (2003).
	Cost targeting litigation		
	Cost of Inventory Obsolescence	(hi/b) . 100	IMAM (2003); Zago (2008)
	Customer Satisfaction Indicators		
	Complaints	(pi/fi) . 100	Zago *et al.* (2008) IMAM (2003).
	Rates of products with defects	qi/ri	Chaves *et al.* (2011)
	Speed assuming the return	yes - you	Chaves *et al.* (2011); Angelo (2005)
	Shipment quality	(vi/fi) . 100	
	Dock-to-stock time - Receiving material and making it available in stock	xi	
	Consumer satisfaction	Not considered by the authors	Chaves *et al.* (2011)
	Quality of service	(zi/A) . 100	Chaves *et al.* (2011); Angelo (2005)
	Legal compliance	Σ j	Chaves *et al.* (2011); Lacerda (2003)
	Compliance with legislation	-	Not found
	Waste generation rate	B/C	Chaves *et al.* (2011); Neto and Schalch (2010)
	Common economic and financial indicators		
	Shareholder value	D - E	Chaves *et al.* (2011); Malvessi (2000)
	Accessibility to capital	Not considered by the authors	Chaves *et al.* (2011)
	Customer attraction and retention		
	Brand value and reputation		
	Operation efficiency		
	License to operate		
	Innovation		
	Intellectual and human capital		
Post-Consumption	% of packaging returned	(g/b) . 100	Chaves *et al.* (2011); Pereira (2018)
	% of recycled inputs and/or recovered	(F/g) . 100	
After-Sales/Post-Consumption	Value recovered through re-processing and reselling products	Not considered by the authors	Chaves *et al.* (2011)
	Social indicators		
	Satisfaction level of agents belonging to the initiatives	G	Hernandez *et al.* (2011)
	Degree of influence of recycling projects - Universities	H	
	Degree of influence of recycling programs - Environmental	J	
	Number of innovations - Environment	K	

	Number of projects - Minimum material output	L	
	Number of programs that encourage recycling	M	
	Type of advertising	N	
	Number of social and educational projects	THE	
	Number of complaints	P	
	Number of employees benefited	Q	
	Number of people involved	R	
	Number of people employed	S	
	Relations with outsourced workers	T	
	Support for supplier development	U	
	Number of complaints resolved	V	
	Existence of policies for exchange	X	
	Number of actions or fines for violation of legislation	Z	
	Reduction - energy consumption	Not considered by the authors	Hassini *et al.* (2012)
	Reduction - emission of polluting gases		
	% of environmentally friendly materials used		
	Variation in cost of using/purchasing environmentally friendly materials		
	Reduction in waste treatment costs		
	Amount of waste discarded		

Source: Based on Rocha and Leite (2015).
*Check the significance of the component in Table 3 – Indicator Components.

Indicators specified in Table 3, which correspond to the components of the indicators presented in Table 2.

Table 3

Components of the Indicators.

Components of indicators	Description	Unit
A	Quantity of returned and exchanged products	Units per year
b	Quantity of products sold in general	
c	Number of sellers	Active employees
d	Quantity of products exchanged	Units per year
e	Total products sold by product type	
f	Amount of packaging and waste recycled	
g	Amount of material collected	
h	Number of sales returns, waste and disposal of reused used products	
j	Cost of fines received for non-compliance with rules and laws	Reais per year
k	Product return cost	
l	Amount of material collected by type of product	Units per year
m	Process cost	Reais per year
n	Logistics cost	
o	Cost of returning and reinserting the product into the market	
p	Depreciation	
q	Cost of disposal, rework, re-inspection, re- testing, overhaul , planned obsolescence	
r	Quantity of discarded, reworked and obsolete products	Units per year
s	Cost of processing customer complaints, costs of returned products from customers, costs of product *recalls*	Reais per year
t	Tax cost	
u	Amount of material collected	Dollars per year

v	Number of sales returns, waste and disposal of reused used products	
x	Amount of packaging and waste recycled	
z	Total cost of distribution trucks	Reais per year
ai	Net operating income	
bi	Opportunity rate - number of days in stock	Unit
ci	Value of goods in stock	Reals per unit
di	Total indirect labor cost	Reais per year
ei	Total warehouse cost	
fi	Total orders shipped	Units per year
gi	Total MOD (labor) cost	Reais per year
hi	Discarded products	Units per year
ji	Product value	Reals per unit
li	Unfulfilled requests	Units per year
mi	Total Orders	
ni	Cost of return to supplier + Cost of unloading + Cost of delays in product delivery	Reais per year
oi	Quantity of obsolete items	Units per year
pi	Complaints	
qi	Defective products	
ri	Total quantity produced	
s i	Product release date	Days
ti	Date of entry of the product back to the institution	
vi	Total orders shipped perfectly	Units per year
xi	Time from dock to warehouse or getting the item ready for sale	Days
zi	Perfect deliveries	Units per year
A	Deliveries made	
B	Residue mass	Kg/year
C	Total area of the town	m²
D	Company market value	Real
E	Value invested by the shareholder	
F	Recovered products	Units per year
G	Level of alacrity of agents regarding commitments made by the recycling script	Institution's own metric
H	Degree of fluency of recycling scripts among members regarding the applicability of the exercise acquired externally from universities	
J	Degree of fluency of recycling scripts among members regarding the change in idiosyncrasy with ecosystem issues.	
K	Number of innovations to protect the environment (intrinsic projects in LR)	
L	Number of routes aimed at minimizing material mobility	
M	Number of programs that support recycling	
N	Archetype of failed propaganda	
O	Number of social and educational projects of LR activities involving the community	
P	Number of protests related to the entity's impact on the community	
Q	Number of employees benefiting from training programs intrinsic to LR duties	
R	Number of people involved in corporate campaigns and projects	
S	Number of salaried individuals in the reverse channel	
T	Liaison with outsourced teams	
U	Support for the development of suppliers concerned with environmental issues	
V	Number of protests resolved through conciliation with the parties involved in the reverse chain	
X	Number of complaints about unfulfilled policies	

Z	Number of actions or fines for violation of legislation

3 METHODOLOGY

Research can be exemplified as: the formal and structured procedure of the scientific method, with the purpose of providing solutions to a problem by applying scientific methodologies (Gil, 1999).

Qualitative research focuses on literature reviews, detailing and specifying the research in its mechanisms (Laurindo & Silva, 2017). From this perspective, to obtain outcomes of the problem presented, the research adopted a qualitative theoretical-methodological approach with bibliographic purposes.

The study adopted a quantitative -qualitative approach, using a Survey. It is worth noting that the quantitative and qualitative data groups complement each other (Duarte *et al.* , 2009).

For the development of the research, the steps described in Table 4 were recommended.

Table 4

Stages of research development.

I	Survey of bibliographic data establishing the scope of meritorious factors for performance indicators.
II	Selection of bibliographic data and indicators with greatest relevance to the study.
III	Structuring the article and creating a table categorizing and correlating indicators - suggested by authors - and their respective metrics.
IV	Development of categories focused on the Brazilian context for classifying metric indicators.
V	Categorization of metric indicators and reorganization to compose a generic model proposal for national Reverse Logistics Systems.

The bibliographic reference was made through surveys, searched in books, as well as laws, *websites* and databases such as Scopus, Capes Periodicals and Science Direct. The search terms were: “Reverse Logistics”, however “Performance Indicators”, subsequently “Performance Evaluation”. Also, terms in English: “ *Reverse Logistic* ”, “ *Supply Chain* ”, “ *Indicators of Reverse Logistic* ”.

After the bibliographic survey, Table 2 was prepared using the article “Performance Indicators for Reverse Logistics: An Exploratory Study” by Rocha and Leite (2015) as a basis, so that the IDs could be metrified. The indicators for which no descriptions were found to metricize them indicated in the base article or in the articles referenced by the base article were searched in the mentioned databases; those that did not yield results were given the description

"Not equated by the authors".

Table 5 presents the bibliographic references that supported the metrication of the IDs found in the base article.

Table 5

Literary figures who supported the metrication of IDs.

Indicator Application	Author
After-Sales	Chaves *et al.* (2008); Silva *et al.* (2018).
Post-Consumption	Chaves *et al.* (2008); Silva *et al.* (2018); Pereira (2018).
After-Sales/Post-Consumption	Chaves *et al.* (2008); Silva *et al.* (2018); Chaves *et al.* (2011); Sellitto and Mendes (2006); Lacerda (2003); Kruger *et al.* (2018); Imam (2003); Zago *et al.* (2008); Kussano and Battle (2012); Angel (2005); Freires (2000); Neto and Schalch (2010); Malvessi (2000); Hernández *et al.* (2011); Hassini *et al.* (2012).

From the aspects found in the literature, their analysis and understanding of the organization of national SLRs and their needs, led to the development of topics of the LR IDs for the Brazilian context. These were used to validate the categories developed. To validate these categories, a questionnaire was carried out using Google Forms and sent by email to representatives of nine LR systems, found on the website of the National Information System on Solid Waste Management - Sinir. The results achieved were tabulated for assimilation and ease of analysis.

According to the categories examined and explained in Table 1, managers were asked about the use of these categories of indicators: **Indicators of return on sales amount** (allude to the relationship of total products sold before those returned/exchanged), **Indicators of reason for return** (deal with the costs of returning products and the reasons for returns), **Indicators of total returns** (alleges the amount returned, recycled materials, reused returned materials), **Indicators of costs** (refer to fines, general costs, return of goods, LR, prevention, maintenance, administrative costs, among others), **Indicators of customer satisfaction** (number of complaints, defective products, quality of service, time to receive material and availability in stock), **Traditional economic-financial indicators** (capital, shareholder value, operational efficiencies, innovation and licenses to operate, among others), and **Social indicators** (involve such as: society, reduction of energy consumption, reduction of pollution, workers involved).

Subsequently, the *feedbacks* and results through the interpretations of the reports were compiled. Considering the metric indicators, their particularities, the prospected categories and

the responses from the questionnaire sent to the SLR managers, the indicators with dominance and representativeness in the mechanisms were selected through justifications presented in the results and discussions of this article.

By reorganizing the indicators presented above, the perspective of a generic model was generated, considering the abundant segments and indicators, to support the Brazilian Reverse Logistics Systems researched. This generic model was derived from several studies carried out in journals and in the actual use by managers, forming a better scenario to evaluate the RLS involved. Finally, the analysis and discussion of the research results, final considerations and suggestions for future work were presented.

4 RESULTS AND DISCUSSIONS

The results were separated into sections: Compilation and analysis of *feedbacks* , (Section 4.1); Indicators with greater expressions in the SLR, (Section 4.2); Proposal of a model of SLR indicators for the Brazilian context, (Section 4.3). In order to meet the points delimited in the methodology of this research.

4.1 COMPILATION AND ANALYSIS OF *FEEDBACK*

As a result of the research, LR systems for polymeric packaging of lubricating oil and packaging in general responded to the inquiry through Google Forms.

The Lubricating Oil and Waste Tire LR systems reported that the official materials/reports should be consulted, therefore, the following materials were consulted respectively: 2018 Collection Report – base year 2017 (Conama, 2018) and 2018 Tire Report – base year 2017 (Ibama, 2018).

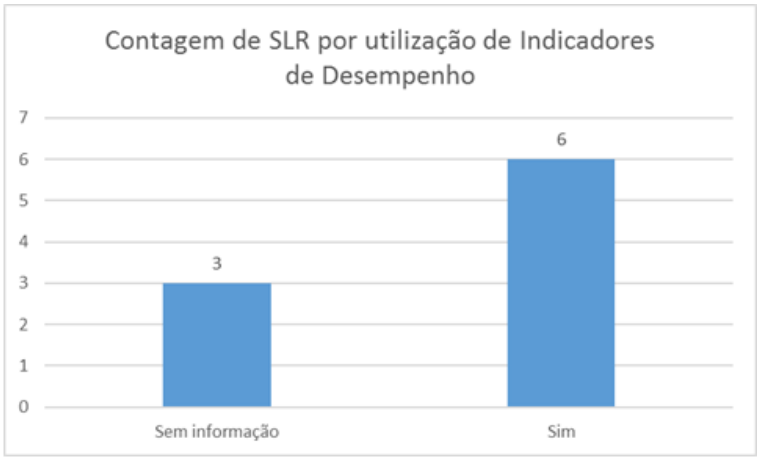
Regarding the SLR of Pesticide Packaging and Fluorescent Lamps, no response was obtained, however the following materials were found and used as a basis for this research, respectively: Sustainability Report 2018 (Inpev, 2018) and Annual Report of Activities and Results (Sinir, 2018).

Regarding the SLR of Medicines, Batteries and other Electronic Products and their components, no response was obtained and no reports or materials relating to the research were found.

The first analysis performed was whether LR systems apply indicators in their system. Thus, the results were demonstrated in Figure 1.

Figure 1

SLR count by using Performance Indicators.



Based on Figure 1, six of the nine systems use IDs, fed and fed back through mechanisms, data obtained by collectors, regulatory bodies, companies and associations linked to LR systems.

The second analysis is based on the use of categories of indicators developed by the systems in question. To this end, these aspects are explicitly set out in Table 6.

Table 6

Performance Indicators spent by SLR.

	Performance Indicators							
Reverse Logistics System	**Return on Sales IDs**	**Return Reason IDs**	**Return Quantity IDs**	**Cost IDs**	**Customer Satisfaction IDs**	**Traditional economic-financial IDs**	**Social IDs**	**Other IDs**
Packaging in general	No	No	Yes	Yes	No	No	Yes	No
Pesticide packaging	Yes	Y/N*	Yes	Yes	Y/N*	Yes	Yes	Y/N*
Plastic packaging for lubricating oils	Yes	No	No	Yes	No	No	Yes	No
Sodium-mercury vapor and mixed-light fluorescent lamps	Yes	Y/N*	Yes	Y/N*	Yes	No, just report on your activities.	Yes	Yes
Medicines	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*
Used or contaminated lubricating oil	Yes	No	Yes	Yes	Y/N*	Y/N*	Yes	Y/N*
Batteries and batteries	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*
Waste tires	Yes	Y/N*	Yes	Y/N*	Y/N*	Y/N*	Yes	Yes

Electronic products and their components	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*	Y/N*

S/I* – no information

Considering only the data from the SLRs that presented materials for the basis of this research, it is clear that 83.33% of those involved use indicators of return of inputs on sales, comparing what this system conceives as products sold to the market with the waste returned through the LR. In contrast, the predicate of reason for return is not used by any of the systems surveyed. Again, 83.33% of those surveyed present indicators of quantity of products/waste returned. All groups handle 100% of the cost indicators. For the customer satisfaction module, it is clear that 66.67% do not operate these indicators, but the LR system for Lamps stated in response to the questionnaire that they do not but have open communication channels with the public (examples such as website, e-mail, WhatsApp). Only 25% use economic-financial indicators in relation to innovations, as all claim to be non-profit organizations. Addressing the social implications, all benefit from them. Only the Lamp SLR denotes another type of performance indicator.

The aim of this research was to verify whether the SLRs examined four topics when returning materials, so the data are listed in Table 7.

Table 7

Verification of the four topics of interest of the present research.

Reverse Logistics System	Quantities of products produced	Lifetime estimates for each product model produced	Consumers' preferences for their destination and/or disposal	Quantities returned by the System *versus* Environmental Demands of the products subject to the Systems
Packaging in general	No	No	No	Yes
Pesticide packaging	Yes	No	No	Yes
Plastic packaging for lubricating oils	Yes	No	No	Yes
Sodium-mercury vapor and mixed-light fluorescent lamps	Yes	No	No	Yes
Medicines	Y/N*	Y/N*	Y/N*	Y/N*
Used or contaminated lubricating oil	Yes	No	No	Yes
Batteries and batteries	Y/N*	Y/N*	Y/N*	Y/N*
Waste tires	Yes	No	No	Yes
Electronic products and their components	Y/N*	Y/N*	Y/N*	Y/N*

S/I* – no information

As a result, it is noticeable that only two topics are appreciated in the plurality of mechanisms that composed the rudiments for the research, which would be the Quantity of products produced and the Quantities returned by the System versus environmental demands of the products that are the object of the System.

4.2 INDICATORS WITH THE HIGHEST EXPRESSIONS IN THE SLR

There are several reasons for giving performance indicators. In LR, government and society behavior, ecosystem laws, cost savings, technologies, among others, generate a group of complex and integrated elements to be evaluated by institutions (Hernández *et al.* , 2011). Based on the tables and other distinguishable inputs in this article and subsequent information presented in section 4.1, the IDs with the greatest expressions in the SLR are highlighted in Table 8.

Table 8

Performance Indicators with greater relevance.

Performance Indicators						
Reverse Logistics System	**Return on Sales IDs**	**Return Quantity IDs**	**Cost IDs**	**Social IDs**	**Other IDs**	**Source**
Packaging in general	Does not use	% of post-consumer packaging	No information on how the indicators are composed	Number of Operational Training actions	*Per capita* waste generation rate	Questionnaire applied via Google Forms and Final Phase 1 Report*
Pesticide packaging	% of packages disposed of correctly in relation to those sold	Tons of empty packaging per year % of received material returned as raw material	Maintenance; Accidents	Tons of CO_2 since activities began	Tons of post-consumer waste per year Health and safety rate being the number of injuries per man-hour worked (in the year)	Inpev (2018)
Plastic packaging for lubricating oils	Through OLAC sales data and the volume of packagin	Tons of packaging returned Control of volume	Cost control and division by *market share* for each associate Total administrative costs in reais	carbon footprint indicator	Tons of plastic with environmentally correct disposal Number of collection vehicles	Questionnaire applied via Google Forms and Report*

	g collected	received per year	Total reverse logistics costs in reais			
Sodium-mercury vapor and mixed-light fluorescent lamps	Quantity of products in units placed on the market per year	Total units per year Total kg per year % or amount of return for specific products per year	No information	% of contact with waste per employee	% of broken bulbs % of other waste present in returned materials	Sinir (2018)
Used or contaminated lubricating oil	Minimum % collection of the volume sold in Brazil	Volume of oil used in the sector per year	Total fines applied in reais Number of companies fined Number of traffic tickets issued	No information	Number of collection vehicles	Conama (2018)
Waste tires	Tons of tires manufactured	Quantity of tires returned per tonne per year Quantity of tires returned in units per year	No information	No information	Final destination by type of technology and quantity or % of unusable tires disposed of Number of collection vehicles Target destination	Ibama (2018)

*Final Phase 1 Report – available at: <https://coalizaoembalagens.com.br/fase-1.html>
*Report – available at: <https://sinir.gov.br/images/sinir/LOGISTICA_REVERSA/RELATORIOS_ANUAIS/EMBALAGENS_PLASTICAS/2017/relatorio_anual_desempenho_%202017.pdf>

From the analysis of Table 8, it is possible to observe within the categories of indicators a homogeneity of the concepts surrounding them, although the metrics and units are different. In the indicators of return on sales amount, except for packaging in general, the quantity of returned objects is assessed considering the products charged to the market, however, the units chosen for the analysis are different according to the characteristics of the system object. In other words, units for lubricating oils are displayed in volumes per year, while lamps display units per year.

The return quantity indicators, coupled to the systems, have as their main objective the monitoring of the quantity of inputs that each SLR collected and the material repeatedly returned to the cycle.

Cost indicators, at the same time, encompass the monitoring of administrative fragments, LR, maintenance and infractions employed, without the objective of measuring how

costly the collection and viability of the LR system are to maintain.

Social indicators address the reduction of polluting gases, product damage to employees and the development of human resources through training.

4.3 PROPOSAL OF A MODEL OF SLR INDICATORS FOR THE BRAZILIAN CONTEXT

Observing the similarity between the indicators presented in Table 8, it was suggested that the indicators exported from Table 1 that best fit the context should be used, as shown here in Table 9.

Table 9

Proposed Performance Indicators.

Indicators	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Return on sales indicators	% Return on Total Sales	-	-	-
Return quantity indicators	% of Quantity Returned *vs* Quantity Sold	% of recycled materials, in units	% of returned materials reused, in units	-
Cost indicators	Amount paid for fines	Reverse logistics costs	Administrative cost with reverse logistics	Cost of spoiled products
Social indicators	% of environmentally friendly materials used	Reduction of pollutant gas emissions	Support for supplier development	-

In the classification of the indicators of regression on sales, the adoption of Indicator 1 was due to the need presented for the metric of the quantity of material returned on total sales, since the systems aim to return inputs from manufacturing and subsequent post-consumption, few SLRs aggregate percentages of this availability of products for the market as a collection target, in this case adopted as a percentage , as found in the literature.

Regarding the quantitative return indicators, Indicator 1 was selected to control the quantity of products returned, taking into account the quantity sold. This indicator is relevantly displayed in the system reports, as can be seen in Table 9. Indicator 2, in its introduction, goes back to the idea of effectiveness of the LR set, as it is not enough to simply collect the material, but it must also be disposed of correctly or recycled. Indicator 3 is related to the SLR of Agrochemical Packaging, which presents the metric of the percentage of the material received that was returned to the cycle as raw material, thus translating into the selected indicator.

In the Cost Indicators classification, Indicator 1 was given due to its importance in demonstrating how the SLR is active and presents inspection activities. Indicators 2, 3 and 4 are shown as a basic source for the continuation of the systems, because if they present a continuous deficit for a long time, causing the possibility of breaking these LR systems, which those involved currently rely on government support and also on investments from companies that manufacture the products.

Entering the social indicators, Indicators 1 and 2 were chosen because the indicators currently adopted by SLR present the environmental appeal such as the carbon footprint of the atmosphere and how reverse logistics aims at the return of these materials to contribute to the environment. Therefore, Indicator 3 denotes value in the development of suppliers entering into training of human resources operationally, developing relationships with collectors.

Other indicator predicates were adopted due to the frequency of manipulation in the various LR mechanisms and the notoriety of complements to the indicators already found in the literature, thus they were reorganized in the categories of indicators developed and are shown in Table 10.

Table 10

Reorganization of Other Indicators found in the SLR.

Performance Indicators								
Reverse Logistics System	**Other indicators**	**Sales Return IDs**	**Return Reason IDs**	**Customer Satisfaction IDs**	**Return Quantity IDs**	**Traditional economic-financial IDs**	**Cost IDs**	**Social IDs**
Packaging in general	***Per capita* waste generation rate**	-	-	**x**	-	-	-	-
Pesticide packaging	**Tons of post-consumer waste per year**	**x**	-	-	-	-	-	-
	Health and safety rate being the number of injuries per man-hours worked (in the year)	-	-	-	-	-	-	**x**
Plastic packaging for lubricating oils.	**Tons of plastic with environmentally correct disposal**	-	-	-	**x**	-	-	-
	Number of collection vehicles	-	-	-	-	-	**x**	-
Sodium-mercury vapor and mixed-light fluorescent lamps	**% of broken bulbs**	-	-	-	-	-	**x**	-
	% of other waste present in returned materials	-	-	-	-	-	**x**	-

Used or contaminated lubricating oil.	**Number of collection vehicles**	Already classified						
Waste tires	**Final destination by type of technology and quantity or % of unusable tires disposed of**	**x**	-	-	-	-	-	-
	Number of collection vehicles	Already classified						
	Target destination	**x**	-	-	-	-	-	-

Analyzing the other categories of indicators not used by the SLR, as observed through results associated with the research and the importance of some of the indicators of these categories , indicators were proposed, extracted from Table 2, according to their categories, for the adoption of the systems, shown in Table 11.

Table 11

Proposal of indicators in which categories are not used.

Indicators	Indicator 1	Indicator 2
Return Reason Indicators	Cost of material return *versus* Logistics delivery cost	-
Customer satisfaction indicators	Quality of service	Waste generation rate
Traditional economic and financial indicators	Operational efficiency	Value recovered through reprocessing and resale of products

Indicator 1 of the reason for return category is suggested to assist in the control of products returned by cooperatives and system members, to verify whether the costs are equivalent, not only using units in reais, but also the depreciation or damage of the materials returned in comparison of costs in contrast to the logistics of delivering the objects to the systems.

The reason for choosing the Service Quality indicator was to measure the quantity of products that were lost or damaged when returning returned products, since the quality of the service provided directly affects the cost relationship of the systems, also as an indicator for improvement and mitigation of losses. The indicator regarding waste generation would be an opportunity for planning the SLR, such as annually, to build the perception of the equation of this waste generation and actions, investments and intentions to be taken for future years.

In the traditional economic-financial aspect, indicators of operational efficiency and the value recovered through reprocessing and resale of products were suggested, being justified respectively by the continuous improvement of the system, taking into account how the current

system is and the other due to the value returned for the system to be maintained, justifying the continuation of the system's activities, not only being an investment but also the return.

By combining all the proposed indicators and the indicators used in the systems, a generic model of indicators was achieved, as shown in Table 12.

Table 12

Proposal of a generic model of performance indicators for SLR.

Indicators	ID 1	ID 2	ID 3	ID 4	ID 5	ID 6	ID 7
Return on sales indicators	% return on total sales	Tons of post-consumer waste per year	Final destination by type of technology and quantity or % of materials destined	Target destination	-	-	-
Return Reason Indicators	Cost of material return *versus* logistics delivery cost	Tons of material with environmentally correct disposal	-	-	-	-	-
Return quantity indicators	% of quantity returned *versus* quantity sold	% of recycled materials, in units	% of returned materials reused, in units	-	-	-	-
Customer satisfaction indicators	Quality of service	Waste generation rate	-	-	-	-	-
Cost indicators	Amount paid for fines	Reverse logistics costs	Administrative cost of reverse logistics	Cost of spoiled products	Number of collection vehicles	% of damaged materials	% of other waste present in returned materials
Traditional economic and financial indicators	Operational efficiency	Value recovered through reprocessing and resale of products	-	-	-	-	-
Social indicators	% of environmentally friendly materials used	Reduction of pollutant gas emissions	Support for supplier development	Health and safety rate being the number of injuries per man-hours worked (in the year)	-	-	-

5 FINAL CONSIDERATIONS

With this research it is possible to see that Reverse Logistics Systems are fundamental for the implementation of new actions, control of current activities and also for the maintenance of the system in general. Each SLR includes a manager who directs the respective actions and guidelines within these systems, that is, each one adopts a posture and prospects it in their vision.

It is necessary to evolve the methodologies applied to SLRs, integrating them, especially in the tangible aspect of performance indicators, as it is a tool that, when applied correctly, reduces process costs and increases efficiency and effectiveness. For this to be possible, the first step must be to understand the specific needs of each SLR.

The objective was to prospect SLR performance indicators applied in Brazil and worldwide, as well as to propose a list of indicators for applicability by managers of nine SLRs – with national magnitude. Some questions were raised, such as whether all such indicators and performance objects are weighted by the managers of the systems studied; this was achieved through research in the literature, highlighting that this is still a relatively recent topic in Brazil. Therefore, complications arose in the accuracy and measurement of the indicators.

It was also possible to propose a generic model, through the questionnaire applied to the SLR managers and consulted materials available electronically; it is possible to be more concise in the generic question with the participation of the other systems that did not obtain feedback.

The research made it possible to perceive the lack of standardization of indicators, both in descriptions and in information collection units, presenting difficulties in the classification and consideration of indicators for the generic model, in many cases using the interpretation of the authors of this article.

The limitations can be seen in the difficulty of obtaining data and the response from SLR representatives, in the lack of application of several of the indicators found in the literature, as the implementation of some of the systems is still recent in the Brazilian context, implying the lack of organization of SLRs in collecting data on the processes to be measured.

As a suggestion for future work: validation of the generic model proposed in this article with managers of LR systems, adoption of other approaches to managers to improve the design of data collection related to systems and verification of newly developed indicators in the practical and literary context, as well as their metrics.

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REFERENCES

Abrelpe - Associação Brasileira das Empresas de Limpeza Pública e Resíduos Especiais. *Panorama dos resíduos sólidos do Brasil*. Abrelpe, São Paulo, 2017. Disponível em: https://www.abrema.org.br/panorama/. Acesso em: 15 fev. 2025.

Agrawal, S.; Singh, R. K.; Murtaza, Q. A literature review and perspectives in reverse logistics. *Resources, Conservation and Recycling*, (2015) 76–92.

Ângelo, L. B. *Indicadores de desempenho logístico*. Santa Catarina: UFSC, 2005.

Anip - Associação Nacional das Indústrias de Pneumáticos. *Produção na Indústria Brasileira e Reciclagem de Pneus*. Anip, São Paulo, 2019.

ANP - Agência Nacional do Petróleo, Gás Natural e Biocombustíveis. *Boletim de Lubrificantes*. ANP, 2017.

Anthony, R. N.; Govindarajan, V. *Sistemas de controle gerencial*. AMGH Editora, São Paulo: Atlas, 2002.

Brasil. Institui a Política Nacional de Resíduos Sólidos; altera a Lei nº 9.605, de 12 de fevereiro de 1998. (Lei nº 12.305, de 2 de agosto de 2010). Diário Oficial da República Federativa do Brasil, 2010.

Bueno, M. J. C.; Moreira, W. O. S.; Rodrigues, J. T.; Braga Filho, M. R. Aplicação da logística reversa no descarte de medicamentos vencidos: Estudos de caso em uma indústria farmacêutica. *South American Development Society Journal*, [S.l.], v. 2, n. 6, p. 66 - 82, mar. 2017. ISSN 2446-5763. Disponível em: http://www.sadsj.org/index.php/revista/article/view/51. Acesso em: 15 feb. 2025.

Carvalho, D. F.; Barata, A. J. S. S.; Alves, R. R. Logística reversa de lixo eletrônico nas organizações públicas. *Ciência e Natura*, Santa Maria, v. 38, n. 32, p.862-872, ago. 2016.

Ceni, L.; Müller, C. J.; Denicol, J.; Corrêa, R. G. F.; Cassel, R. A. Diagnóstico de um sistema de indicadores de desempenho na área logística de uma empresa de bens de consumo. *Produção em Foco*, v. 6, n. 2, 2016.

Cestari, W.; Martins, C. H. Logística reversa de lâmpadas fluorescentes pós-consumo Estudo de caso: Sistema de armazenagem em uma instituição de ensino. *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental*. Santa Maria, v. 19, n. 3, p. 124-135, set-dez. 2015. Disponível em: https://periodicos.ufsm.br/reget/article/view/17725. Acesso em 15 fev. 2025.

Chaves, G. L. D.; Alcântara, R. L. C.; Assumpçao, M. R. P. Medidas de desempenho na

logística reversa: o caso de uma empresa do setor de bebidas. *Relatórios de Pesquisa em Engenharia de Produção da UFF*, v. 8, n. 2, 2008. Disponível em: https://www.producao.uff.br/conteudo/rpep/volume82008/RelPesq_V8_2008_02.pdf. Acesso em: 15 fev. 2025.

Chaves, G. L. D.; Barbosa, J. R.; Alcântara, R. L. C. *Medidas de Desempenho para Avaliação da Logística reversa*. Anais do XXXI Encontro Nacional de Engenharia de Produção. Belo Horizonte/MG: ABEPRO, 2011.

Conama - Conselho Nacional do Meio Ambiente. *Coleta de óleo lubrificante usado ou contaminado* - 2018 (ano base 2017), 2018.

Conama - Conselho Nacional do Meio Ambiente. Resolução nº. 416 de 30 de setembro de 2009. *Dispõe sobre a prevenção à degradação ambiental causada por pneus inservíveis e dá outras providências*. Conama, 2009.

Costa, L.; Mendonça, F. M.; Souza, R. G. *O que é Logistica Reversa*. Logistica Reversa. Editora Atlas – São Paulo, 2014.

Demajorovic, J.; Massote, B. Acordo setorial de embalagem: Avaliação à luz da responsabilidade estendida do produtor. *Revista Administração de Empresas*, São Paulo, v. 57, n. 5, p. 470-482, set. 2017.

Duarte, E. N.; Ramalho, F. A.; Autran, M. M. M.; Paiva, E. B.; Araújo, M. B. S. Estratégias metodológicas adotadas nas pesquisas de iniciação científica premiadas na UFPB. Encontros Bibli: *revista eletrônica de biblioteconomia e ciência da informação*, v. 14, n. 27, p. 170-190, 2009.

Esteves, R. Indicadores de desempenho. In: Esteves, R. O papel da coopetição na relação entre a gestão da cadeia de suprimentos reversa e o desempenho. 2017. Dissertação (Mestrado em Administração de Empresas) - Universidade Presbiteriana Mackenzie, São Paulo. f.219.

Fernandes, S. M.; Rodriguez, C. M. T.; Bornia, A. C.; Trierweiller, A. C.; Silva, S. M.; Freire, P. S. *Revisão sistemática da literatura sobre as formas de mensuração do desempenho da logística reversa*. *Gestão & Produção*, v. 176, p. 190, 2018.

Ferreira, C. G. N.; Deloski, M. C.; Rodrigues, I. M. *Gerenciamento de embalagens de agrotóxicos pós-consumo nos campos gerais*. Anais da Jornada Científica dos Campos Gerais, v. 15, 2017. Disponível em: https://www.iessa.edu.br/revista/index.php/jornada/article/view/240. Acesso em: 15 fev. 2025.

Freires, F. G. M. *Proposta de um modelo de gestão dos custos da cadeia de suprimentos*. 2020. Dissertação (Mestrado em Engenharia de Produção) – Universidade Federal de Santa Catarina, UFSC, 2000.

Fonseca, F. E. A.; Rozenfeld, H. Medição de desempenho para a gestão do ciclo de vida de produtos: uma revisão sistemática da literatura. *Revista Produção Online*, v. 12, p. 159-184, 2012. Disponível em: https://producaoonline.org.br/rpo/article/view/853. Acesso em: 15 fev. 2025.

Gama, E. F.; Vasconcellos, J. M. S.; Machado, A. L. S. A logística reversa do lixo eletrônico: um estudo de caso no Instituto Federal do Amazonas – Campus Manaus Distrito Industrial. *Nexus-Revista de Extensão do IFAM*, v. 2, n. 2, 2016.

GIL, A. C. Método e técnicas de pesquisa social. 5. ed. São Paulo: Atlas. 1999.

Guarnieri, P. Logística Reversa: Desafios e Oportunidades no Brasil e no Mundo. *Revista em Gestão, Inovação e Sustentabilidade*, v. 2, n. 1, 30 jun. 2016.

Guarnieri, P.; Dutra, D.J.S.; Pagani, R.N.; Hatakeyama, K.; Pilatti, L.A. Obtendo competitividade através da logística reversa: um estudo de caso em uma madeireira. *Journal of Technology Management and Innovation*, v.1, n.4 p.121-130, 2006.

Harrington, J. *Aperfeiçoando processos empresariais*. São Paulo: Makron Books, 1993.

Hassini, E.; Surti, C.; Searcy, C. A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics*, v. 140, n. 1, p. 69-82, 2012.

Hernández, C. T.; Marins, F. A. S.; Salomon, V. A. P. *Análise da importância dos indicadores de desempenho da logística reversa mediante a utilização do Analytic Network Process*. 43rd Simpósio Brasileiro de Pesquisa Operacional. Ubatuba, Brasil, 2011.

Ibama - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. *Relatório de Pneumáticos*, 2018. Disponível em: http://www.ibama.gov.br/phocadownload/pneus/relatoriopneumaticos/ibama-relatorio-pneumaticos-2018_atualizado_em_novembro_2018.pdf . Acesso em: 15 fev. 2025.

Inpev - Instituto Nacional de Processamento de Embalagens Vazias. *Logística Reversa*. Inpev, 2019.

Inpev - Instituto Nacional de Processamento de Embalagens Vazias. *Relatório de Sustentabilidade*, 2018. Disponível em: https://www.inpev.org.br/noticias-publicacoes/relatorio-sustentabilidade/. Acesso em: 15 fev. 2025.

Imam - Instituto de Movimentação e Armazenagem de Materiais. Pesquisa sobre logística. Imam, 2003.

Kaplan, R. S.; Norton, D. P. *A estratégia em ação Balanced Scorecard*. Elsevier, 1 edição. Rio de Janeiro: Campus, 1997.

Kaplan, R. S.; Norton, D. P. The Balanced Scorecard: measures that drive performance. *Harvard Business Review*, Boston, vol.70, n. 1, p.71–79, 1992.

Kim, V. J. H.; Conte, G. G.; Ometto, A. R. *Similaridade entre os conceitos de economia circular e política nacional de resíduos sólidos (PNRS)*. Anais eletrônicos do 9° Fórum Internacional de Resíduos Sólidos, Porto Alegre, 2018.

Kruger, S. D.; Solivo, C.; Diel, F. J. *Análise da formação de custos logísticos entre rotas de transportes de uma Cooperativa do Oeste Catarinense*. Anais do Congresso Brasileiro de Custos-ABC. 2018. Disponível em: https://anaiscbc.emnuvens.com.br/anais/article/view/4424. Acesso em: 15 fev. 2025.

Kussano, M. R.; Batalha, M. O. Custos logísticos agroindustriais: avaliação do escoamento da soja em grão do Mato Grosso para o mercado externo. *Gestão & Produção*, v. 19, n. 3, p. 619-632, 2012.

Lacerda, L. *Logística reversa*: uma visão sobre os conceitos básicos e as práticas operacionais. Rio de Janeiro: COPPEAD/UFRJ, v. 6, 2003.

Lagarinhos, C. A. F.; Tenório, J. A. S. Logística reversa dos pneus usados no Brasil. *Polímeros*, v. 23, n. 1, p. 49-58, 2013.

Laurindo, A. P.; Silva, J. A. P. Introdução à pesquisa: Características e diferenças teórico-conceituais entre o estudo qualitativo e quantitativo. *Revista Uniabeu*, v. 10, n. 26, p. 45-55, 2017.

Machado, R. L.; Pasqualetto, A.; Morais, J.; Rocha, W. S. Resíduos de filtros lubrificantes e OLUC (Óleo lubrificante usado e contaminado) em automóveis da marca FIAT e a logística reversa. *Revista da Universidade Vale do Rio Verde*, v. 17, n. 1, 2019.

Malvessi, O. Criação ou destruição de valor ao acionista. *Revista Conjuntura Econômica*, v. 54, n. 1, p. 42-44, 2000.

Magarão, M.; Cuvillier, S. Avaliação de desempenho. *Logistica Reversa*. Editora Atlas – São Paulo, 2014.

Mendonça, J. C. A.; Vasconcelos, P. E. A.; Nobre, L. B. O.; Casarotto, E. L. Logística reversa no Brasil: Um estudo sobre o mecanismo ambiental, a responsabilidade social corporativa e as legislações pertinentes. *Revista Capital Científico – Eletrônica (RCCe)*, Guarapuava, v. 15, n.2, Abril/Junho 2017.

MMA - Ministério do Meio Ambiente. Cerca de oito milhões de pilhas e baterias já foram recolhidas no País. 2011b. Disponível em: https://antigo.mma.gov.br/informma/item/7237-cerca-de-oito-milhoes-de-pilhas-e-baterias-ja-foram-recolhidas-no-pais.html. Acesso em: 15 fev. 2025.

MMA - Ministério do Meio Ambiente. Logística reversa já recolhe 36% do óleo lubrificante usado no Brasil. 2011a. Disponível em: https://antigo.mma.gov.br/informma/item/6828-logistica-reversa-ja-recolhe-36-do-oleo-lubrificante-usado-no-brasil.html. Acesso em: 15 fev. 2025.

Moretti, S. L. A.; Lima, M. C.; Crnkovic, L. H.; Gestão de resíduos pós-consumo: avaliação do comportamento do consumidor e dos canais reversos do setor de telefonia móvel. *Revista de Gestão Social e Ambiental*, São Paulo, v. 5, n. 1, p.03-14, abr. 2011.

Nascimento, J. R. H.; Lima, R. A. O sistema de logística reversa como forma de desenvolvimento das empresas brasileiras: O caminho do capital natural. Veredas do Direito: *Direito Ambiental e Desenvolvimento Sustentável*, Belo Horizonte, v. 15, n. 32, p. 201-217, set. 2018.

Neely, A.; Gregory, M. Performance measurement system design. *International Journal of Operations & Producy Management*, v. 15, 1995.

Neto, A. O. C.; Neto, F. P. F.; Nunes, D. R. L.; Melo, A. C. S.; Martins, V.. Sistema de avaliação

de desempenho logístico: proposta para uma rede de suprimentos de uma Instituição Pública de Ensino Superior. *Revista GEPROS*, v. 12, n. 2, p. 177, 2017.

Neto, J. C.; Schalch, V. Gestão dos resíduos de construção e demolição: estudo da situação no município de São Carlos-SP, Brasil. *Revista Engenharia Civil*, v. 36, p. 41-50, 2010.

Novaes, A. C. *Logística e gerenciamento da cadeia de distribuição*: estratégia, operação e avaliação. Rio de Janeiro: Campus, 2003.

Oliveira, U. R.; Marins, F. A. S.; Muniz Júnior, J. Logística reversa e identificação de produtos: revisão teórica para indústria eletroeletrônica. *Revista Produção Online*, v. 16, n. 2, p. 633-677, 2016. Disponível em: https://producaoonline.org.br/rpo/article/view/2049/1403. Acesso em: 15 fev. 2025.

Pedram, A.; Yusoff, N. B.; Udoncy, O. E.; Mahat, A. B.; Pedram, P.; Babalola, A. Integrated forward and reverse supply chain: a tire case study. *Waste Management*, v. 60, p. 460-470, 2017.

Pereira, R. S. C. Indicadores para sistemas de logística reversa de REEE. In: Pereira, R. S. C. Logística reversa de resíduos de equipamentos elétricos e eletrônicos: proposta de indicadores de monitoramento para órgãos ambientais. Tese de Doutorado. Universidade de São Paulo, 2018.

PSP - Prefeitura da Cidade de São Paulo. *Plano de gestão integrada de resíduos sólidos da cidade de São Paulo*. PSP, São Paulo, 2014. Disponível em: https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/servicos/arquivos/PGIRS-2014.pdf. Acesso em: 15 fev. 2025.

Quintana, J.F.; Benetti, L.B. Gestão de resíduos eletrônicos: estudo de caso em uma organização militar de São Gabriel/RS. *Ciência e Natura*, Santa Maria, v. 38, n. 02, p.889-905, mai/ago. 2016.

Rocha, M. F. A. L.; Leite, P. R. *Indicadores de desempenho para Logística Reversa*: Um estudo exploratório. XVIII SEMEAD - Seminários em Administração, ISSN 2177-3866, 2015.

Santos, M. H. S.; Marchesini, M. M. P. Logística reversa para a destinação ambientalmente sustentável dos resíduos de construção e demolição (RCD). *Revista Metropolitana de Sustentabilidade* (ISSN 2318-3233), [S.l.], v. 8, n. 2, p. 67-85, maio 2018.

Sellitto, M. A.; Mendes, L. W. Avaliação comparativa do desempenho de três cadeias de suprimentos em manufatura. *Production*, v. 16, n. 3, p. 552-568, 2006.

Shaik, M.; Abdul-Kader, W. A *Comprehensive Performance Measurement Framework for Reverse Logistics Enterprise*. Institute of Industrial and Systems Enfinners (IISE). Proceedings of IIE Annual Conference, 2011.

Silva, A.; Leite, P. Empresas brasileiras adotam políticas de logística reversa relacionadas com o motivo de retorno e os direcionadores estratégicos?. *Revista de Gestão Social e Ambiental*, São Paulo, v. 6, n. 2, p. 79-92, maio/ago, 2012.

Silva, A. B. N.; Souza, I. N. T.; Farage, F. C.; Silva, M. G.; Silva, A. L. P. *Análise qualitativa da conscientização ambiental sobre coleta e disposição final de medicamentos inservíveis*

em Belém do Pará. Fórum Internacional de Resíduos Sólidos-Anais, 2017.

Silva, A. L. E.; Moraes, J. A. R.; Machado, E. L. Proposta de produção mais limpa voltada às práticas de ecodesign e logística reversa. *Eng Sanit Ambient*, v. 20, n. 1, p.29-37, jan/mar. 2015.

Silva, F. A.; Silva H. A.; Novôa, N. F.; Siqueira, J. C. C. A importância dos indicadores de desempenho logístico no alcance das metas organizacionais. *REMAP – Revista Multidisciplinar do Amapá*, v. 1, n. 1, p. 09-27, 2018a.

Silva, K. F.; Correio, J. G. P.; Correio, A. L. S. D.; Martins, R. Análise dos termos de compromisso firmados pelos fabricantes, importadores, distribuidores e comerciantes de embalagens plásticas usadas de óleos lubrificantes. *Perspectivas em Políticas Públicas*, v. 11, n. 22, p. 147-187, 2018b.

Silva, N. D. B.; Guarnieri, P.; Junqueira, A. M. R. Logística reversa das embalagens de agrotóxicos: um olhar sobre a evolução da legislação até a lei 12.305/2010. *Agropampa: Revista de Gestão do Agronegócio*, v. 2, n. 1, 2017.

Sinir - Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos. *Acordo setorial de embalagens em geral*. Sinir, 2015.

Sinir - Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos. *Acordo Setorial de Lâmpadas Fluorescentes de Vapor de Sódio e Mercúrio e de Luz Mista*. SINIR, 2016.

Sinir - Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos - SINIR. *Relatório Anual de Atividades e Resultados*, 2018.

Soares, P. B. P.; Silva, C. L.; Garcia, G. P. P. A logística reversa de medicamentos vencidos nas farmácias da região do centro de Belo Horizonte. *Sustentare*, v. 2, n. 2, p. 145-162, 2018.

Souza, V. L. *Gestão do desempenho*: julgamento ou diálogo. Editora FGV, Rio de Janeiro, 2002.

Xavier, L. H.; Corrêa, H. L. *Sistemas de logística reversa*. Editora Atlas S/A, 2013.

Zago, C. A.; Abreu, L. F.; Grzebieluckas, C.; Bornia, A. C. Modelo de avaliação de desempenho logístico com base no Balanced Scorecard (BSC): proposta para uma pequena empresa. *Revista da Micro e Pequena Empresa*, v. 2, n. 2, p. 19, 2008.