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GREY DEMATEL TECHNIQUE FOR EVALUATING PRODUCT RETURN DRIVERS: A MULTIPLE STAKEHOLDERS' PERSPECTIVE

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Abstract

In order to reduce environmental impacts from final disposal, an interest in reverse logistics has caught the attention of both firms and academicians. However, motivational factors or drivers have to be considered to efficiently perform reverse logistics, as well as the different perspectives from stakeholders. Thus, the purpose of this study is to evaluate the interrelationship among reverse logistics drivers under the perspectives of the key stakeholders. A grey-based DEMATEL (Decision Making Trial and Evaluation Laboratory) was applied to obtain a multiple company-customer-society-government combination perspective. Experts were consulted to extract the pair-wise comparison of drivers. The most prominent drivers are from inside the organization, namely: 'Eco-design', 'Long-term sustainability', 'Economic viability', and 'Reduction on material consumption and disposal cost.' The main contribution to the field is the uncovering of net effect and the prominence level of each RL driver from each stakeholder perspective separately, and from the overall perspective (aggregated form). The uniqueness and innovation of this research relies on the fact that, as far as the authors know, no study has yet addressed RL drivers under a multidimensional view of the stakeholders, that is: company, customer, society, and Government.

Keywords: DEMATEL, driver, grey theory, reverse logistics, stakeholder

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1. Introduction

Considering the growing awareness of environmental issues, firms are compelled to consider green activities to reinforce their ecological or green image (Avsec and Kaučič, 2018), coupled with the purpose of protecting the natural environment (Al-Ghwayeen and Abdallah, 2018; Anvar et al., 2018; Dias and Braga Junior, 2016; Entezaminia et al., 2017). Reverse logistics (RL) is a means of reducing this harm for the natural environment by closing the cycle in supply chains (Couto et al., 2017; Hammes et al., 2020), thus cooperating for more sustainable waste management systems. Reverse Logistics is the "process of moving goods from their typical final destination for the purpose of capturing value or proper disposal" (Bing et al., 2014; Rogers and Tibben-Lembke, 1999).

Recently, the field of RL has experienced notable growth both from a practitioner and research angle (González-Torre et al., 2010). Several motivational factors (i.e. drivers) have been suggested to comprehend why firms participate in green initiatives (El Baz et al., 2018), such as Reverse Logistics. These pressures arise from employees, from government, clients, community, the firm's strategy to diminish cost or assure the intellectual property and even from the media. It is still uncertain how external and internal factors interactively support green initiatives, and how diverse are the multiple

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viewpoints concerning these drivers from the several stakeholders included in the execution process (Sarkis et al, 2011). The presence of these drivers and the linkage between them indicate the inclination of a firm to adopt RL. In addition, Crane and Ruebottom (2011) state that companies might get advantages from stakeholder management, through cooperative relationships, reputation, risk reduction, and other material gains. Moreover, the failure to attain the interests of several stakeholders may damage company performance (Avkiran and Morita, 2010; Bouzon et al., 2016).

In developed countries, goods are progressively being recycled and/or reused. Nevertheless, in emerging nations, the most usual practice is sending used products to landfills, causing intense harm to the natural environment and, thus, costs to society (Hsu et al., 2013). Among the most relevant emerging nations, Brazil is the leading economy in Latin America and the world's fifth largest nation, both by population and by geographical area. Given the difficulty of motivational factors under diverse perspectives from the various stakeholders embedded in the Reverse Logistics processes, this manuscript aims to tackle the following research problematic: *What are the major Reverse Logistics influential factors, and what is the connection among them under the viewpoints of the most relevant Reverse Logistics stakeholders in the Brazilian panorama?*

As a result, the main purpose of this work is to appraise the interrelationship among Reverse Logistics drivers using the perceptions of the key Reverse Logistics stakeholders in Southern Brazil. For this matter, RL drivers were evaluated by a Multi-Criteria Decision Making (MCDM) tool entitled Decision Making Trial and Evaluation Laboratory (DEMATEL) associated with grey system theory. Regarding RL and stakeholder problems, few previous papers have been published that combine these areas. Abraham (2011), Abdullah et al. (2012) and Alvarez-Gil et al. (2007) recognize the relevance of analysing the connection between stakeholders' pressures and Reverse Logistics implementation.

Nevertheless, to the best of the authors knowledge, no study has observed the manifold perspectives of stakeholders to investigate drivers for Reverse Logistics implementation in this international panorama. Additionally, no previous paper has dealt thoroughly with Reverse Logistics drivers in Brazil. Therefore, research in Brazil on aspects promoting Reverse Logistics employment as well as on the stakeholders' power becomes crucial.

2. Theoretical background

Globally, increasing population, advanced industrialization and developing economies contribute to the rapid increase in waste (Coutinho et al., 2020; Kumar and Dixit, 2018a). In this sense, Reverse logistics (RL) has attracted growing attention over the past two decades (Li et al., 2016), as it is considered a sophisticated research domain in the supply chain management (Acar et al., 2015). A worldwide tendency is leading the international community to investigate the possible ways for the conversion from a linear to a circular model in supply chains (Gnon et al., 2017).

Traditional logistics handles the supply of products from the producer to the end consumer, while RL relates to goods returned by the customer to the focal organization (Ashby, 2018). For instance, effective Reverse Logistics concentrate on the backward flow of resources from customer to supplier (or another disposition) with the objectives either of exploiting value from the returned good or reducing the total Reverse Logistics cost (Bouzon et al., 2016). In a comprehensive sense, Reverse Logistics is the shared responsibility of manufacturers and consumers to diminish waste generation by reuse, recycle, remanufacturing, and harmless disposal of unwanted products (Kim and Lee, 2018) with the purpose of enhancing the absorptive and reformative capacity of the earth, contributing to circular economy subjects. In this sense, resource depletion, environmental issues, growing costs of landfills, and the considerable return rules of retailers have headed to the increasing importance given to Reverse Logistics by academicians, industrials, and their stakeholders across the world.

2.1. RL most relevant stakeholders and RL drivers

There are several definitions of stakeholders, but all of them have their origins in the characterization of Freeman (1984): *"any group or individual who can affect or is affected by the achievement of the organization's objectives." Groups, organizations, neighborhoods, societies, and also the natural environment are usually thought as stakeholders"* (Mitchell et al., 1997).

Stakeholder pressure is understood as a relevant motivational factor for green initiatives (Chu et al., 2018; López-Toro et al., 2016). The necessities of various stakeholders including suppliers, customers, NGOs, governmental agencies, and shareholders can be considered as indicators of Reverse Logistics implementation. However, Avkiran and Morita (2010) posit that diverse stakeholders may show different perceptions on the desirability of features. The goals of these several groups are not inevitably the same, many times they can be fairly dissimilar (Wassenhove and Besiou, 2013). In this sense, this work considers RL drivers from the perspective of the organization, and also from the perspectives of the society, government, and customers for RL implementation.

In previous works, numerous drivers have been suggested to understand the motivational elements that lead companies to engage in Reverse Logistics activities, as presented in Table 1. Drivers were classified by internal and external, and related to the stakeholders: customer, society, organization and/or government.

Table 1. RL drivers and stakeholders

Driver	***Internal/ External***	***Stakeholder involved***
D1.Presence of regulatory pressure for product return/recovery.	External	Government
D2.Firms must have a RL plan to obtain the license to operate.	External	Government
D3.Presence of motivation laws for RL.	External	Government
D4.Qualification and support of business partners for implementing RL.	External	Customers
D5.Integration and cooperation with SC partners for RL.	External	Customers
D6.RL may increase customer satisfaction.	External	Customer
D7.Consumers valorize green products (green consumerism).	External	Customer
D8.Companies perform RL for green marketing.	External	Society
D9.RL helps firms to assure the supply of scarce raw materials in the future (long-term sustainability in the market).	Internal	Organization
D10.Design for Environment (DfE) practices facilitate end of life (EOL) activities such as RL.	Internal	Organization
D11.RL may diminish raw material consumption and costs regarding waste disposal.	Internal	Organization
D12.RL boosts value recovery from used products.	Internal	Organization
D13.The economic viability of product take-back and recuperation impels RL implementation.	Internal	Organization
D14.Greater concern by the population about the environment (higher public awareness) boosts RL operations.	External	Society, Customer
D15.Corporate citizenship pressure helps to implement RL	External	Society
D16.Shortage of landfills and the increasing cost of disposal propel RL activities.	External	Society
D17.Concern on environmental conservation drives RL operations.	External	Society

Sources: (Abdullah et al., 2012; Aitken and Harrison, 2013; Alvarez-Gil et al., 2007; Chan et al., 2012; Chiou et al., 2012; Hsu et al., 2013; Jayaraman and Luo, 2007; Jindal and Sangwan, 2013; Kannan et al., 2014; Kapetanopoulou and Tagaras, 2011; Mangla et al., 2016; Scur and Barbosa, 2017; Shaik and Abdul-Kader, 2013; Subramoniam et al., 2009; Van der Wiel et al., 2012)

2.2. MCDM tools and DEMATEL

Multiple Criteria Decision Making (MCDM) has been a rapidly growing field of management, engineering and other areas (Roy, 2013). MCDM is a category of decision-making method based on the idea of supporting a decision-maker during the decision process by means of explicit formalized models (Ashby, 2018; Coelho et al., 2017).

In this research, a grey-based DEMATEL method is applied to analyse RL drivers found in literature and supporting field study data. The subjective and intangible characteristics of the influential factors identified in previous studies and in the present work make them difficult to measure. In addition, it is not clear how these elements are linked to each other. With the view to advance the quality of decision-making and thus to facilitate the process of converting strategic objectives into effective actions, causal knowledge using causal analysis can be useful (Bai and Sarkis, 2013). In other words, causal analysis can significantly influence the efficiency of decision-making. However, causal analysis typically requires causal mapping, cognitive mapping, and structural modeling (Bai and Sarkis, 2013). These requirements are met by using the DEMATEL methodology.

Causal mapping is the process of creating a type of concept map with links between nodes representing causality or influence. The use of conceptual mapping can range from manual approaches using simple affinity – for example, grouping similar items and connecting them by string – to a more complex matrix oriented technique (Bai and Sarkis, 2013) such as fuzzy cognitive mapping (FCM) (Kosko, 1986), interpretive structural modelling (ISM) (Ravi and Shankar, 2005; Kannan et al., 2014), or causal maps (Nadkarni and Shenoy, 2004).

Each conceptual mapping approach has its advantages and disadvantages, but the DEMATEL method is relatively versatile. The advantage of DEMATEL over ISM is that it allows for a broader discrimination of measures. Specifically, whereas ISM uses 0-1 levels, DEMATEL allows for variations in strength of relationships among factors. DEMATEL is considered relatively versatile not only for this reason, but also because it allows two-way relationships, unlike ISM, FCM, and basic casual maps (Bai and Sarkis, 2013). When compared to the Analytical Hierarchy Process (AHP) approach, the advantage relies on the fact of possible multiple directional relationships, while AHP has a unidirectional relationship and multiple separate matrices requiring integration (Zhu et al., 2011). In all, the application of the DEMATEL approach is preferred for the following three reasons (Shaik and Abdul-Kader, 2014): (i) it provides mutual and effective relations of factors by using graph theory: it scores the rate of each relation by a number; (ii) it uses a feedback of relations where each factor can affect other factors at all levels (same, upper, and lower); and (iii) the importance of each factor is determined by all available factors in the system.

2.3. Reverse logistics and the use of MCDM tools

MCDM tools have become increasingly popular in RL related topics because of the multiplicity of dimensions of the strategic goal and the complexity of green policies (Bouzon et al., 2016). Some previous works have been developed associating RL influential factors and MCDM tools. These prior studies have used various methods to demonstrate the interrelationships between RL drivers.

Akdoğan and Coşkun (2012) study the RL drivers from the producers' point of view using analytical hierarchy process (AHP). Mangla et al. (2012) develop a multi-objective decision model using Interpretive Structural Modelling (ISM) to improve and to begin flexible product recovery activities in a company in India. Jindal and Sangwan (2013) create a hierarchical relationship model among RL drivers by also applying ISM tool. Kannan et al. (2014) come up with a framework to analyse the drivers of RL tire management. They validate this framework in India using ISM approach. Shaik and Abdul-Kader (2014) used DEMATEL method aiming at enhancing RL performance by grouping influential elements into clusters to enhance them in a stepwise way. Mangla et al. (2016) used AHP and DEMATEL tools to evaluate the critical success factors related to the implementation of RL in manufacturing industries in India. Luthra et al. (2017) applied AHP method to identify and prioritize the critical factors (CFs) in implementing the RL practices in an auto component manufacturer in India. Differently from prior literature, the present study applies an enhanced method named grey-based DEMATEL to investigate the causal relationship for RL drivers under multiple stakeholders' perspectives in Brazil.

3. Material and methods

Figure 1 depicts the proposed research design for detecting and examining the causal drivers for Reverse Logistics implementation. The research design begins with the theoretical background development, presented in the previous portion of this article. After this, field procedures take place. A research procedure was created as well as a inquiry form with pair-wise comparison of motivational factors. This questionnaire is responded by experts from society, organization, customer, and government. The initial direct relationship matrices are acquired from their replies. Then, grey-DEMATEL steps occur to evaluate the causal drivers to Reverse Logistics implementation in Brazil. Finally, results are compared to previous works and validated by academicians and stakeholders. Field techniques are presented in the next sub-section.

3.1. Field procedures

Four respondents were chosen, one from each perspective. Respondent 1 represents the organizational perspective. He is an environmental analyst from a large machinery-manufacturing firm in Southern Brazil with 12 years of experience. Respondent 2 represents the customer point of view as takes part from an electrical electronic equipment-manufacturing firm that buys parts from the previous company (organizational perspective). The third respondent is an environmental technician from an environmental NGO.

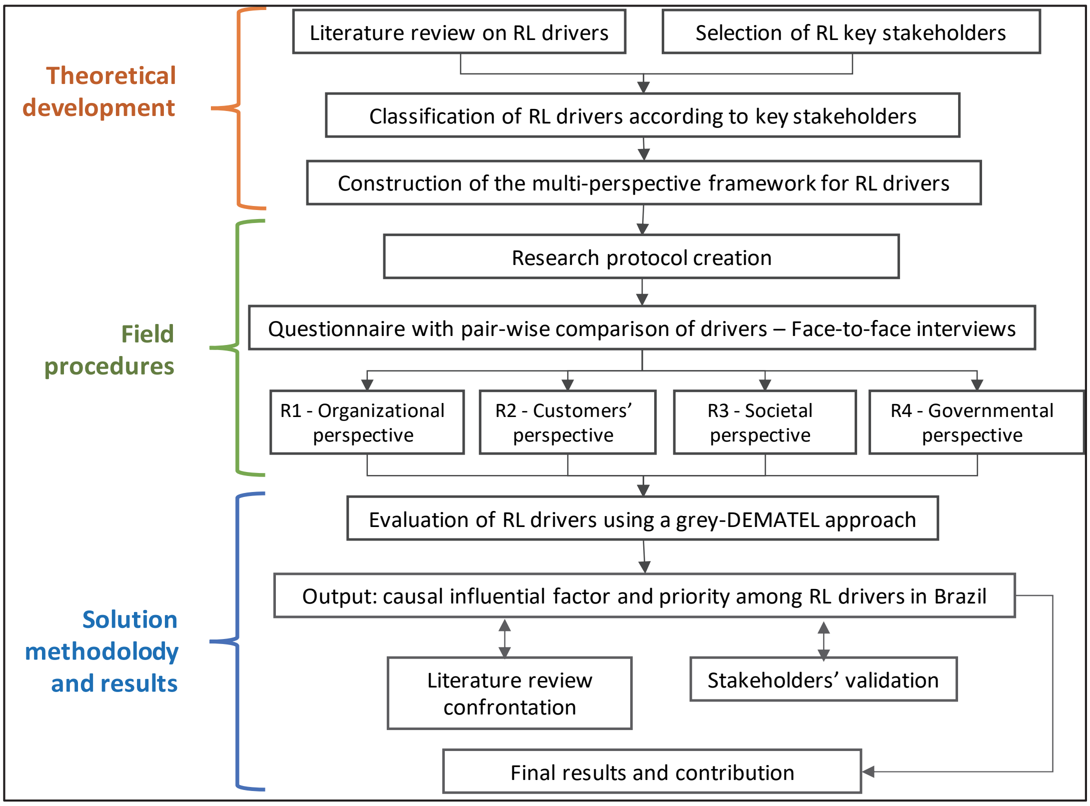

Fig. 1. Research design

At last, respondent 4 is from a governmental entity named Sustainable economic development agency of Santa Catarina state, Brazil. He is an environmental engineer working in this entity for 23 years. These four experts allowed us to obtain a more comprehensive internal and external picture of drivers for RL implementation. Using the information from the literature review on RL drivers, a research protocol was built with five main sections: (1) overview of the study proposal; (2) clarification of relevant terms for the respondents, such as 'driver' and 'reverse logistics;' (3) general questions regarding the respondent profile and RL practices; (4) the core data acquisition part for the methodology consisting of a matrix that required completion for further grey-DEMATEL analysis; (5) additional information concerning confidentiality issues.

Respondents from the organizational and customers' viewpoints were designated based on criteria for refining the quality and consistency of data, as follows: (i) the company should be located in Brazil; (ii), large manufacturing firms should be designated due to representativeness and resources available issues; (iii) the firms should have a Reverse Logistics program fully or partially implemented; and (iv) the firms' representatives should approve to participate in the research and reply to the questionnaire during an interview.

Regarding the societal representative respondent, an environmental NGO with regional operations was contacted. For the governmental perspective, a respondent from the sustainable economic development agency of Santa Catarina State in Brazil was designated by this agency to answer the questions since he has been working with the implementation of solid waste policies in the state. These four experts allowed this research to acquire a more complete and comprehensive internal and external picture of the drivers for RL implementation.

Respondents were first contacted by phone, when the on-site meetings were schedule. The objective of the meetings was to present the research protocol and fulfil the pair-wise comparison matrices. Thus, the interviewer annotated the answers while the interviewee was able to be completely concentrated on the list of drivers to answer the posed questions. This fact simplified the data collection process and might have improved the reliability of results. The pair-wise comparison matrices are required for using the grey-DEMATEL approach to accomplish the comparative analysis. Each step of this solution methodology is described in the sequence.

3.2. Solution methodology and initial results

DEMATEL was created in the 1970s (Karadağ and Delice, 2018; Zhu et al., 2011) and consists of a Multi-Criteria Decision Making (MCDM) approach (Banasik et al., 2016). This technique is suitable for examining structural models with causal linkage between multifaceted elements with matrices (Karadağ and Delice, 2018; Wu and Lee, 2007), and seems to be appropriate for enabling clear hierarchical and relationship structure strategically (Kumar and Dixit, 2018b). Respondents have to complete the questionnaire matrix by completing paired comparisons for all motivational factors from the multiple perspective framework. Using this approach, the factors can be categorized into two clusters: the cause group and the effect group.

The DEMATEL approach is preferred for this work when compared to other MCDM approaches because it provides mutual and effective relations of factors by using graph theory, scoring the rate of each relation by a number. It also uses a feedback of relations where each factor can affect other factors at all levels. In addition, DEMATEL determines the importance of each factor based on all available factors in the system. However, DEMATEL has its limitations. This method is incapable to deal with uncertain situations. It cannot express ambiguous values around a given discrete value (Bai and Sarkis, 2013). To overcome this fragility, a grey-based methodology is associated with DEMATEL. Grey system theory is an extension of fuzzy set theory or rough set theory (Yamaguchi et al., 2007). The grey number is a numeral with an indefinite position inside a clear boundary with upper and lower limits, assuming there is uncertainty surrounding this number. The general notation for grey numbers is shown in Eq. (1):

$$\otimes x = \left[\underline{\otimes x}; \overline{\otimes x}\right] = \left[x' \in x, \underline{\otimes x} \le x' \overline{\otimes x}\right] \quad (1)$$

where $\underline{\otimes}$ x and $\overline{\otimes}$ x are the lower and upper bounds of ⊗x, respectively.

For this work, let us describe $\otimes\, x_{ij}^k$ as the grey number for an expert k who assesses the influence of factor *i* on factor *j*. Moreover, $\underline{\otimes}\, x_{ij}^k$ and $\overline{\otimes}\, x_{ij}^k$ are respectively the lower and upper grey numbers by the evaluator k for the association between drivers *i* and *j*. That is: $\otimes x_{ij}^k = [\underline{\otimes} x_{ij}^k, \overline{\otimes} x_{ij}^k]$. The grey numbers may be transformed into crisp numbers by the use of the modified-CFCS method, in a three-step procedure. For details, please refer to the paper of Zhu et al. (2011).

The grey-based DEMATEL approach used in this paper comprises the following steps, adopted from Zhu et al. (2011) and Xia et al. (2014).

Step 1: Generate a crisp direct-relation matrix, divided into 3 steps (for the four stakeholders):

Step 1a: Define scale for comparison for the factors/variables representing grey pair-wise impact. A 5-level scale was chosen for this study. Table 2 presents the grey scales for the linguistic values.

Step 1b: Elaborate the grey direct-relation matrix X from evaluators' answers. A set of decision makers *k* from the key stakeholders should develop sets of pair-wise comparisons in linguistic values/terms for the selected RL factors, aiming at measuring the relationship between the factors. The principal diagonal elements are equaled to zero (crisp value 0 - no influence). An example of a specific pair-wise influence question is "How much influence does 'License to operate' (D2) have on 'Motivation laws' (D3)?". The direct-relation matrix for RL drivers for the four respondents are shown in Tables 3 to 6.

Table 2. The grey linguistic scale

Linguistic terms	***Grey numbers***	***Normal values***
No influence (N)	[0, 0]	0
Very low influence (VL)	[0, 0.25]	1
Low influence (L)	[0.25, 0.5]	2
High influence (H)	[0.5, 0.75]	3
Very high influence (VH)	[0.75, 1]	4

Step 1c: Grey direct-relation matrices X^k are converted into the crisp matrices Z^k using the modified-CFCS process (refer to Zhu et al. (2011)). This process has to be completed for each of the experts' direct-relation matrices.

Step 2: The normalized direct-relation matrices N^k are obtained using Eqs. (2-3), based on the crisp direct-relation matrices Z^k.

$$s = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} z_{ij}}, i, j = 1, 2, ...n. \quad (2)$$

$$N = s \cdot Z \quad (3)$$

Step 3: A total relation matrix T has to be generated. Using the identity matrix I, the normalized matrices are created (Eq. 4).

$$T = N\left(N - 1\right)^{-1} \quad (4)$$

The RL drivers total relation matrices are presented in Tables 7 to 14.

Table 3. Organizational perspective - respondent k=1 - Direct-relation matrix

Drivers	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***	***D7***	***D8***	***D9***	***D10***	***D11***	***D12***	***D13***	***D14***	***D15***	***D16***	***D17***
D1	0	4	4	0	1	0	0	0	1	0	0	0	0	1	0	1	2
D2	4	0	4	4	3	0	0	0	1	0	1	0	0	1	2	3	3
D3	4	4	0	3	4	1	0	0	2	0	2	4	4	2	3	4	3
D4	0	0	0	0	4	4	3	3	3	4	4	3	3	1	0	2	4
D5	2	2	2	3	0	3	3	3	4	2	3	4	3	3	3	3	4
D6	0	0	0	3	4	0	4	4	4	4	3	3	3	3	4	3	3
D7	1	0	1	3	4	4	0	4	3	4	3	3	3	4	4	2	4
D8	0	0	0	3	3	4	4	0	3	4	2	2	2	4	4	2	4
D9	2	2	2	3	3	3	3	3	0	3	4	4	4	2	3	4	4
D10	0	0	0	4	4	4	4	4	3	0	4	3	3	3	3	3	4
D11	0	0	0	4	4	4	4	4	4	4	0	4	4	2	2	4	4
D12	0	0	3	4	3	4	1	1	4	3	4	0	4	2	1	3	1
D13	0	0	4	4	4	4	4	4	4	4	3	4	0	2	0	1	0
D14	0	0	0	0	1	4	4	4	2	3	0	1	1	0	4	0	4
D15	3	0	3	1	1	3	3	3	2	4	0	0	1	3	0	0	4
D16	3	4	3	1	2	1	3	3	3	3	4	2	3	1	3	0	4
D17	4	4	4	3	3	3	4	3	2	4	3	2	2	4	3	4	0

Note: 0 – no influence; 1 – very low influence; 2 – low influence; 3 – high influence; 4 – very high influence

Table 4. Customer perspective - respondent k=2 - Direct-relation matrix

Drivers	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***	***D7***	***D8***	***D9***	***D10***	***D11***	***D12***	***D13***	***D14***	***D15***	***D16***	***D17***
D1	0	4	3	3	3	4	4	3	4	4	4	4	4	2	3	0	0
D2	0	0	0	1	1	1	3	3	3	2	2	2	2	2	2	0	0
D3	4	3	0	3	3	2	2	2	3	2	2	0	3	0	0	0	0
D4	0	0	0	0	2	3	1	1	2	3	3	4	4	1	1	0	0
D5	0	0	0	3	0	2	1	1	3	3	3	4	4	1	1	0	0
D6	1	0	1	1	1	0	0	0	2	2	2	0	0	1	1	0	0
D7	4	4	4	3	3	2	0	4	3	3	3	3	3	0	0	1	1
D8	1	1	1	1	1	1	2	0	2	1	0	0	0	1	1	0	0
D9	0	0	0	3	3	3	1	1	0	4	4	4	4	1	0	0	0
D10	0	0	0	3	3	4	4	4	4	0	4	4	4	1	1	0	1
D11	0	0	0	3	3	2	3	3	4	4	0	4	4	1	0	0	1
D12	0	0	0	2	4	2	1	1	2	3	3	0	4	0	0	0	0
D13	0	0	0	1	3	3	1	1	3	3	3	3	0	1	0	0	0
D14	2	2	2	2	2	1	1	1	1	1	1	1	1	0	3	1	1
D15	4	4	4	4	3	2	2	2	1	1	1	1	3	3	0	0	1
D16	4	4	4	4	3	1	3	3	2	1	3	1	1	1	1	0	1
D17	4	4	4	4	4	1	3	3	2	2	2	1	1	1	1	1	0

Note: 0 – no influence; 1 – very low influence; 2 – low influence; 3 – high influence; 4 – very high influence

Table 5. Societal perspective - respondent k=3 - Direct-relation matrix

Drivers	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***	***D7***	***D8***	***D9***	***D10***	***D11***	***D12***	***D13***	***D14***	***D15***	***D16***	***D17***
D1	0	2	4	1	3	0	3	3	3	3	3	2	1	1	2	0	3
D2	3	0	3	3	1	2	0	3	3	3	3	3	2	0	2	0	3
D3	3	3	0	3	3	3	2	3	3	3	3	2	3	2	2	0	4
D4	0	0	0	0	3	1	2	3	3	3	3	3	2	0	2	0	3
D5	0	2	2	3	0	3	2	3	3	3	4	3	3	3	2	0	3
D6	3	1	1	1	1	0	3	3	3	3	1	2	3	2	3	0	3
D7	3	2	3	3	3	3	0	3	3	3	4	3	2	3	3	0	4
D8	0	2	3	3	3	3	3	0	2	3	2	2	3	2	2	0	2
D9	3	2	3	3	3	3	3	3	0	4	3	3	3	2	2	0	4
D10	2	0	3	3	3	3	3	3	4	0	4	3	3	3	2	0	4
D11	1	1	3	3	3	2	2	2	3	3	0	3	3	2	2	0	2
D12	2	3	3	3	3	1	3	3	3	3	3	0	3	2	2	0	3
D13	3	3	3	3	3	2	3	3	3	3	4	3	0	2	2	0	3
D14	2	0	2	0	0	0	3	3	2	3	1	1	0	0	3	0	3
D15	3	0	3	2	2	0	2	3	3	3	1	1	1	2	0	0	3
D16	4	3	4	3	3	0	0	0	3	3	3	0	2	2	3	0	3
D17	3	2	3	2	2	1	3	3	3	3	3	3	3	1	3	0	0

Note: 0 – no influence; 1 – very low influence; 2 – low influence; 3 – high influence; 4 – very high influence

Table 6. Governmental perspective - respondent k=4 - Direct-relation matrix

Drivers	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***	***D7***	***D8***	***D9***	***D10***	***D11***	***D12***	***D13***	***D14***	***D15***	***D16***	***D17***
D1	0	2	2	2	4	0	1	2	0	1	0	0	0	1	1	0	0
D2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
D3	0	0	0	2	3	0	0	2	1	3	1	3	4	1	0	0	0
D4	0	0	0	0	3	1	0	1	1	2	2	3	3	0	0	0	0
D5	0	0	0	2	0	3	1	3	3	3	3	4	4	1	1	0	0
D6	0	0	0	2	3	0	0	3	1	3	0	0	2	0	1	0	0
D7	0	0	0	1	2	0	0	3	1	3	1	0	3	1	2	0	0
D8	0	0	0	1	2	3	1	0	0	2	0	0	2	2	0	0	0
D9	0	0	0	0	3	1	0	3	0	2	3	3	2	0	0	0	0
D10	0	0	0	0	2	3	1	3	2	0	3	4	4	1	0	0	0
D11	0	0	0	0	4	1	0	3	1	1	0	1	3	0	0	0	0
D12	0	0	0	1	4	1	0	3	3	0	2	0	3	0	0	0	0
D13	0	0	0	3	4	0	0	3	2	3	0	3	0	0	0	0	0
D14	2	0	0	0	1	0	4	2	0	2	0	0	0	0	3	0	1
D15	0	0	0	1	3	2	0	3	0	2	3	3	0	0	0	0	0
D16	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0
D17	3	3	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0

Note: 0 – no influence; 1 – very low influence; 2 – low influence; 3 – high influence; 4 – very high influence

Step 4: Calculate row (*Ri*) and column (*Dj*) sums for each row *i* and column *j* from the total relation matrix. This is generated through Eqs. (5-6).

$$R_i = \sum_{j}^{n} t_{ij} \forall i \tag{5}$$

$$D_j = \sum_{i=1}^{n} t_{ij} \forall j \tag{6}$$

The row values R_i represents the global direct and indirect effect of a factor *i* on other factor, while the column values D_j stand for the global direct and indirect effects of all the drivers on driver *j*. These outcomes were separately determined for each of the four stakeholders regarding RL drivers.

Step 5: Define the global/overall prominence (P_i) or importance of factor *i* and net effect (E_i) of factor *i* using Eqs. (7-8):

$$P_i = \{R_i + D_j \mid i = j\} \tag{7}$$

$$E_i = \{R_i - D_j \mid i = j\} \tag{8}$$

The greater the value of P_i, the greater the overall influence of factor *i* in terms of global relationships with other drivers (Zhu et al., 2011). If $E_i > 0$, it means that driver *i* is a foundation or net cause for other drivers. On the contrary, if $E_i < 0$, then factor *i* is net effect of other factors. These outcomes (P_i and E_i) are used onto a two-dimensional axis for each factor. Tables 15 and 16 present the results for the stakeholders' perspectives, which are plotted in Figs. 2 to 5.

Table 7. Organizational perspective - Total relation matrix from respondent k=1

Drivers	*D1*	*D2*	*D3*	*D4*	*D5*	*D6*	*D7*	*D8*
D1	0.0407	0.1095	0.1189	0.06	0.0839	0.058	0.0565	0.0546
D2	0.1391	0.0611	0.1523	0.1799	0.1766	0.1181	0.1157	0.1123
D3	0.1658	0.1554	0.1238	0.2278	0.2631	0.2078	0.184	0.1794
D4	0.0891	0.0781	0.1201	0.2019	0.2943	0.2997	0.2761	0.2706
D5	0.1442	0.1296	0.1782	0.2747	0.2437	0.3025	0.2944	0.2885
D6	0.103	0.0867	0.1364	0.2763	0.3173	0.2563	0.3209	0.3152
D7	0.1236	0.0902	0.1575	0.28	0.322	0.3324	0.2534	0.3187
D8	0.0943	0.0786	0.1229	0.2545	0.2772	0.3053	0.2997	0.2226
D9	0.1488	0.134	0.1855	0.2873	0.3118	0.3149	0.3071	0.3009
D10	0.105	0.0894	0.1393	0.3004	0.3254	0.3353	0.3283	0.3222
D11	0.1102	0.0953	0.1483	0.3139	0.3396	0.3479	0.3401	0.3337
D12	0.0878	0.0774	0.1701	0.2652	0.2691	0.2887	0.2299	0.2255
D13	0.0936	0.0814	0.195	0.2868	0.31	0.3139	0.3024	0.2979
D14	0.067	0.0539	0.0859	0.1409	0.174	0.2351	0.2319	0.2276
D15	0.1266	0.0641	0.1451	0.1614	0.1794	0.2175	0.2139	0.2095
D16	0.1572	0.1608	0.1864	0.2189	0.2565	0.2372	0.2657	0.2602
D17	0.1895	0.1743	0.2214	0.2838	0.3104	0.31	0.3203	0.2975

Table 8. Organizational perspective - Total relation matrix from respondent k=1 – continuation

Drivers	*D9*	*D10*	*D11*	*D12*	*D13*	*D14*	*D15*	*D16*	*D17*
D1	0.0767	0.0577	0.0545	0.0538	0.0547	0.0701	0.0558	0.0761	0.1073
D2	0.134	0.1198	0.1249	0.1041	0.1062	0.1174	0.137	0.1578	0.19
D3	0.2214	0.1921	0.2045	0.2339	0.237	0.1908	0.209	0.2303	0.2584
D4	0.2701	0.3008	0.2709	0.247	0.249	0.2029	0.186	0.2185	0.3055
D5	0.3071	0.2872	0.2691	0.2797	0.2666	0.2567	0.2588	0.254	0.3334
D6	0.3116	0.33	0.2729	0.2658	0.2696	0.2617	0.2809	0.2525	0.3205
D7	0.2983	0.3337	0.2748	0.2689	0.2725	0.2838	0.2852	0.2391	0.3425
D8	0.2711	0.3074	0.2338	0.2272	0.2308	0.262	0.2642	0.2161	0.3148
D9	0.2483	0.3174	0.2988	0.2913	0.2955	0.2489	0.2676	0.2818	0.3456
D10	0.3017	0.2662	0.2969	0.2725	0.2761	0.2672	0.2686	0.2592	0.3446
D11	0.3323	0.3505	0.2401	0.3027	0.3064	0.2593	0.2605	0.2886	0.3564
D12	0.2797	0.272	0.2631	0.1875	0.2617	0.2087	0.1937	0.2289	0.2445
D13	0.3013	0.3114	0.2653	0.2793	0.2096	0.2304	0.198	0.2119	0.2519
D14	0.1864	0.2201	0.136	0.149	0.1519	0.1371	0.2107	0.1253	0.2417
D15	0.1885	0.2353	0.1389	0.1362	0.1557	0.1925	0.1395	0.1313	0.2467
D16	0.2626	0.2736	0.2617	0.2215	0.2423	0.2002	0.2369	0.1809	0.3069
D17	0.2812	0.3286	0.2759	0.252	0.2564	0.2836	0.2712	0.2808	0.2785

Table 9. Customer perspective - Total relation matrix from respondent k=2

Drivers	*D1*	*D2*	*D3*	*D4*	*D5*	*D6*	*D7*	*D8*
D1	0.0392	0.1185	0.0951	0.1574	0.1676	0.1778	0.1541	0.1398
D2	0.0209	0.0208	0.0205	0.0696	0.0746	0.0689	0.096	0.0994
D3	0.0984	0.0835	0.0211	0.119	0.1244	0.1044	0.0888	0.0904
D4	0.0142	0.0128	0.0139	0.0484	0.0959	0.1103	0.0553	0.0572
D5	0.0141	0.0131	0.0139	0.1094	0.06	0.0946	0.0571	0.0591
D6	0.0299	0.0107	0.0293	0.0491	0.0503	0.029	0.0225	0.0228
D7	0.11	0.1142	0.108	0.1431	0.1516	0.1259	0.07	0.149
D8	0.034	0.0351	0.0334	0.0498	0.0509	0.0491	0.0617	0.0242
D9	0.0134	0.0119	0.0132	0.1123	0.1211	0.1171	0.0601	0.0622
D10	0.0265	0.025	0.026	0.1301	0.1393	0.1505	0.1289	0.1334
D11	0.0205	0.0196	0.0201	0.1217	0.131	0.1062	0.1048	0.1085
D12	0.0103	0.0091	0.0101	0.0829	0.1269	0.0868	0.0519	0.0537
D13	0.0116	0.0102	0.0114	0.0643	0.1077	0.1042	0.0515	0.0533
D14	0.0652	0.0678	0.064	0.0926	0.095	0.0699	0.0613	0.0624
D15	0.1122	0.1168	0.1101	0.1524	0.1393	0.1147	0.0993	0.101
D16	0.1148	0.1198	0.1126	0.1593	0.1448	0.0993	0.1249	0.1275
D17	0.1152	0.1202	0.113	0.1617	0.1662	0.1021	0.1265	0.1292

Table 10. Customer perspective - Total relation matrix from respondent k=2

Drivers	*D9*	*D10*	*D11*	*D12*	*D13*	*D14*	*D15*	*D16*	*D17*
D1	0.1926	0.1923	0.1899	0.1888	0.2014	0.0822	0.0909	0.0051	0.0146
D2	0.1138	0.0953	0.0936	0.0944	0.0996	0.0607	0.0552	0.0034	0.0083
D3	0.1329	0.114	0.1124	0.0757	0.1369	0.0281	0.0226	0.0025	0.0075
D4	0.0968	0.1175	0.1165	0.1358	0.1405	0.0397	0.0332	0.0021	0.0074
D5	0.1182	0.1213	0.1202	0.1406	0.1454	0.0407	0.0336	0.0022	0.0077
D6	0.071	0.0714	0.071	0.0334	0.0369	0.0322	0.0293	0.0012	0.0046
D7	0.16	0.1582	0.1563	0.1545	0.1648	0.0367	0.0296	0.0232	0.0301
D8	0.0719	0.0528	0.0335	0.0328	0.0365	0.0328	0.0307	0.002	0.0044
D9	0.0658	0.1444	0.1434	0.1453	0.1495	0.0413	0.0154	0.0022	0.0083
D10	0.1603	0.0868	0.1599	0.1606	0.1667	0.0486	0.0398	0.0042	0.03
D11	0.1512	0.1536	0.0762	0.1539	0.1587	0.0444	0.0181	0.0036	0.0286
D12	0.0928	0.1129	0.1119	0.0565	0.1355	0.0181	0.0117	0.0016	0.0063
D13	0.1099	0.1117	0.1108	0.1116	0.0572	0.0369	0.0126	0.0019	0.0066
D14	0.0772	0.0763	0.076	0.0745	0.0826	0.0242	0.0786	0.0227	0.0273
D15	0.1076	0.1061	0.1044	0.1026	0.1506	0.0931	0.0305	0.0045	0.0293
D16	0.1334	0.1127	0.1482	0.1095	0.12	0.0551	0.0495	0.0043	0.0305
D17	0.1359	0.1338	0.1323	0.1125	0.1231	0.056	0.0506	0.0244	0.0107

Table 11. Societal perspective - Total relation matrix from respondent k=3

Drivers	*D1*	*D2*	*D3*	*D4*	*D5*	*D6*	*D7*	*D8*
D1	0.1049	0.1221	0.2122	0.1502	0.1873	0.1024	0.1854	0.2056
D2	0.1596	0.0813	0.1897	0.1834	0.1486	0.1346	0.129	0.2029
D3	0.1822	0.1546	0.1607	0.2086	0.2097	0.1737	0.1928	0.2347
D4	0.0863	0.0693	0.114	0.1091	0.1664	0.1038	0.1477	0.1804
D5	0.1174	0.1277	0.186	0.1984	0.1414	0.1661	0.1823	0.2215
D6	0.1599	0.0981	0.1514	0.1409	0.1432	0.0926	0.1828	0.1997
D7	0.1895	0.141	0.2272	0.217	0.2189	0.1796	0.1643	0.2453
D8	0.1077	0.1204	0.1903	0.1863	0.1858	0.1579	0.1869	0.1507
D9	0.1889	0.1416	0.2262	0.2171	0.2189	0.1804	0.2203	0.2443
D10	0.1669	0.1022	0.2212	0.2127	0.2151	0.1774	0.2179	0.2394
D11	0.1259	0.103	0.1918	0.1869	0.1878	0.1388	0.1703	0.1897
D12	0.1586	0.1516	0.2119	0.205	0.2053	0.134	0.2044	0.228
D13	0.1849	0.1577	0.2224	0.2141	0.2151	0.1592	0.2146	0.2392
D14	0.1117	0.0557	0.1331	0.0874	0.0896	0.0674	0.1465	0.1581
D15	0.145	0.0703	0.172	0.1459	0.1488	0.0845	0.1496	0.1831
D16	0.1846	0.1402	0.2145	0.1868	0.1885	0.098	0.1297	0.152
D17	0.1732	0.1301	0.2074	0.1808	0.1825	0.1286	0.1993	0.2209

Table 12. Societal perspective - Total relation matrix from respondent k=3 – continuation

Drivers	*D9*	*D10*	*D11*	*D12*	*D13*	*D14*	*D15*	*D16*	*D17*
D1	0.2074	0.2134	0.2053	0.1685	0.1466	0.1177	0.1543	0	0.2172
D2	0.2051	0.2106	0.2008	0.1845	0.1634	0.094	0.1514	0	0.213
D3	0.2363	0.2435	0.2317	0.1935	0.2063	0.1523	0.1775	0	0.2648
D4	0.1823	0.1872	0.1804	0.1664	0.1457	0.0839	0.1349	0	0.1889
D5	0.223	0.2301	0.236	0.2003	0.1963	0.1641	0.1678	0	0.2328
D6	0.2004	0.2065	0.1598	0.1611	0.1749	0.1317	0.1689	0	0.2099
D7	0.247	0.2548	0.2589	0.2198	0.1964	0.1787	0.2046	0	0.2764
D8	0.1906	0.2144	0.1866	0.1694	0.1838	0.1368	0.1564	0	0.2003
D9	0.1897	0.2713	0.2418	0.22	0.2147	0.16	0.1852	0	0.2757
D10	0.2588	0.1925	0.2541	0.2155	0.211	0.1767	0.1821	0	0.2705
D11	0.2093	0.2154	0.1492	0.1881	0.1843	0.1372	0.1561	0	0.201
D12	0.2296	0.2366	0.2268	0.1498	0.2008	0.1489	0.1718	0	0.2404
D13	0.2413	0.2486	0.2554	0.2161	0.1537	0.1562	0.1809	0	0.2522
D14	0.1403	0.163	0.1185	0.106	0.0851	0.0673	0.1368	0	0.1661
D15	0.1836	0.1893	0.1447	0.1288	0.1251	0.1208	0.0983	0	0.1927
D16	0.2112	0.2165	0.2075	0.132	0.1639	0.1343	0.1749	0	0.2203
D17	0.2228	0.2293	0.2195	0.1996	0.1948	0.1268	0.1843	0	0.1764

Table 13. Governmental perspective - Total relation matrix from respondent k=4

Drivers	D1	D2	D3	D4	D5	D6	D7	D8
D1	0.002	0.0515	0.0515	0.0718	0.1432	0.0291	0.0373	0.0924
D2	6E-05	5E-06	5E-06	0.0022	0.028	0.0031	0.001	0.0041
D3	0.0021	0.0002	0.0002	0.08	0.1422	0.0382	0.0137	0.1128
D4	0.0005	5E-05	5E-05	0.0248	0.131	0.0561	0.0086	0.0788
D5	0.0022	0.0002	0.0002	0.0863	0.0939	0.1214	0.0399	0.1591
D6	0.0007	6E-05	6E-05	0.0722	0.1223	0.0342	0.0104	0.1208
D7	0.002	0.0002	0.0002	0.0486	0.1037	0.035	0.0129	0.1268
D8	0.0031	0.0003	0.0003	0.0453	0.0896	0.0974	0.0373	0.0416
D9	0.0007	6E-05	6E-05	0.0246	0.1319	0.0599	0.0102	0.1286
D10	0.0021	0.0002	0.0002	0.0338	0.1268	0.1124	0.038	0.1455
D11	0.0006	6E-05	6E-05	0.0246	0.145	0.0555	0.0096	0.1198
D12	0.0006	6E-05	6E-05	0.0512	0.1553	0.0585	0.0096	0.1276
D13	0.0007	7E-05	7E-05	0.099	0.1576	0.0405	0.0118	0.1301
D14	0.0539	0.0048	0.0048	0.019	0.068	0.0277	0.1116	0.0931
D15	0.0007	6E-05	6E-05	0.0477	0.1303	0.0858	0.0101	0.1271
D16	0.0029	0.0003	0.0003	0.0035	0.0088	0.0032	0.0577	0.0113
D17	0.0773	0.0809	0.0809	0.0174	0.0335	0.085	0.0048	0.0254

Table 14. Governmental perspective - Total relation matrix from respondent k=4 - continuation

Drivers	D9	D10	D11	D12	D13	D14	D15	D16	D17
D1	0.0254	0.0636	0.0285	0.0397	0.0477	0.038	0.0349	0	0.001
D2	0.0031	0.0035	0.0031	0.0041	0.0046	0.001	0.0009	0	3E-05
D3	0.0662	0.1217	0.0628	0.13	0.1628	0.0386	0.0083	0	0.001
D4	0.0602	0.0874	0.0807	0.1182	0.1272	0.0099	0.006	0	0.0003
D5	0.1222	0.1362	0.1206	0.1618	0.1783	0.0408	0.0364	0	0.001
D6	0.0531	0.113	0.0308	0.0445	0.0982	0.0125	0.0312	0	0.0003
D7	0.0533	0.1163	0.0563	0.0458	0.1231	0.0382	0.0585	0	0.001
D8	0.0233	0.0852	0.021	0.0314	0.088	0.0589	0.0113	0	0.0015
D9	0.034	0.0882	0.1044	0.1152	0.1048	0.0125	0.0064	0	0.0003
D10	0.091	0.0532	0.1089	0.1469	0.1641	0.0387	0.0111	0	0.001
D11	0.054	0.0628	0.0254	0.0633	0.1195	0.0117	0.0066	0	0.0003
D12	0.1062	0.0446	0.0805	0.045	0.1268	0.0119	0.0069	0	0.0003
D13	0.0872	0.1162	0.0401	0.1257	0.0626	0.014	0.0068	0	0.0004
D14	0.0186	0.0844	0.0253	0.0292	0.0375	0.013	0.0875	0	0.026
D15	0.0324	0.0873	0.1052	0.113	0.0561	0.0124	0.007	0	0.0003
D16	0.0037	0.0103	0.0042	0.0038	0.0082	0.0539	0.0075	0	0.0014
D17	0.0114	0.0232	0.0096	0.0168	0.0241	0.0069	0.0058	0	0.0002

Table 15. Degree of prominence and net cause/effect values for drivers from organizational, and customer's perspectives

	Organizational				***Customer***			
	Rsum	***Dsum***	***R+D (P)***	***R-D (E)***	***Rsum***	***Dsum***	***R+D (P)***	***R-D (E)***
D1	1.189	1.986	3.174	-0.797	2.207	0.850	3.058	1.357
D2	2.246	1.720	3.966	0.526	1.095	0.909	2.004	0.186
D3	3.484	2.587	6.071	0.897	1.363	0.815	2.178	0.547
D4	3.881	4.014	7.894	-0.133	1.097	1.823	2.921	-0.726
D5	4.368	4.454	8.823	-0.086	1.151	1.946	3.097	-0.796
D6	4.378	4.481	8.858	-0.103	0.595	1.711	2.306	-1.116
D7	4.477	4.340	8.817	0.136	1.885	1.415	3.300	0.470
D8	3.983	4.237	8.220	-0.254	0.636	1.473	2.109	-0.838
D9	4.585	4.272	8.858	0.313	1.227	1.991	3.218	-0.764
D10	4.498	4.504	9.002	-0.006	1.617	1.961	3.578	-0.345
D11	4.726	3.882	8.608	0.844	1.421	1.956	3.377	-0.536
D12	3.754	3.772	7.526	-0.019	0.979	1.883	2.862	-0.904
D13	4.140	3.842	7.982	0.298	0.974	2.106	3.080	-1.133
D14	2.774	3.673	6.448	-0.899	1.118	0.771	1.888	0.347
D15	2.882	3.723	6.606	-0.841	1.675	0.632	2.307	1.043
D16	3.930	3.633	7.563	0.296	1.766	0.111	1.877	1.655
D17	4.615	4.789	9.405	-0.174	1.813	0.262	2.075	1.551

Table 16. Degree of prominence and net cause/effect values for drivers from societal, governmental, and overall perspectives

	Societal				***Government***				***Aggregated values (Overall)***			
	Rsum	***Dsum***	***R+D (P)***	***R-D (E)***	***Rsum***	***Dsum***	***R+D (P)***	***R-D (E)***	***Rsum***	***Dsum***	***R+D (P)***	***R-D (E)***
D1	2.701	2.547	5.248	0.153	0.758	0.152	0.910	0.605	2.498	1.706	4.204	0.793
D2	2.652	1.967	4.619	0.685	0.059	0.139	0.198	-0.080	1.895	1.509	3.404	0.386
D3	3.223	3.232	6.455	-0.009	0.981	0.139	1.119	0.842	2.872	2.051	4.922	0.821
D4	2.247	3.031	5.277	-0.784	0.790	0.752	1.542	0.038	2.448	3.086	5.535	-0.638
D5	2.991	3.053	6.044	-0.062	1.300	1.811	3.112	-0.511	3.085	3.741	6.827	-0.656
D6	2.582	2.279	4.861	0.303	0.744	0.943	1.687	-0.199	2.366	2.954	5.320	-0.588
D7	3.419	3.024	6.443	0.396	0.822	0.425	1.246	0.397	3.292	2.740	6.032	0.552
D8	2.724	3.495	6.220	-0.771	0.636	1.645	2.280	-1.009	2.282	3.447	5.728	-1.165
D9	3.396	3.579	6.975	-0.183	0.822	0.845	1.667	-0.023	3.067	3.341	6.409	-0.274
D10	3.314	3.723	7.037	-0.409	1.074	1.297	2.371	-0.223	3.301	3.611	6.912	-0.309
D11	2.735	3.477	6.212	-0.742	0.699	0.908	1.606	-0.209	2.900	3.244	6.144	-0.344
D12	3.104	3.020	6.123	0.084	0.825	1.235	2.060	-0.409	2.634	3.196	5.829	-0.562
D13	3.311	2.947	6.258	0.365	0.893	1.534	2.426	-0.641	2.803	3.444	6.247	-0.641
D14	1.833	2.287	4.120	-0.455	0.704	0.413	1.118	0.291	2.009	2.095	4.105	-0.086
D15	2.283	2.786	5.069	-0.504	0.816	0.333	1.149	0.482	2.499	2.130	4.629	0.369
D16	2.755	0.000	2.755	2.755	0.181	0.000	0.181	0.181	2.644	0.964	3.609	1.680
D17	2.976	3.799	6.775	-0.822	0.503	0.036	0.539	0.467	3.046	2.384	5.430	0.663

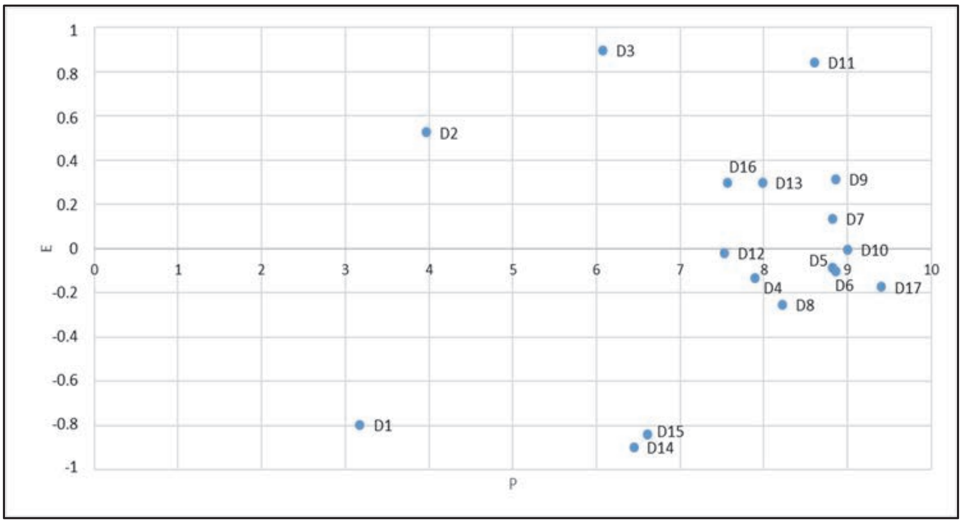

Fig. 2. The prominence-causal graph for the organization expert

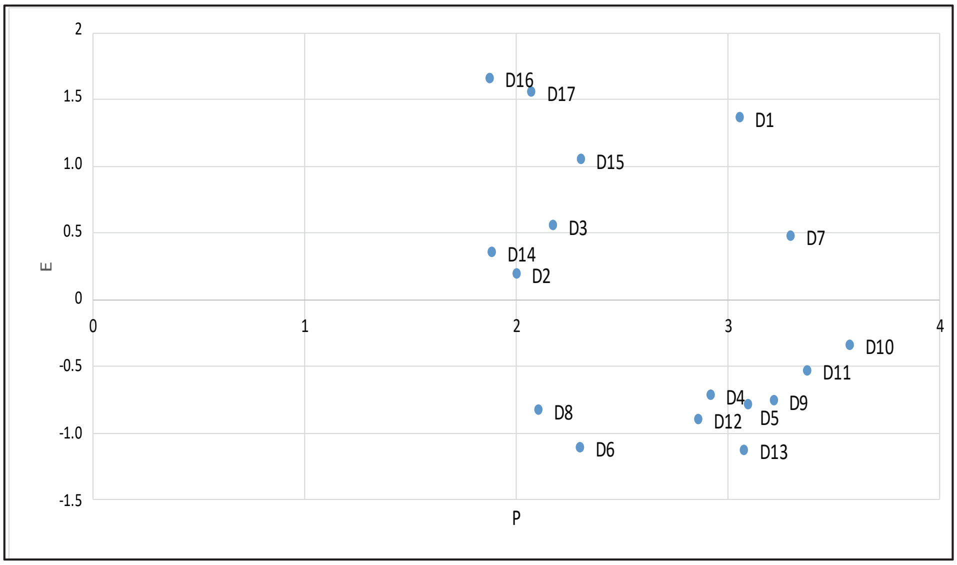

Fig. 3. The prominence-causal graph for the customer expert

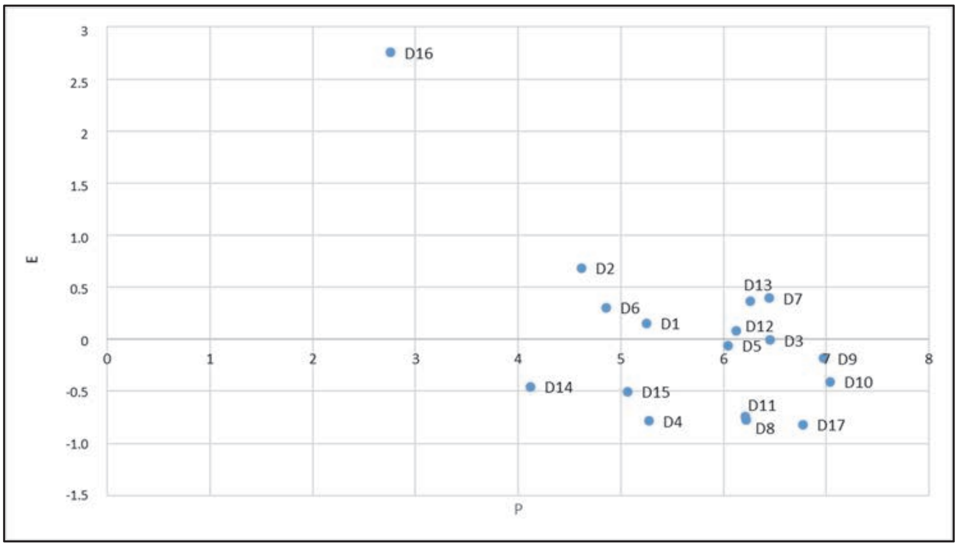

Fig. 4. The prominence-causal graph for the society expert

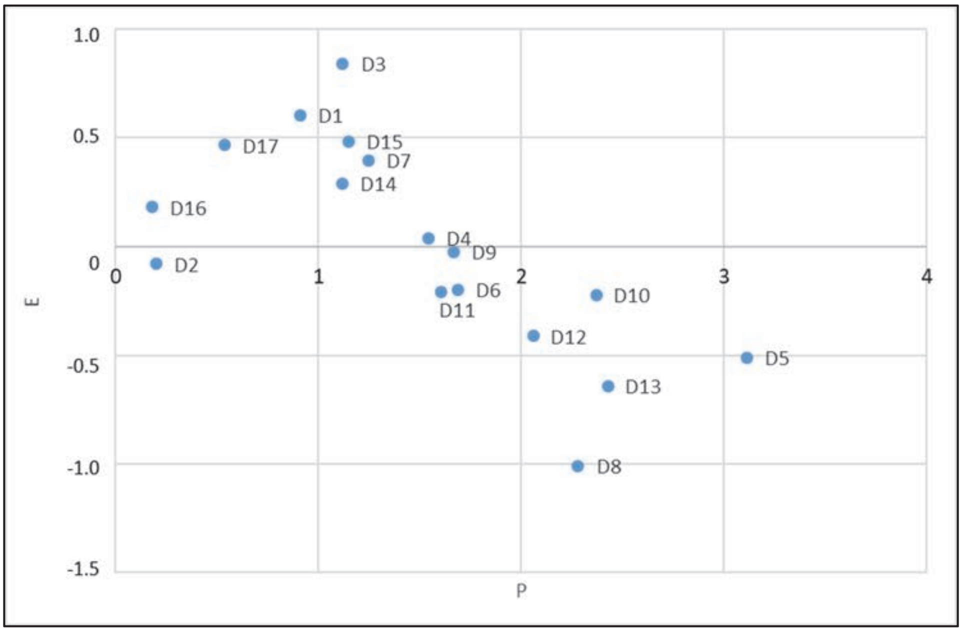

Fig. 5. The prominence-causal graph for the Government expert

Step 6: Create the overall/global prominence-causal graphs for aggregation of the key Reverse Logistics stakeholders. This procedure intends to obtain a global cause-effect analysis of drivers considering an unique viewpoint based on all stakeholders, by performing the following two steps.

Step 6a: Values from crisp direct-relationships (Tables 3 to 6) are used to create a direct-relation matrix for all stakeholders in aggregation by means of a simple averaging approach. With the purpose of determining aggregated prominence and net cause, the above five DEMATEL steps were applied. The final two columns in Table 16 show the aggregated results for Reverse Logistics drivers. Tables 17 and 18 present the overall total-relation matrix for the aggregation of the stakeholders, while Fig. 6 exhibits the overall prominence–causal graph.

Step 6b: Develop an overall prominence-causal relationship diagram in order to observe global patterns and linkages amongst all the drivers concurrently and in pairs. A threshold θ was calculated in order to build this diagram. Only the relationships exceeding the threshold θ were considered. The threshold was determined using T matrix, by taking the mean of the values t_{ij}, and adding one standard deviation to this value. Thus, $\theta = 0.1579 + 0.0565 = 0.2145$.

All the values in Tables 17 and 18 meeting or exceeding the limit 0.2145 are underlined and in bold. Fig. 6 shows these strongest dyadic relationships. Dashed lines mean one-way linkages, whereas solid lines depict two-way significant relationships.

Table 17. The overall total-relation matrix for RL drivers

Driver	***D1***	***D2***	***D3***	***D4***	***D5***	***D6***	***D7***	***D8***
D1	0.0684	0.1286	0.1549	0.1609	0.2139	0.1443	0.1549	0.185
D2	0.0918	0.0466	0.1028	0.1408	0.1503	0.1093	0.1015	0.1399
D3	0.1378	0.1254	0.0941	0.2069	**0.2485**	0.1735	0.1502	0.2002
D4	0.0616	0.0542	0.0776	0.1255	**0.2197**	0.1749	0.1451	0.1857
D5	0.0914	0.0918	0.1209	**0.2176**	0.1904	0.2144	0.1782	**0.2312**
D6	0.0856	0.0606	0.0886	0.159	0.1953	0.1177	0.1474	0.1914
D7	0.1326	0.1114	0.152	**0.222**	**0.2682**	0.2126	0.1477	**0.2637**
D8	0.0679	0.0694	0.096	0.1596	0.1891	0.1746	0.1595	0.1302
D9	0.1076	0.0932	0.1268	0.2067	**0.2566**	0.2081	0.1775	**0.2301**
D10	0.097	0.0752	0.1224	**0.2232**	**0.2706**	**0.2422**	**0.2159**	**0.2659**
D11	0.0805	0.0716	0.1093	0.2039	**0.2569**	0.1962	0.1814	**0.2321**
D12	0.0785	0.0764	0.1164	0.1908	**0.2412**	0.1767	0.1466	0.1948
D13	0.0875	0.0794	0.1262	0.2044	**0.2514**	0.1914	0.1706	**0.2208**
D14	0.0925	0.062	0.0923	0.1126	0.1446	0.1271	0.1587	0.1711
D15	0.1245	0.0839	0.1385	0.1704	0.2027	0.162	0.1521	0.2024
D16	0.1368	0.1295	0.1516	0.1782	0.206	0.1382	0.1621	0.1817
D17	0.1634	0.1497	0.1804	0.2037	**0.2358**	0.1906	0.1902	**0.2203**

Table 18. The overall total-relation matrix for RL drivers - continuation

Driver	***D9***	***D10***	***D11***	***D12***	***D13***	***D14***	***D15***	***D16***	***D17***
D1	0.1815	0.1912	0.1721	0.1663	0.171	0.1138	0.1202	0.0459	0.1256
D2	0.1427	0.14	0.1349	0.1286	0.1306	0.0816	0.0987	0.0473	0.1075
D3	0.2086	0.2143	0.1989	0.204	**0.2408**	0.1254	0.1256	0.068	0.1493
D4	0.1887	**0.2146**	0.2015	0.2068	0.2111	0.0965	0.1	0.0511	0.1336
D5	**0.2428**	**0.2459**	**0.238**	**0.2483**	**0.2552**	0.1502	0.1444	0.0661	0.1584
D6	0.1858	0.2082	0.161	0.1548	0.1797	0.1167	0.1329	0.0542	0.1266
D7	**0.2363**	**0.267**	**0.2361**	**0.2247**	**0.2482**	0.1584	0.1639	0.069	0.1779
D8	0.1645	0.1923	0.1445	0.1438	0.1687	0.13	0.1205	0.0474	0.1237
D9	0.1704	**0.2548**	**0.243**	**0.2423**	**0.2494**	0.1336	0.1327	0.0716	0.1629
D10	**0.2548**	0.1985	**0.2598**	**0.254**	**0.2677**	0.1589	0.1476	0.0697	0.1778
D11	**0.2283**	**0.241**	0.1576	**0.2241**	**0.246**	0.1287	0.122	0.0689	0.1515
D12	0.214	0.2089	0.2104	0.1442	**0.2316**	0.113	0.1063	0.0593	0.1245
D13	**0.2234**	**0.24**	0.209	**0.2251**	0.1645	0.1247	0.1075	0.051	0.1261
D14	0.1363	0.1691	0.1165	0.1201	0.123	0.0711	0.1451	0.0371	0.1302
D15	0.17	0.2031	0.16	0.1596	0.1696	0.1315	0.0871	0.0396	0.1423
D16	0.1882	0.1938	0.1955	0.1561	0.1823	0.1237	0.1307	0.0417	0.1481
D17	0.2049	**0.228**	0.2052	0.1925	0.205	0.1375	0.145	0.0766	0.1176

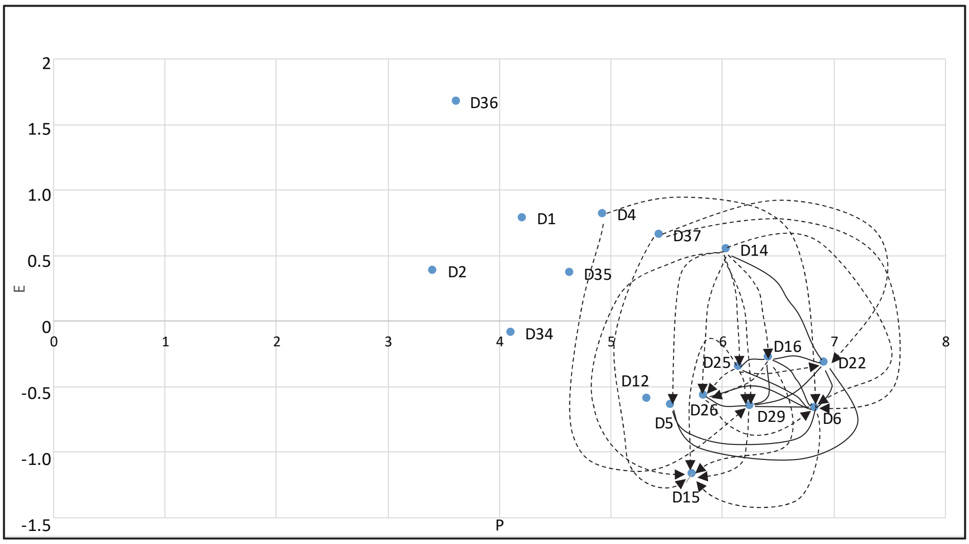

Fig. 6. Overall prominence–causal graph diagram

4. Results and discussion

The discussion of results is twofold to better show the detailed treatment of outcomes. At first, a broad discussion of major results is given, which contains a determination of clusters of cause and effect groups and the prominence level of RL influential factors. Secondly, stakeholders' differences and similarities are briefly discussed.

4.1. Net effect and importance

The employment of grey-based DEMATEL allows the uncovering of the cause and effect groups of factors from the different stakeholders' viewoints. The RL drivers in the cause cluster are understood as influencing criteria, and RL drivers in the effect cluster correspond to the influenced criteria.

From the organizational perspective (Fig. 2), the influencing drivers are organized as follows: D3 > D11 > D2 > D9 > D13 > D9 > D7. In this causal cluster, Motivation laws (D3) is on the top of the cluster, which implies that D3 is the main causal factor. This result reinforces the aforementioned underdeveloped condition of Reverse Logistics practices in Brazil, due to the lack of laws encouraging product return or even offering tax discounts on recycled assets. Furthermore, this outcome is in line with the general perception in the literature concerning the key role of 'the governmental perspective', who promotes Reverse Logistics through drivers related to laws and policies (Chileshe et al., 2018). The effect group for the organizational respondent includes the following factors: D10, D12, D5, D6, D4, D17, D8, D1, D15, D14.

However, with the view to have a broad conclusion from Fig. 2, the prominence level of the drivers (denoting the correlation with other factors) should also be considered. Thus, the list of the head five drivers is as follows: D17 > D10 > D6 > D9 > D5. Environmental conservations (D17), an effect factor, achieved the highest correlation with other factors. From the organizational evaluator perspective, closing the supply chain loop by facilitating a proper final destination to EOL goods is the most relevant effect RL driver. The motivation of firms to meet environmental requirements largely rests on local circumstances and the social values prevalent in the community (Chileshe et al., 2016). Eco-design and Design for 'X' techniques (D10) attained second place. This factor almost reached null net effect, denoting it is a relevant linkage factor in the system, that is, it may act either as a cause or as an effect element. For the organization, this output means that the presence of environmental issues in the design phase helps to put Reverse Logistics in practice. This factor is respectively followed by Customer satisfaction (D6), Long-term sustainability (D9), and Integration and cooperation with SC partners (D5).

On the other hand, from the customer perception (Fig. 3), the influencing factors are set as follows: D16 > D17 > D1 > D15 > D3 > D7 > D14 > D2. Increasing landfill (D16) is the most influencing factor. Thus, Reverse Logistics seems to be an answer for the scarcity of landfills. In this sense, however, it is relevant to mention that current landfill levy is not sufficient to make RL cost effective (Chileshe et al., 2016). Regarding the effect group, the group includes the following factors: D13, D6, D12, D8, D6, D9, D4, D11, and D10.

According to the customer evaluator, the top five factors regarding their prominence level is sorted as follows: D10 > D11 > D7 > D9 > D5. Design for environment practices (D10) attained the first level of relevance, while in the prior analysis from the organizational expert D10 got the second position. This factor is an effect driver in the system, that is, eco-design is affected by other factors, such as Regulatory pressure for product recovery (D1) and Green consumerism (D7). The following places in the prominence scale are: Reduction on material consumption and disposal cost (D11), Green consumerism / consumers' environmental awareness (D7), Long-term sustainability (D9) and Integration and cooperation with SC partners (D5), respectively.

Regarding the society expert standpoint (Fig. 4), the influencing factors are sorted in the following sequence: D16 > D2 > D7 > D13 > D6 > D1 > D12. The most influencing factor is Increasing landfill (D16), which corroborates the customer viewpoint. The NGO evaluator considers that EOL products should have an appropriate final destination to reduce the use of landfills. The effect drivers cluster is composed of D3, D5, D9, D10, D14, D15, D11, D8, D4 and D17.

Regarding the importance level according to the societal perspective, drivers are sorted as follows: D10 > D9 > D17 > D3 > D7. The most prominent driver is Eco-design and Design for 'X' techniques (D10), same result obtained by the customer expert. The society expert considers that Reverse Logistics is mainly driven by economic matters, and that investments in eco-design initiatives are crucial for reducing Reverse Logistics costs. Long-term sustainability (D9), Environmental conservations (D17), Motivation laws (D3) and Green consumerism / consumers' environmental awareness (D7), respectively follow this factor.

The Government respondent selected as influencing factors: D3 > D1 > D15 > D17 > D7 > D14 > D16 > D4, as presented in Fig. 5. Motivation laws (D3) achieved the ultimate influence in the structure. This result is in some way expected, since this specific driver arises from the Government. The paper of Govindan et al. (2014) provided analogous outcomes, stating that "government regulations get high priority because in modern business, firms concentrate only on economic profit; they don't practice these types of sustainable practices voluntarily." The group of effect factors from this perspective comprises: D9, D2, D6, D11, D10, D12, D5, D13, D8.

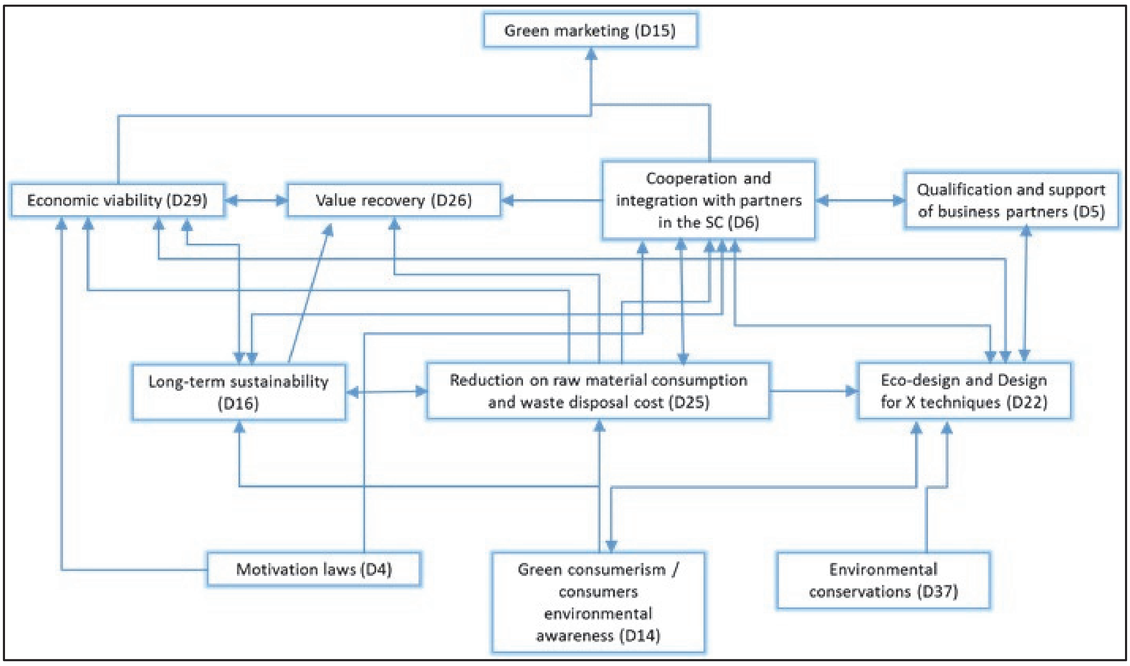

Fig. 7. Drivers interrelationship digraph according to overall perspective

From the Government standpoint, the head five drivers concerning their relevance are: D5 > D13 > D10 > D8 > D12. The high ranking driver is Integration and cooperation with SC partners (D5). The evaluator from the Government considers that employing solid waste policies depends mainly on the shared responsibility on product returns across the reverse supply chain. Companies should cooperate to execute product return initiatives. In this matter, considering that product returns are uncertain, fourth party logistics may play an essential role via collaboration and integration (Agrawal et al., 2015).

This factor is followed by Economic viability (D13), Eco-design and Design for X techniques (D10), Green marketing (D8) and Value recovery (D12).

At last, an overall perspective is shown in Fig. 6. From the aggregated viewpoint, the following motivational factors are placed in the cause cluster: D16 > D3 > D1 > D17 > D7 > D2 > D15

Thus, Increasing landfill (D16) achieved the top cause value, even though it does not represent an relevant driver (low P value). It means that the scarcity of landfills drives Reverse Logistics implementation, but it does not have a strong connection to other factors in the system. The effect group contemplates D14, D9, D10, D11, D12, D6, D4, D13, D5, and D8.

Regarding the relevance level of the factors, the aggregated perspective shows the following most important drivers: D10 > D5 > D9 > D13 > D11. Design for environment practices (D10) obtained the greatest importance level. This result is in agreement with (Scur and Barbosa, 2017), who states that "the design stage is the mechanism through which an efficient product with appropriate pricing and environmental performance is obtained." This factor is followed by Integration and cooperation with SC partners (D5), Long-term sustainability (D9), Economic viability (D13), and Reduction on material consumption and disposal cost (D11), respectively.

Moreover, by examining the strongest dyadic relationships in Fig. 6, it is unmistakable that D7 (Green consumerism) plays an important role in the drivers system. D7 influences other eight drivers, including the three most important ones (D10, D5, and D9). Consumers' environmental awareness is a growing trend, pressuring firms to cope with environmental legislation and standards. Still in the causal group, Environmental conservations (D17) is remarkable, influencing three other factors: Integration and cooperation with SC partners (D5), Green marketing (D8) and Design for environment practices (D10). Lastly, Motivation laws (D3) stands out in the causal cluster, having effect on Integration and cooperation with SC partners (D5) and Economic viability (D13).

In order to clarify the outcomes from Fig. 6, the most relevant dyadic relationships are arranged in a diagram (Fig. 7). The relationship between the factors *i* and *j* is shown by an arrow pointing from *i* to *j*.

4.2. Stakeholders similarities and differences

Concerning the stakeholders similarities, D3 (Motivations laws) is a strongly significant factor since the government and organization experts assign D3 the highest E value (R – D score); this is the most influencing driver in the system. Society and Customer experts have the same opinion that D16 (Increasing landfill) is the highest causal factor and Design for environment practices (D10) is the most prominent (R + D score) factor impelling RL activities.

On the differences, the organization expert strongly disagrees with the customer expert on driver

D14 (Higher public awareness). The organization expert views driver D14 as the greatest influenced (effect) factor, while the customer expert sees D14 as an influencing (causal) factor. That is, the organization expert thinks that greater concern of environment by the population is mainly influenced by other factors in order to impel RL operations. This result is partially surprising since green consumerism issues usually play a causal role in the employment of green initiatives such as RL.

5. Conclusions

RL is a growing trend among industries due to social, legislative and environmental issues. It is influenced by different groups of interest and driven by influential factors that are interrelated in a complex way. These drivers reveal the tendency of a company to engage in product return practices. Thus, the core goal of this work was to assess the relationship among Reverse Logistics drivers under the standpoints of the key stakeholders in Brazil. Thus, this research offered the net effect and the importance level of each motivational factor from each angle separately, and from the overall/global perspective (aggregated form). Therefore, the exclusive contribution of this study is the evaluation of Reverse Logistics drivers under a multidimensional picture of the stakeholders (society, company, customer, and Government). In this matter, the major innovation of this manuscript is the uncovering of the prominence level and net effect for each driver from each stakeholder point of view separately and in an global/aggregated form (overall perspective).

Concerning the practical implications, a critical assessment of RL drivers, as well as obtaining the knowledge on the stakeholders triggering them or being influenced by them, can be a rich fount of information to industrial managers. Essentially, an analysis of the multiple perspectives can help to minimize uncertainties while implementing RL. The consideration and understanding of the motivational factors from a multiple stakeholder point of view is essential for creating a comprehensive industry strategy of successfully employing RL and managing environmental issues.

Even pondering all the improvements made by this work, it presents some limitations and, hence, it also leaves space for future work. The first drawback of this paper's approach is the appraising effort required from experts when performing the pair-wise comparisons. We had seventeen drivers, which ended in 272 pair-wise comparisons. In that way, the experts may have had mental exhaustion during the interviews. From this, further research can be developed clustering the drivers in order to reduce the quantity of pair-wise evaluations.

The drivers gathered from previous literature were selected from an international panorama of papers dealing with product return issues. For this reason, the list of motivational factors and their classification can be further used in future studies worldwide. However, it is recommended to expand the scope of this research, by reproducing the grey-DEMATEL application in another country context, which may affect the final results. Reverse Logistics is progressively advancing from an elective status to a mandatory practice worldwide. This research generates first insights to aid to identify potential factors that need to be focused on and guidelines for future research paths.

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