

# Assessment of maturity of reverse logistics as a strategy to sustainable solid waste management

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## Abstract

Small- and medium-sized enterprises primarily focus on their operations and rarely pay attention to issues related to sustainable solid waste management that originate from their production processes. A suitable strategy to support sustainable solid waste management is reverse logistics. Through the use of maturity models, it is possible to determine the grade to which small- and medium-sized enterprises are prepared to perform this strategy. This study proposes an adapted maturity model to measure maturity levels of reverse logistics aspects at small- and medium-sized enterprises in regions from Colombia in order to contribute to sustainable solid waste management. The maturity model was applied to seven small- and medium-sized enterprises in the plastics sector in the central and southern regions of Colombia by adapting a maturity model that was previously correlated to suggested drivers and barriers in this sector. Results show that maturity levels range from naïve to immature owing to the incipient development of reverse logistics in Colombia. Therefore, it is necessary to establish a holistic vision of the organisation to improve the reverse logistics decision-making process to achieve sustainable solid waste management.

## Keywords

Maturity, reverse logistics, small- and medium-sized enterprises, solid waste, sustainability

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## Introduction

Small- and medium-sized enterprises (SMEs) are not only relevant to global economies; their performance and productivity also impacts large firms' operation, performance, and productivity (Fernández and Rajagopal, 2018). SMEs pay greater attention to aspects related to their central operation, but they often leave issues, such as environmental management, unattended. Further, they frequently consider environmental issues as low priority, expensive, and financially worthless pursuits (Bradford and Fraser, 2008).

In Colombia, SMEs are a key to improve competitiveness indicators; they produce goods and services that demand raw materials and they perform productive chains that generate sources of employment (Cali Chamber of Commerce (CCC), 2014). Nevertheless, according to Sánchez (2010), SMEs in Colombia and other Latin American countries face logistics difficulties, such as a level of informality in their processes, a lack of infrastructure, reduced flexibility, and a decreased availability of human talent (Govindan and Bouzon, 2018). Other limitations are the short life of SMEs, high costs of loans, poor standards for innovations, and smuggling (Montoya et al., 2010). These issues suggest that SMEs should devote more attention to the business strategy towards sustainable development in order to obtain

competitive advantage, and it is reasonable that their process will differ from that of large enterprises.

SMEs represent, in aggregated terms, a significant amount of industries that mainly act as providers to larger enterprises (Talbot et al., 2007) and that generate environmentally harmful solid waste. Specifically, plastics make up 85% of marine debris worldwide (Feil et al., 2019). Because of the increased use of plastic in the market, researchers seek to explore recovery methods to avoid adverse effects to marine life. Incineration of plastics generates air pollution with negative effects to human health, and the disposal of plastics reduces the lifespan of landfills

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(Al-Salem et al., 2009). Plastic sectors represent a key initiative for SMEs in Colombia as highlighted by Peña-Montoya et al. (2015a), because this sector uses scarce and expensive raw material that may be recovered by strategies such as reverse logistics (RL), which allows costs to be reduced and negative impacts to the environment and society to be minimised or avoided.

According to Logožar et al. (2006) and Stewart and Ijomah (2012), it is a priority to extend RL research to manage waste sourced out of the manufacturing process. RL is a suitable strategy to support sustainable solid waste management (SSWM). However, it is necessary to identify context characteristics to confirm the relationship between RL and SSWM and to propose strategies directed to the integral benefit of the SMEs and the environment (Khalili-Damghani et al., 2015).

In this sense, a maturity model (MM) is an analysis and positioning tool that may promote learning and performance of the management practices in organisations. It is considered a conceptual model that includes a sequence of discrete levels of maturity for a group of processes in one or more domains, and the model should represent a desired or typical advancement route for these processes (Tarhan et al., 2016). Therefore, the main objective of a business MM is to describe the behaviour presented by a company in a given area and to provide a number of maturity levels for each aspect of the area under study (Fraser et al., 2002). However, studies linking MMs and RL are scarce (Janse et al., 2010; Kosacka-Olejnik and Werner-Lewandowska, 2018).

This study proposes an adapted MM for measuring the maturity levels of RL aspects of SMEs in the central and southern regions of Colombia, in order to contribute to SSWM. To attain this purpose, this article unfolds as follows. The next section establishes the theoretical background, while the following section presents the methodology. The research results and discussion are then demonstrated. Finally, the conclusions are stated, along with suggestions for future paths of research.

## Theoretical background

To build a theoretical foundation for this work, this section is divided into two topics: (a) SSWM and RL, and (b) MMs.

### *Sustainable solid waste management and reverse logistics*

When sustainability practices are included in enterprise efforts, such as solid waste management, temporal and spatial scales should be considered, as well as the inclusion of multiple backgrounds, in order to build a plural approach that allows for the participation of different actors (Gasparatos et al., 2009). Research that involves more than technical aspects is the key to sustainability in SSWM (van de Klundert and Anshütz, 2001; Vergara and Tchobanoglous, 2012).

Solid waste management is a manifold task that includes a diverse set of operations and shareholders (Massoud et al., 2019). Society and governments are challenged to consider the complexity

of solid waste management and the limits of the environment to face the pressure of resources' consumption and solid waste generation (Seadon, 2010; Shekdar, 2009). A suitable strategy to support SSWM is through RL, which provides a way to recover value from the materials that have diminished it (Kinobe et al., 2012).

According to Rogers and Tibben-Lembke (1999), RL is the process to plan, implement, and control the efficient flow and effective cost of raw material, process inventory, and finished products. Further, RL involves the flow of information from a consumption point to an origin point so as to recapture value or to dispose of it appropriately. Afterwards, Dekker et al. (2004) adjusts the concept to stress that consumption and origin points could be a manufacturing, distribution, or use point. In this way, this adjusted concept allows to include the devolutions generated from different reasons.

De Brito and Dekker (2004) point out that activities related to RL involve material recovery; therefore, activities involved are collection, inspection, sorting, recovery or reprocessing, and redistribution. Among the reprocessing options, there are the direct ones, such as reuse, and those that require processes, such as restoration, reconditioning, remanufacturing, recycling, and final disposal. The actors involved in these processes are retailers, distributors, manufacturers, and solid waste managers (De Brito and Dekker, 2004).

RL development has a significant effect on successful supply chain performance (Khalili-Damghani et al., 2015). Implementing RL within the supply chain can support operational, tactical, and strategic decision making, and may, for example, evaluate end-of-life options for returned products or define a suitable take-back policy (Jayant et al., 2012).

Traditionally, developed countries lead the world in their RL programmes (Rubio-Locoba et al., 2008). However, emerging and transitional economies are increasing their implementation of RL programmes to manage the materials that have diminished or depleted their value in the supply chain (Garcia-Rodriguez et al., 2013; Kinobe et al., 2012; Subramanian et al., 2014). In these countries, economic motivations are more important to recover value as a source of income and to avoid raw material extraction (Bouzon et al., 2015); nevertheless, more attention is needed to address social and environmental aspects (Peña-Montoya et al., 2013).

A weakness in the RL programmes of developing countries is the lack of a substantial link to the objectives of the SMEs. RL programmes are adopted according to the international trends without knowledge of the importance of the context and the particular characteristics of each sector and enterprise (Lambert et al., 2011). Therefore, it is necessary to identify context characteristics to confirm the relationship between RL and SSWM and to develop strategies directed to the integral benefit of the SMEs, the community, and the environment (Khalili-Damghani et al., 2015). In addition, strategies should take into account that responsiveness, known as the measures related to flow and time, is reported as the most important factor on RL performance.

Table 1 shows the complementary relationship between the two strategies (SSWM and RL) through practices widely reported in literature to each; it also shows the scope of each strategy related to the hierarchy of SSWM. Key articles regarding SSWM (Abarca-Guerrero et al., 2013; Shekdar, 2009; van de Klundert and Anschutz, 2001; Vergara and Tchobanoglous, 2012) and RL (Bing et al., 2014; De Brito and Dekker, 2004; Kinobe et al., 2012; Pokharel and Mutha, 2009; Stewart and Ijomah, 2012; Veiga, 2013) provide meaningful insights that confirm this relationship. For instance, RL supports SSWM in aspects such as localisation of reprocessing plants and flows allocation (Stewart and Ijomah, 2012). Similarly, RL provides optimisation methods to define transporting routes, frequencies, fleets, and crew involved in the routes (Ghiani et al., 2014). Finally, the RL scope

**Table 1.** Complementary relationship between sustainable solid waste management and reverse logistics.

SSWM	RL
<i>Generation and sorting</i>	
Prevention in solid waste generation; sorting at source is important to guarantee the following recovering of the materials (van de Klundert and Anschutz, 2001) Generation from different sources and managed by the municipality, increase of the generation owing to consumption patterns, data of generation are available in developed economies (Shekdar, 2009) Awareness, knowledge, and machinery affect significantly (Abarca-Guerrero et al., 2013)	Demands from sorting centres are considered (Bing et al., 2014)
<i>Collection</i>	
Selective collection is recommended if sorting at source is carried out, depending on the final destination of the solid waste (van de Klundert and Anschutz, 2001) Public participation, awareness, and cooperation in developed countries. Public participation is limited in developing countries (Shekdar, 2009) Collection affects the quality and amount of material to recover. The collection type depends on the level of industrialisation of the region (Vergara and Tchobanoglous, 2012) Collection and transportation represents between 80% and 90% of the SWM costs (Abarca-Guerrero et al., 2013) It is necessary to implement distinct operational schemes between urban centres and rural areas in Lebanon (Massoud et al., 2019)	Materials are taken from the point of consumption to a recovery one. Quality is inspected and a recovery option is decided afterwards (De Brito and Dekker, 2004) Location of collection centres (Pokharel and Mutha, 2009) Selective collection routes are designed (Coelho et al., 2011) Distribution channels, it is important to decide what type of material is collected from where and the quality conditions of them (Stewart and Ijomah, 2012) From the cities to the reprocessing centres (Bing et al., 2014)
<i>Transportation</i>	
Transportation efficiency is required since materials are driven separately. It is recommended to have a treatment site close to the source (van de Klundert and Anschutz, 2001) Standardised design of vehicles in developed countries. Different types of vehicles are used in developing countries owing to the differences in generation and management of the solid waste (Shekdar, 2009) From small to big trucks and from these to the landfill (Vergara and Tchobanoglous, 2012) Road networks, equipment, and personal availability are required in order to improve frequency (Abarca-Guerrero et al., 2013)	Materials are driven to different sites according to the recovery destination (De Brito and Dekker, 2004) Coordination with collection to predict the amount, quality, time, and price of the transported materials (Pokharel and Mutha, 2009) Transportation from the collection centres to the reprocessing centres (Coelho et al., 2011) Routes optimisation (Kinobe et al., 2012) It involves transportation and emissions costs (Bing et al., 2014) Transportation routes (Stewart and Ijomah, 2012) Transportation to temporal storage and to final disposing (Veiga, 2013)
<i>Storage</i>	
Promoting the use of the transfer centres to reduce the amount of solid waste to dispose (van de Klundert and Anschutz, 2001) It is possible to manage transfer centres for sorting solid waste (Shekdar, 2009)	Management of different materials from different sources create the need to inventory control (Pokharel and Mutha, 2009) Temporal storage (Veiga, 2013)

(continued)

**Table 1.** (Continued)

SSWM	RL
<i>Treatment</i>	
Recovering for incineration, anaerobic digestion, or similar processes (van de Klundert and Anschütz, 2001)	Some option of treatment is carried out (recycling, remanufacturing, energy recovering, etc.) (Pokharel and Mutha, 2009)
Recycling sector success depends on cost-effective methods determined by the purchasing power (developed or developing countries) (Shekdar, 2009)	Recycling or incineration, use in the productive cycle (Coelho et al., 2011)
Involves reduction of both size and volume; sorting of ferrous material (Vergara and Tchobanoglous, 2012)	Capacity of reprocessing centres is included (Bing et al., 2014)
Lack of knowledge and infrastructure to assess the quality of the materials recovered; it is required for community participation and support from the leaders; suitable infrastructure and equipment (Abarca-Guerrero et al., 2013)	Recycling or incineration (Veiga, 2013)
Delegate treatment to promote municipal cooperation by adopting different methodologies and technologies (Massoud et al., 2019)	
<i>Final disposal</i>	
Developed countries have suitable technologies in landfills involving high cost. In developing countries dumps are common and there are some efforts to adopt control in order to prevent environmental pollution (Shekdar, 2009)	Material unrecovered is driven to landfills (De Brito and Dekker, 2004)
Lead to the landfill only the solid waste that is not suitable to recover. Limited availability of resources in the regions lead to use of dumps. Regulation promotes the use of landfills (Vergara and Tchobanoglous, 2012)	
Legal framework, suitable infrastructure, and equipment are needed (Abarca-Guerrero et al., 2013)	
Decentralise disposal that would limit the number of landfills and facilitate their operation and monitoring (Massoud et al., 2019)	

SSWM: sustainable solid waste management; RL: reverse logistics; SWM: solid waste management.

and utility remain even after accounting for solid waste treatment options related to the distribution of reprocessed materials to different links in the supply chain.

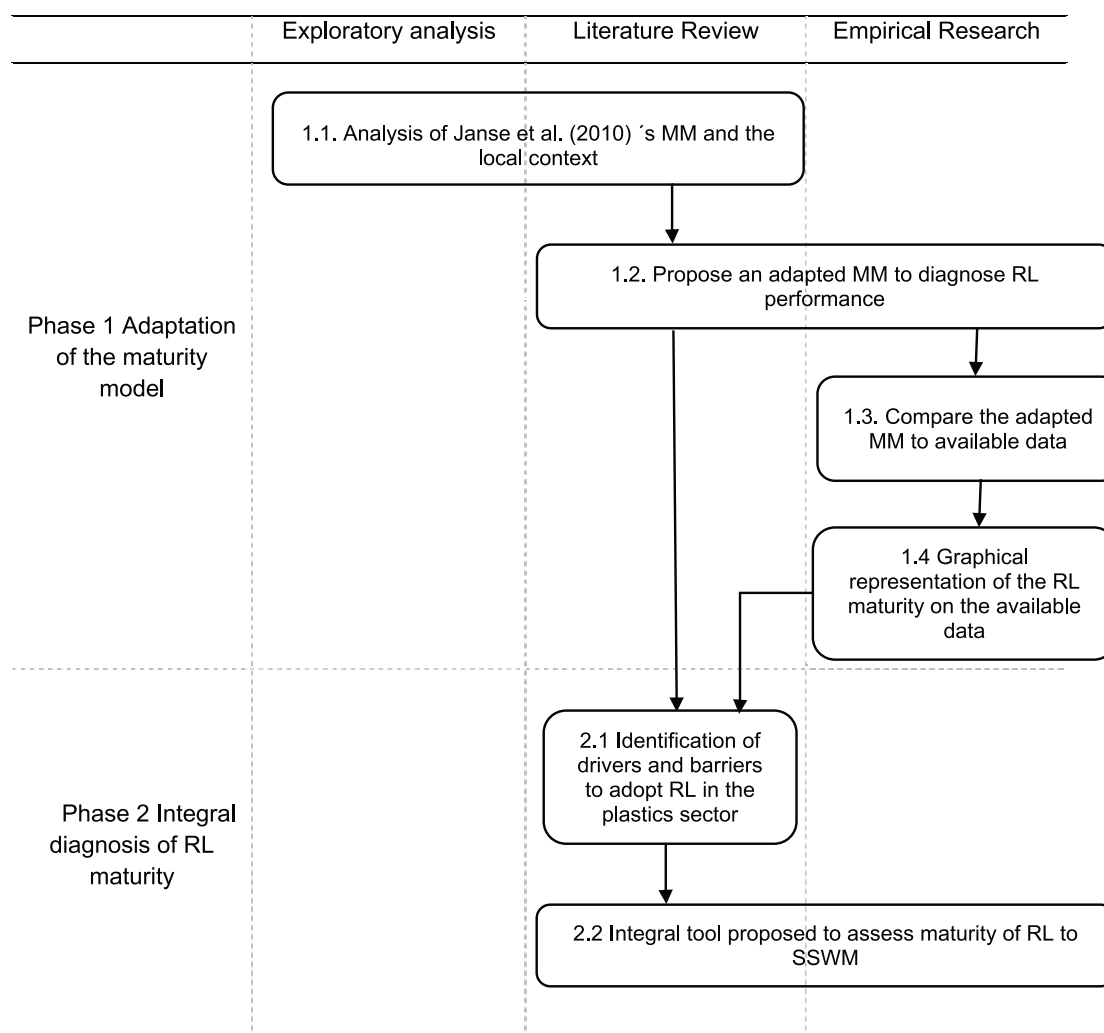
Although De Brito and Dekker (2004) state that RL and SSWM are conceptually different, they have common issues that are important to recognise in order to approach the difficulties (i.e. growth of waste, reduce of lifespan in landfills) originated by current production and consumption patterns. These difficulties can be tackled by assessing the maturity for RL at SMEs to determine the grade to which they are prepared to perform this strategy and strengthen the complementary between RL and SSWM.

### *Maturity model*

MMs describe the development of an entity over time (Cuenca et al., 2013); they are also a set of practices that define the level of formality, sophistication, and integration of practices from a basis state to an improved state (Bititci et al., 2015). The value of a MM relies on it serving as an analysis and positioning tool (Duffy, 2001) that promotes organisational learning and performance of the management practices of the organisations (Bititci

et al., 2015). Thus, the analysis and evaluation of organisational maturity is essential in the pursuit of excellence. Organisational maturity is the result of business process maturity resulting from the activities of the organisation and the maturity of the teams that perform these processes (Stachowiak and Ole ków-Szłapka, 2018). Regarding publications on the topic, the number of MMs proposed recently has increased considerably. Nevertheless, there are a number of inherent difficulties to consider, such as the limited empirical studies on their practical validation (Tarhan et al., 2016), as the one proposed in this article.

In terms of sustainability, Correia et al. (2017) provide a systematic review of the existing literature on MMs related to supply chain sustainability. Among their main findings, they observe the reduced number of studies involving sustainability and MMs and the lack of validations of the proposed models. MMs are able to be repeated; however, individuals add their own knowledge to adapt the proposed models according to the subjects under assessment. For instance, MMs may be employed to assess the performance in projects (Brookes et al., 2014), in process measurement (Bititci et al., 2015), in sustainability initiatives (Correia et al., 2017), and in key strategic business issues (Duffy, 2001).



**Figure 1.** Methodological approach.

MM: maturity model; RL: reverse logistics; SSWM: sustainable solid waste management.

Concerning logistics maturity models (LMMs), Battista et al. (2012) proposed a MM that allows both to assess their logistic processes' current status and to provide an action plan for improvement. This MM considers four key elements: maturity framework, modelling framework, performance framework, and improvement systems. However, the authors did not consider RL aspects in their MM.

If one focuses on the RL domain, studies relating to MMs and RL are scarce (Janse et al., 2010; Kosacka-Olejnik and Werner-Lewandowska, 2018). Janse et al. (2010) proposed a MM including RL aspects to assess the extent to which a company can fulfil the specific requirements associated with it. This model proposes four levels for maturity (immature, naïve, semi-mature, and mature) based on the companies' performance in the RL dimensions. Kosacka-Olejnik and Werner-Lewandowska (2018) proposed a cross-company MM for RL assessment, which is process-oriented, but which also considers RL stakeholders and many types of material flows and resources consumed. However, their MM does not consider RL barriers that involve building a roadmap for improvements in RL processes.

Articles dealing with RL and performance evaluation appeared over the last years (i.e. Govindan et al., 2012; Pandian and Abdul-Kader, 2017; Shaik and Abdul-Kader, 2014). However, a performance evaluation model differs from a MM, since the last one aims not only to provide the state of development of a certain process/area, but also to assess and to improve the capabilities, such as skills or competencies, of business processes.

Finally, previous studies for the implementations of RL in different contexts are available, including RL drivers (Lau and Wang, 2009; Subramanian et al., 2014) and barriers (Bouzon et al., 2018; Cure-Vejollín et al., 2006; Halabi et al., 2013; Monroy and Ahumada, 2006; Peña-Montoya et al., 2015a; Pirachicán-Mayorga et al., 2014). These studies allow researchers to structure and assess MMs since they provide information to verify to what extent RL is developed in a particular context.

## Materials and methods

The study was carried out at SMEs in the plastics sector in the central and southern regions of Colombia. As aforementioned,

**Table 2.** Internal and external drivers and barriers in the local context.

Internal	Drivers	ID1. Skilled personnel in solid waste management ID2. Financial availability to invest on infrastructure and training ID3. Connections and influences to call for participation ID4. Responsibility and ethical values to accomplish the current regulations	
	Barriers	IB1. Lack of commitment of the stakeholders IB2. Lack of information technology systems IB3. Focusing on operational and productive issues IB4. Lack of investment on environmental aspects	
	External	Drivers	ED1. Cooperation among the supply chain actors ED2. Incentives to effective solid waste management ED3. Environmental awareness and community participation ED4. Availability and control of environmental management policies in the industry
		Barriers	EB1. Perception of poor quality of recovered materials EB2. Absence of secondary markets EB3. Absence of legal support and regulations accomplishment EB4. Weak information systems for solid waste management EB5. Unfair competition and free markets that discourage solid waste management

Source: Peña-Montoya et al. (2015b).

this sector is key to manage solid waste originated in the production process; however, materials are not being recovered, which affects the environment negatively and increases the costs. Figure 1 summarises the methodology of this research.

### *Adaptation of the maturity model*

In this research, the MM proposed by Janse et al. (2010) was adapted in order to diagnose the performance of RL at SMEs in the plastics sector in the central and southern regions of Colombia. The Janse et al. (2010) MM was chosen because it was the only MM proposed to assess RL performance as of the date of our current study, confirmed by means of a literature review in journal articles and databases. An exploratory analysis was conducted for the adaptation of the MM; this step consisted of an analysis of the local context related to the plastics sector in the central and southern regions of Colombia.

Based on the literature review from journal article databases and the summary presented in Table 1, MM adaptation was performed. The expertise of the participating researchers in subjects such as SSWM and RL was the basis to the empirical research that allowed the adaptation of the Janse et al. (2010) MM. This adaptation involved removing the remanufacture and commercialisation aspects, since they both are out of the scope of this research. The sustainability aspect to manage solid waste was included; this aspect involves economic, social, and environmental dimensions. In summary, the model involved three aspects and eight dimensions. According to Batenburg et al. (2014), the MM element called 'level' is used to verify if a model has a reasonable number of maturity levels. Typically, the number of levels ranges from four to six. For the present article, the MM uses four maturity levels between one (1) and four (4), with four (4) being the highest mature level.

Afterwards, the adapted MM is tested with regard to Halabi et al. (2013)'s research that presents a diagnosis of the RL in five

SMEs in the plastics sector in the central region of Colombia. Moreover, the results of semi-structured interviews carried out with collaborators of the SMEs at a southern region of Colombia were analysed under the adapted MM. There were seven SMEs from the plastics sector, in total, and ten collaborators responded to the semi-structured interviews. This study was performed from March 2016 to January 2017.

Researchers of this study allocated a maturity level to the results of the companies based on the information adapted to the MM. The average diagnosis was represented graphically and provided results of the eight dimensions and the maturity level. A score of four (4) for all dimensions represents an ideal level of maturity.

### *Integral diagnosis of reverse logistics maturity*

The drivers and barriers for the adoption of RL in the plastics sector were identified in the research by Peña-Montoya et al. (2015a) (see Table 2). Through empirical research based on the researchers' expertise, the adapted MM was related to the drivers and barriers suggested to the plastics sector to provide a tool by which to diagnose RL maturity. The tool allows verifying the effect of drivers to favour the maturity levels and to confirm whether the barriers favour the immaturity levels.

## **Results and discussion**

Two main phases were developed and results are presented according to Figure 1.

### *Adaptation of the maturity model*

Table 3 shows the adapted model for diagnosing the implementation of RL at SMEs in the plastics sector in the central and southern regions of Colombia. The model allows to assess the

**Table 3.** Maturity of the business in reverse logistics: Adapted tool.

Aspect	Dimension	Maturity levels			
		Level 1 Immature	Level 2 Naive	Level 3 Semi-mature	Level 4 Mature
Business strategy	Integration of RL in the supply chain strategy	RL is attached to supply chain strategy	RL is secondary to supply chain strategy	RL is semi-integrated to supply chain strategy	RL is integrated to supply chain strategy
Strategy and objectives of the reverse supply chain	RL management as a key process in the business	RL is irrelevant and drive to costs	RL processes are important but people are unaware of how to manage them	Strategic approach of RL that generate costs and value	RL is a strategic process that generates value
	Holistic approach of supply chain	Isolated approach to manage RL in each link of the reverse chain	Cross-functional approach to manage RL	Integral approach in the whole supply chain to manage RL	Full approach of the supply chain to manage RL
	Clear objectives of the RL management	No clear objectives	Objectives are clear in few of the processes	Objectives are clear in several of the processes	Objectives are clear in all of the processes
	Alignment with the business objectives	RL operations are not aligned with the business objectives	RL operations are partially aligned with the business objectives	RL operations are aligned with the business objectives	RL operations are aligned with the business objectives and with the market development
Sustainability	Employees and shareholders	RL operations are unknown and there is no participation	RL operations are superficially known and participate from some of them	RL operations are known and participate from some of them	RL operations are known and promote the participation in most of them
	Infrastructure and equipment	Work is done with the same equipment and there is not suitable infrastructure	Acquisition of some equipment and some infrastructure modifications	There is a fixed budget for the next 5 years for equipment and infrastructure	Budget is reviewed and allocated each year for investment in equipment and infrastructure
	Environmental management	Mandatory practices of environmental management are adopted	Mandatory and some voluntary practices of environmental management are adopted	Integral practices are adopted and also certifications	Specialised evaluations and monitoring the impact of RL operations

RL: reverse logistics.

Source: Adapted by permission from Springer Nature Customer Service Centre GmbH (Janse et al., 2010).

performance of the SMEs at three aspects: Business strategy, strategy and objectives of the reverse supply chain, and sustainability. However, there are dimensions within each of these aspects. For each dimension it is necessary to assess the four levels of maturity according to the current performance of the SME. The design of the MM should consider its progress across key indicators for the organisations to be self-assessed frequently; hence, it facilitates organisational learning and continuous improvement of managerial capabilities (Bititci et al., 2015). Nevertheless, MMs must be under constant revision for best performance (Duffy, 2001). The model depicted in Table 3 represents a formal assessment tool to confirm the implementation of RL at SMEs, as stated by Cuenca et al. (2013). This model reflects data that is in spite of the early development of RL in Colombia (Peña-Montoya et al., 2016).

As stated in Table 3, the mature level is characterised by the integration of RL within the business strategy, thus generating

value for the supply chain. Moreover, RL requires allocation of resources to operate adequately; managers must make them available through structured budgets. In fact, MMs like this reveal fundamental information for the organisations about the current position regarding RL and the actions that should follow in order to exceed the basic position (Duffy, 2001). On the contrary, an immature level considers unnecessary RL and leads the organisation to higher costs and a lack of managerial commitment to allocate resources for RL operations.

Additionally, Table 4 shows the dimensions of the adapted tool (Table 3) compared with the results from Halabi et al. (2013) who stated the situation of RL in five Colombian SMEs. Moreover, Table 4 exposes the results from interviews carried out to collaborators at two SMEs as a part of this research. According to the results, it is important to notice that RL is not recognised as a strategy to support solid waste management; this finding is opposite to the complementary of RL and SSWM shown in Table

**Table 4.** Application of maturity model to small to medium-sized enterprises.

Aspect	Dimension	Halabi et al. (2013) Summary of five SMEs	Chair and components for vehicle manufacturing	Battery boxes manufacturing
Business strategy	Integration of the RL in the supply chain strategy	RL supply chain is operated by the raw material and components providers, also they manage the solid waste collection	It is not integrated; RL is not practiced	Application of RL is known as solid waste management
Strategy and objectives of the reverse supply chain	RL management as a key process in the business	It is not integrated in the business strategy	Production is the key process	Operation process are fundamental, also meeting the deadlines to customers
	Holistic approach of supply chain	Only providers take benefits from RL	Do not exist. The company itself recovers the material from the processes and reuse it in the processes	Do not exist. Scrap from raw material is recovered by milling. Foreign recycled material is also used
	Clear objectives of the RL management	The objective is to save production costs and raise profits	Costs savings	
	Alignment with the business objectives	RL is not aligned with the business objectives	RL is excluded from the mission, vision, and objectives	RL objectives are unclear and they are not aligned with the business objectives
Sustainability	Employees and shareholders	Sorting is carried out	They know some solid waste management operations but isolated from RL	RL is a new topic. Some solid waste management operations are carried out
	Infrastructure and equipment	Facilities are inadequate to RL operations. There are no specialised and trusted RL service providers. The informal recyclers recover the material at their facilities	There is a miller in the same infrastructure	
	Environmental management	Compulsory and voluntary practices are adopted		

RL: reverse logistics.

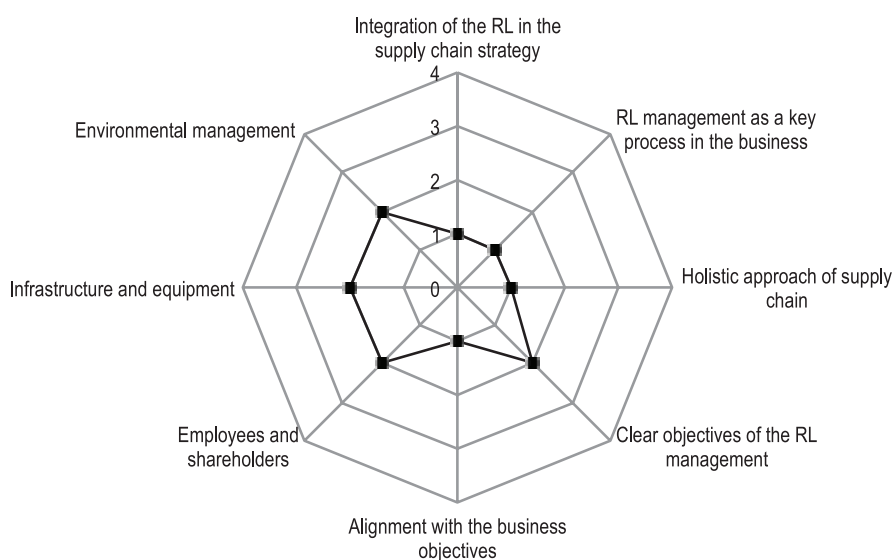
1. Besides, the SMEs focus on their operations and little attention is devoted to additional strategies such as RL; sorting is performed among RL activities. The sustainability aspect in RL is weak, mainly because RL results in previous dimensions of the business strategy and the incipient objectives of the supply chain.

Figure 2 represents the maturity level at SMEs in the plastics sector in the central and southern regions of Colombia according to the results obtained from comparing Table 4 subject to the guidelines in Table 3. Note that the RL maturity levels are clearly defined for each dimension in Table 3. Hence, the SMEs' RL self-assessment in these dimensions (Table 4) must be carefully compared with the guidelines in Table 3. Next, the researcher assigns a maturity level to the SMEs' assessment based on his/her expertise. It is strongly recommended to design the interview to match, as closely as possible, the information in each maturity level to avoid any interpretive bias. Figure 2 depicts the average levels achieved from the seven SMEs derived from the comparison of the information in Table 4 to the guidelines in Table 3. For example, the maturity level is ranked as naïve in the objectives of RL,

employees and shareholders, infrastructure and equipment, and environmental management dimensions, which indicates that some drivers are recognised to link these dimensions with the general strategies of SME businesses. However, there are still barriers to overcome in order to reach the next level. The score in the remaining dimensions is immature, representing that RL is not recognised as a business strategy and, moreover, that the limiting barriers remain unidentified in order to reach the upper levels. The implication of this finding is related to the incipient development of RL in Colombia and the trend to adopt business models developed in other countries; apparently, the particular conditions of SMEs in Colombia remain unrecognised (Peña-Montoya, 2016). Therefore, further work is needed between managers and practitioners to move forward to achieve a mature level in all the dimensions. As stated by Janse et al. (2010), managing RL requires collaboration of all departments and actors in the supply chain.

This adapted MM is different from the approach presented by Shaik and Abdul-Kader (2018) to measure the performance of





**Figure 2.** Maturity level of reverse logistics at plastics small to medium-sized enterprises. RL: reverse logistics.

RL enterprises by considering performance attributes, such as product lifecycle stages, strategies, processes, capabilities, and perspectives and measures. There are two main differences: First, the focus of this adapted MM is on linking RL to contribute to SSWM, and second, the specific sector is plastics. Previous studies were taken as foundational to a discussion of drivers and barriers that propose a diagnosis by which to assess maturity of RL.

Furthermore, this adapted MM also differs from the proposal by Kosacka-Olejnik and Werner-Lewandowska (2018), who proposed six achievements for the RL maturity framework: Physical network, formalisation, structuration and performance measurement, information flow and data exchange, optimisation, and stakeholders' relations and engagement. Further, this adapted MM focuses on three main aspects, which are business strategy, objectives of the reverse supply chain, and sustainability; all of them are oriented to SSWM.

Finally, Janse et al. (2010) provided the basis for this proposed MM; nevertheless, they tackled the case of the consumer electronics industry and exposed a fictitious case to illustrate their model's performance. In summary, the use of MM-based assessments supports the development of managerial capabilities of SMEs (Bititci et al., 2015). Despite the SMEs' focus being mainly on operational aspects, revealing the value of MM to processes measurements allows them to rely on this formal tool to assess their performance (Bititci et al., 2015).

### *Integral diagnosis of reverse logistics maturity*

The results of the relation of both the adapted MM shown in Table 3 and the drivers and barriers proposed by Peña-Montoya et al. (2015b) are demonstrated in Table 5. For example, the dimension 'Clear objectives of the RL management' is fundamental to take into account the performance of internal driver 1 (ID1, skilled personnel in solid waste management) and external drivers 3 and 4 (ED3, environmental awareness and community

participation, and ED4, availability and control of environmental management policies in the industry). Those drivers suggest a high maturity level, and the dimension with persistence of barriers is a sign of a low maturity (Janse et al., 2010). Immaturity in one area can affect successes in other areas; therefore, a change in the maturity level is not smooth in the dimensions and requires effort from the participants to achieve their desired goal performance (Duffy, 2001).

It is recommended to diagnose the RL maturity grade at SMEs that apply the adapted MM to obtain an initial diagnosis. Then, it is necessary to assess drivers and barriers and, finally, to apply the integral diagnosis tool to evaluate the RL performance towards SSWM.

### **Conclusion**

This research proposes an adapted MM for measuring the level of maturity of RL aspects of SMEs in the central and southern regions of Colombia. In this research, RL is focused on the link to the SSWM of SMEs. Research on RL has primarily focused on managing inventory excess and devolutions, so this approach provides meaningful insights with which to structure a framework to link RL and SSWM.

The assessment of the model suggests that performance of SMEs in the plastics sector in central and southern regions of Colombia ranges from naïve to immature levels for RL and SSWM; therefore, it is recommended to apply the model to gradually advance from level 1 to level 4. For achieving this, SMEs must be available to undertake SSWM by means of RL. The process becomes possible by presenting a holistic vision of the organisation, by paying attention to the effective use of resources, and by assessing the effects of the operations to the environment and society with the goal of improving the decision-making process related to RL for SSWM. It is also necessary to stress the role of identifying the drivers and barriers for RL to SSWM

**Table 5.** Integral diagnosis tool for maturity of reverse logistics.

Dimension of MM	Relationship with drivers and barriers exposed by Peña-Montoya et al. (2015b)
Integration of the RL in the supply chain strategy	ID3, ED1, EB2, EB3, EB5
RL management as a key process in the business	ID4, IB1, IB3, IB2
Holistic approach of supply chain	ID3, ED1, EB1, EB2
Clear objectives of the RL management	ID1, ED3, ED4
Alignment with the business objectives	ID2, ID4, ED3, IB1, IB3, IB4, EB3
Employees and shareholders	ID1, ID2, IB1
Infrastructure and equipment	ID2, ED2, IB2, EB4
Environmental management	ID1, ID4, ED2, ED3, ED4, IB4

MM: maturity model; RL: reverse logistics.

implementation in order to achieve higher maturity levels. It is expected that the adapted MM can be used at SMEs in developing countries that want to strengthen RL to SSWM regardless of the industrial sector.

The main managerial implication of this research is that the adapted model provides a starting point for managers at SMEs in the plastic sector to consider dimensions and maturity levels to link RL and SSWM. The availability of this key information allows managers to make better informed decisions regarding a subject of knowledge, which is between consumption and recovering patterns in order to contribute to sustainability.

The value added of this article entails the assessment of the performance of SMEs in RL dealing with solid waste management, which contributes to sustainability issues, such as reducing the pressure to extract virgin raw material and to expand the lifespan of the landfills. This progress, in turn, contributes to meet Sustainable Development Goals like responsible production and consumption issued by the United Nations (2015). Therefore, this work has a strong link with sustainability concerns as it has been also included in the proposed MM. Additionally, RL has usually reported the material recovery from sources, such as excess of inventory or returns (De Brito and Dekker, 2004); nevertheless, this article deals with solid waste management inside SMEs. This fact promotes the assessment of RL by means of MMs so as to improve the performance of the SMEs in this field. Finally, this research provides meaningful insights to Latin American research regarding RL as a benchmark to include within the National Policy of Solid Waste; this is the case of Brazil National Policy of Solid Waste (Brazil, 2010), Law No. 12305. Currently, Circular Economy is included in the National Policy of Integral Solid Waste Management for Colombia (National Planning Department, 2016). A remarkable step forward in the topic would be to include RL principles as well.

The fact that this adapted model was tested by seven SMEs in the plastic sector in the central and southern regions of Colombia represents a limitation. Future studies may wish to recognise that the results are generalised to SMEs in the plastics sector in Colombia.

Further research is proposed to test the adapted model to a bigger sample of SMEs in the same regions and other different regions in the plastics sector to generalise the results to that

particular sector. Once the adapted MM has been broadly proven, it can be tested to other sectors that are engaged to RL initiatives. The adapted MM for RL can also be applied in SMEs from other developing countries for even broader comparisons.

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