

# Reverse logistics in the plastics subsector: Main facilitators and barriers

## Logística de reversa en el subsector de plásticos: principales facilitadores y barreras

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### ABSTRACT

Industrial solid waste (ISW) is increasing in both quantity and complexity, and it is a priority to establish strategies in order to manage it. Reverse Logistics (RL) is a strategy that enables material recovery and reuse, avoiding the damage that ISW may cause; it also organizes solid waste management activities and supports other activities such as ISW trading. Most of the research linking ISW and RL in developed countries is related to the electronics subsector due to the negative effects on the environment; however, research oriented towards plastics subsector waste is lower. This is the case in Colombia, where the plastics subsector is composed mainly by small and medium-sized enterprises (SMEs) facing diverse constraints for their operation. Main facilitators and barriers that face SMEs in the Colombian plastics subsector to undertake RL programs were identified. An exploratory study in which business managers assessed facilitators and barriers identified in scientific literature was carried out. The results showed that the availability of skilled people to perform RL activities is one of the most important internal facilitators, and that the lack of secondary markets for recovered materials is among the external barriers. The findings contribute to the body of knowledge in the field that is still maturing in Colombia.

**Keywords:** Barriers, facilitators, industrial solid waste, reverse logistics, small and medium sized enterprises.

### RESUMEN

Los residuos sólidos industriales (RSI) están incrementando en cantidad y complejidad, y es prioritario establecer estrategias para gestionarlos. La logística de reversa (LR) es una estrategia que permite la recuperación y reutilización de materiales, evitando el daño que los RSI causan; también organiza las actividades de gestión de residuos sólidos y apoya otras actividades como comercialización de RSI. La mayoría de las investigaciones en países desarrollados que vinculan RSI y LR se dan en el subsector de aparatos electrónicos debido a los impactos negativos sobre el ambiente; no obstante, se publica en menor cantidad acerca de los residuos plásticos. Este es el caso de Colombia, donde el subsector de plásticos se compone principalmente de pequeñas y medianas empresas (Pymes), las cuales enfrentan diversas limitaciones para su funcionamiento. En este estudio se identificaron los principales facilitadores y barreras que enfrentan las Pymes del subsector plásticos en Colombia para la implementación de programas de LR. Se llevó a cabo un estudio exploratorio en el cual empresarios valoraron los facilitadores y barreras identificados en literatura científica. Los resultados mostraron que la disponibilidad de personal capacitado para desarrollar actividades de LR es uno de los facilitadores internos más importantes, y que la falta de mercados secundarios para los materiales recuperados está entre las barreras externas. Los hallazgos contribuyen al conocimiento en un área aún en desarrollo en Colombia.

**Palabras clave:** Barreras, facilitadores, residuos sólidos industriales, logística de reversa, pequeñas y medianas empresas.

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### Introduction

Industrial solid waste (ISW) produced by industrial operations is increasing worldwide due to population growth and consumption patterns. In addition, products and processes have increased in complexity in order to meet these needs. Therefore, both the volume and complexity of ISW have increased. This situation encourages decision makers to adopt strategies to improve industry's interactions with the environment in order to preserve natural resources and the general welfare.

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Nevertheless, before adopting such strategies it is important to note that understanding solid waste management practices, particularly in developing countries, still requires significantly more attention from government, industrial sectors and communities in order to promote research on reducing generation, recovering options, and public environmental awareness (Kinobe et al., 2012). In developing countries it is common to find a large body of research regarding management of electrical and electronic waste; however, sectors like the plastics industry have received minimal attention despite its environmental negative effects (Subramanian et al., 2014).

This article presents the partial results of a major project on recovering strategies of material such as plastics by means of Reverse Logistics (RL). The project is focused on SMEs in Colombia, where RL practices are in an early stage of development, and therefore it is important to explore the local characteristics instead of adopting reported experiences. The aim of this study is to identify the internal and external facilitators and barriers faced by SMEs in the plastic sector in a Colombian region, as they seek to implement RL programs. The following section provides a background on the main topics of the research; after this, the exploratory methodological approach used in this study is presented. Then the main facilitators and barriers assessed by the actors in the SMEs are discussed in the results section. Finally, some conclusions are presented.

## Background

*Reverse logistics:* Effective solid waste management can be affected and related to reverse logistics (RL) activities. RL is a tool to manage used products from consumption to a recovery point, and provides opportunities to sustainably manage ISW by integrating economic, environmental, legal, commercial, and social objectives (Rogers & Tibben-Lembke, 1998). RL also comprises coordination, route optimization, and innovative materials handled in solid waste management (Kinobe et al., 2012). RL supports reuse and helps to avoid damages that ISW may cause, organizes solid waste management activities, and supports other activities such as ISW trading (Starostka-Patyk & Grabara, 2010).

RL is regarded as a low value added in developing countries because of the low reprocessing of waste materials due to the lack of knowledge on recycling and remanufacturing (Kinobe et al., 2012). Characteristics such as limited legislation, social inequalities, low availability of economic resources, lack of public infrastructure, and low scores in logistics performance may have a negative impact in the development of RL (Thiell et al., 2011). In order to promote RL, it is necessary to increase both the support from government by introducing legislation and providing incentives and the commitment from key actors in the supply chain to invest in infrastructure and technology (Abdulrahman et al., 2014; Lau & Wang, 2009; Subramanian et al., 2014). Additionally, RL experiences in developed countries are not easily adapted for developing countries because the characteristics to support and manage LR are different (Lau & Wang, 2009).

Some developing countries like Brazil have established national policies on Integrated Solid Waste Management and RL; however, there are still constraints such as the lack of collaboration among the supply chain actors and expert knowledge in the field (Lopes de Sousa et al., 2014). RL experiences in emerging countries are scarce and the early stage programs reported are related to large enterprises that support their programs on the experiences reported in developed countries (Monroy & Ahumada, 2006). Nevertheless, smaller manufacturers can follow the examples of leading large enterprises, which have more resources and stronger capabilities to take a lead and invest in RL (Lau & Wang, 2009).

The mentioned constraints directly impact the efforts from small and medium-sized enterprises (SMEs) to adopt RL programs because they lack resources and need a greater effort to allocate them in an optimal way (González-Torre et al., 2010). SMEs are key players in global supply chains by acting as subcontractors, suppliers or distributors (Talbot et al., 2007). They also represent the largest number of companies in the industrial sector composition; therefore they produce solid waste in aggregated terms (Talbot et al., 2007).

Some recent research is available involving plastic sector and reverse logistics as stated by Coelho et al. (2011), Bing et al., (2012) and Halabi et al., (2013). However it is still required to have primary information regarding facilitators and barriers associated to the SMEs in the plastic sector in a developing country so as to promote RL practices.

*Colombian context:* The plastics sector in Colombia is integrated by facilities that process plastics, chemicals, petrochemical, paint, ink, rubber, and plastic fibers (Garay-Salamanca, 2012). For 2012 the transformation of plastics was represented by 663 facilities (92% were SMEs) and contributed 3.6% to gross industrial production (Asociación Colombiana de Plásticos, ACOPLASTICOS, 2014).

The plastic sector in Colombia faces constraints regarding the high costs of transportation and electrical power supply, poor quality of transportation network and harbors, and the increase of imports from countries such as Peru, Ecuador and China (Garay-Salamanca, 2012). Nevertheless, the sector is willing to improve its performance with strategies to promote recycling among the members, regardless of the existence of regulations on recyclable materials and RL (Halabi et al., 2013).

Plastic solid waste's adverse environmental effects are associated with the large accumulation of waste from the use of low biodegradable plastics. In addition, land issues arise from reduction of the landfills' life span because of the volume occupied by the waste. Plastic waste also produces greenhouse gases when incinerated, affecting human health by gas inhalation and the pollution of groundwater by ashes (European Commission, 2011).

Yet, Colombia still lacks an overarching legal framework for waste management to provide a comprehensive and consistent guide for action (OECD/ECLAC, 2014). For instance, there is insufficient information regarding non-

hazardous industrial waste policies, allowing most of it to be disposed without exploring recovery options.

## Methodology

An exploratory study was carried out involving a scientific literature review in order to identify the main facilitators and barriers; next, it was necessary to verify the adaptation of these to the local context and the sector. Once the set of facilitators and barriers was defined, actors in the plastic sector were asked to assess them by means of a questionnaire. Finally, the results were processed.

### Set of facilitators and barriers

*Literature Review:* A set of facilitators and barriers was identified from the literature review dealing with the above-mentioned issues in RL. The articles chosen involved a variety of sectors and countries, as well as issues regarding RL at SMEs.

### Definition of facilitators and barriers within the local context

*Assessment by members of the research group:* The set obtained was reviewed by members of the research group who analyzed it according to their expertise on both supply chain and solid waste management topics. Moreover, the regulations regarding solid waste management and the development of the RL issues in the Colombian context were considered.

### Field work across SMEs

*Questionnaire design:* A questionnaire that included general information of the company was designed. This information included the number of employees, activities performed in RL, and the main source of waste stream. Additionally, internal and external facilitators and barriers were included. A five point Likert scale (1: strongly disagree; 5: strongly agree) was used to evaluate the respondent's position. A pilot study among 10 key people representing academic and manufacturing sectors was used to improve the questionnaire.

*Data gathering:* The questionnaire was handed out during a four-month period, between April and July 2013, to selected SMEs in the plastic sector according to a public database. The profile of the responders ranges from managers and directors in environmental management, to supply chain, and solid waste management topics. Although 66 responses out of 200 were retrieved, only 26 met the criteria of being both SMEs and plastic sector companies.

### Assessment

*Descriptive statistics:* This analysis was carried out for the general information provided in the first section of the questionnaire.

*Assessment Index:* An assessment index (Equation (1)) was proposed to classify the responses from the Likert scale in

the second section of the questionnaire. The values of the assessment index range from a scale between 0 and 100%, being of low importance those values between 0 and 33%, medium importance between 34% and 66%, and high importance more than 67%.

$$\begin{aligned}
 D_i &= \frac{\left(\sum_{i=1}^E x_i\right) - E}{C - E} \times 100 \\
 &= \frac{\left(\sum_{i=1}^E x_i\right) - E}{(E \times 5) - E} \times 100 \\
 &= \frac{\left(\sum_{i=1}^E x_i\right) - E}{4E} \times 100
 \end{aligned}
 \tag{1}$$

$x_i$  = Assessment to question I,  
 $E$  = Number of effective responses  
 $C$  = Maximum possible score ( $E \times 5$ )

## Results

### Set of facilitators and barriers

The review of the research articles provided a set of both internal and external facilitators and barriers. Some of the articles referred only to barriers (Abdulrahman et al., 2014; González-Torre et al., 2010; Ravi & Shankar, 2005; Sasikumar & Haq, 2010) or facilitators (Subramanian et al., 2014), and some of them approached both facilitators and barriers (Almada et al., 2013; Janse et al., 2010; Lau & Wang, 2009; Zoeteman et al., 2010). Even though the articles from Colombia addressed a broad number of topics, they provided some insights regarding the barriers for RL in the Colombian industry (Cure-Vejollín et al., 2006; Halabi et al., 2013; Monroy & Ahumada, 2006; Pirachicán-Mayorga et al., 2014).

It can be highlighted that some of the articles made a difference among internal and external issues, while other articles presented these without any classification. Most of the articles referred to Asian countries, the electronics sector, and SMEs. Facilitators and barriers identified by the authors depended on the sector and the context. The facilitators and barriers have been classified into internal and external according to the description provided in the articles; additionally, those with similar meaning were grouped under the same label.

Most of the reviewed articles involved issues in developing countries and SMEs, therefore their situation was close to the industries targeted in this study. Integration and coordination with supply chain partners, production cost reduction, and opportunities to open new markets were mentioned more often as the main facilitators (Abdulrahman et al., 2014; Janse et al., 2010; Lau & Wang, 2009; Subramanian et al., 2014; Zoeteman et al., 2010).

The reviewed articles mainly referred to barriers such as financial constrains and high costs, lack of awareness about

the benefits of RL practices, lack of managerial commitment, lack of collaboration with supply chain partners, lack of information technology systems, lack of trained personnel, and regulations regarding RL practices (Abdulrahman et al., 2014; Cure-Vejollín et al., 2006; González-Torre et al., 2010; Janse et al., 2010; Lau & Wang, 2009; Ravi & Shankar, 2005; Sasikumar & Haq, 2010).

It is worth pointing out that facilitators were fairly mentioned, while barriers were identified in a major basis due to the general context of SMEs in developing countries where it is common that the lack of financial resources and weak regulations limit their smooth performance in RL. In fact, financial constraints are strategic barriers because they have an effect on the investment in personnel training, infrastructure, and information technology systems (Ravi & Shankar, 2005). Additionally, the lack of enforceable legislation on solid waste management (i.e. the take-back, RL, Extended Producer Responsibility) and the lack of incentives from the government may reduce motivation to invest on training of personnel, infrastructure, and technology (Abdulrahman et al., 2014). As suggested by Monroy & Ahumada (2006), the recovery activities in Colombia were performed mainly by large companies, which have the availability to invest in infrastructure and technology; however, some SMEs performed recovering activities in a much lower basis.

**Definition of facilitators and barriers within the local context**

It was necessary to choose the facilitators and barriers that better fit the local context. Due to the early stage of development of RL in Colombia, there is minor recognition of the facilitators; for instance, metrics, design for recovery, reduction of production costs, and demand for green products (Lau & Wang, 2009; Subramanian et al., 2014) were removed from the analysis and the reminders were adapted according to the local conditions. Additional facilitators including connections and influences to call for participation and responsibility and ethical values to accomplish the current regulations were added to the assessment in the local context.

The main barriers reported in the local context were based on financial issues such as the lack of training, the lack of investment, the lack of information technology systems, and the lack of appropriate facilities and technologies; other barriers reported were the lack of regulations and the lack of awareness (Cure-Vejollín et al., 2006; Halabi et al., 2013; Monroy & Ahumada, 2006; Pirachicán-Mayorga et al., 2014). Some barriers reported in international scientific literature were withdrawn from the assessment because they are far from applying to the local context; these barriers are the lack of collaboration with partners in the supply chain (Abdulrahman et al., 2014; González-Torre et al., 2010; Ravi & Shankar, 2005; Sasikumar & Haq, 2010; Zoeteman et al., 2010) and the lack of take back and return policies (Cure-Vejollín et al., 2006; Janse et al., 2010). Barriers such as weak information systems and unfair competition and

free markets that discourage solid waste management were added. The final set of facilitators and barriers assessed are presented in Tables 1 and 2, respectively.

**Table 1.** Internal and external facilitators in the local context.

| Aspects               |  |
|-----------------------|--|
| Internal facilitators | IF1. Skilled personnel in solid waste management                                   |
|                       | IF2. Financial availability to invest on infrastructure and training               |
|                       | IF3. Connections and influences to call for participation                          |
|                       | IF4. Responsibility and ethical values to accomplish the current regulations       |
| External facilitators | EF1. Cooperation among the supply chain actors                                     |
|                       | EF2. Incentives to effective solid waste management                                |
|                       | EF3. Environmental awareness and community participation                           |
|                       | EF4. Availability and control of environmental management policies in the industry |

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

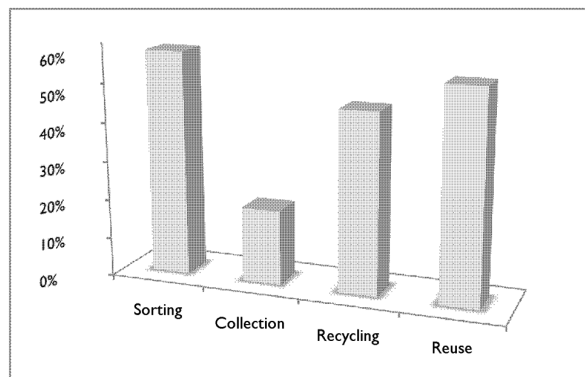
| Aspects           |   |
|-------------------|---|
| Internal barriers | IB1. Lack of commitment of the stakeholders                                     |
|                   | IB2. Lack of information technology systems                                     |
|                   | IB3. Focusing on operational and productive issues                              |
|                   | IB4. Lack of investment on environmental aspects                                |
| External 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 |

**Field work across SMEs**

The responses to the questionnaire were processed in a database to perform descriptive statistics. The assessment index was carried out to the facilitators and barriers shown in Tables 1 and 2.

**Assessment**

*Descriptive statistics:* Figures 1 and 2 describe the situation of the companies that participated in this study, according to the information provided by them in the first part of the questionnaire.



**Figure 1.** Activities of RL performed.

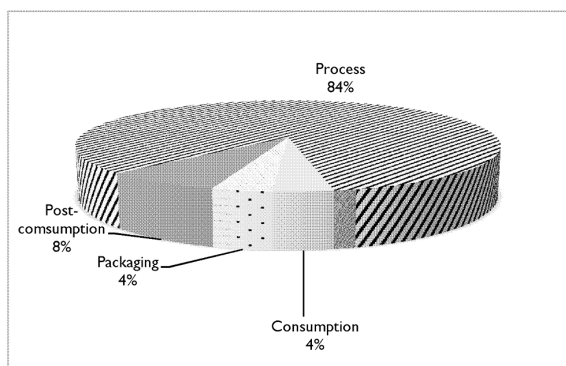


Figure 2. Main source of waste stream.

The major responders were medium size enterprises (38%) employing between 51 and 200 people. The main activities of RL performed for the companies were sorting (57.7%), reuse (53.8%), and recycling (46.2%) (Figure 1), and the main source of waste was found in the production process (84%) (Figure 2).

*Assessment index:* Equation (1) was applied to the Likert assessment corresponding to the final set of facilitators and barriers exposed in Tables 1 and 2. The results are shown in Figure 3 and suggest that all the proposed facilitators are relevant for the Colombian context represented in SMEs and the plastic sector, because they were assessed above 67% of importance. The assessment showed that the internal facilitator of skilled personnel in solid waste management (IF1, 88.3%) and the external facilitator of environmental awareness and community participation (EF3, 87.5%) were considered as the most important among the facilitators. However, these facilitators have not been identified by authors reporting RL issues in developing countries, mainly in Colombia where RL is in an early stage of development. The goodness of the mentioned facilitators could be minimized by the lack of investment on RL programs and the main focus on operational aspects at SMEs. The internal facilitator of connection and influences to call for participation had medium importance (IF3, 65.5%). None of the facilitators had low importance (0-33%), which means that all the proposed facilitators were to some extent important among the responders.

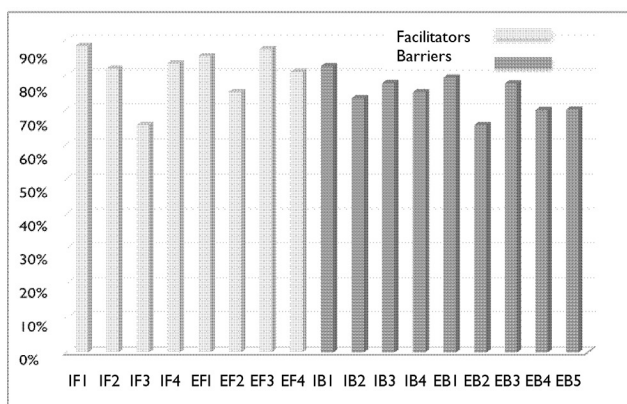


Figure 3. Results of the assessment index.

The results for the barriers showed that most of the internal and external barriers were ranked above 67%, representing highly important barriers for the local context. Even though the lack of commitment among stakeholders was considered as an important internal barrier (IB1, 82.5%), it has not been reported yet in the Colombian cases. The commitment of personnel in all levels within the organization is a key issue to tackle this barrier with managerial commitment as the core one (Janse et al., 2010). The second internal barrier was focusing on operational and productive issues in SMEs (IB3, 77.6%) that limits the attention on other issues such as personnel training and awareness on environmental aspects. According to Monroy & Ahumada (2006) and Pirachicán-Mayorga et al. (2014), Colombian industries are more focused on economic aspects rather than on environmental ones when recovering materials. This is because companies consider that direct gains can increase when reducing the use of raw materials (Akdoğan & Coşkun, 2012). Additionally, SMEs have to allocate the scarce resources in an optimal way and devote major effort to operations as the core competence in the business (Ravi & Shankar, 2005; Talbot et al., 2007). The internal barriers known as the lack of investment on environmental aspects (IB4) was scored 75%, and the lack of information technology systems (IB2), 73.2%; they both are based on the low availability of economic resources in Colombian SMEs and are also reported by Cure-Vejollín et al. (2006). Unfortunately, those barriers originate weak structures to develop proper RL programs, despite the SMEs effort to perform recovery activities.

The perception of poor quality of the recovered products was the highest external barrier (EB1, 79.2%), which is comparable to the exposed by Pirachicán-Mayorga et al. (2014) in the tire sector in Colombia. Similarly, Monroy & Ahumada (2006) stated that a strong barrier in the Colombian context was the low quality of the materials to be recovered since they were usually polluted due to poor sorting and collection practices.

The second external barrier was the absence of legal support and regulations accomplishment (EB3, 77.5%). Although the Colombian government had issued regulations regarding solid waste management (Colombian Ministry for Housing, Urban Issues and Territorial Development, 2013), there was still a lack of rigorous supervision for its application and laws suggesting a need for RL. It has been reported (in the Colombian context) that the lack of incentives to the recovery activities and the lack of accomplishment of the international environmental regulations were strong barriers to RL programs (Pirachicán-Mayorga et al., 2014). Conversely, in other regions, companies have adopted RL as a strategy to be prepared for the upcoming environmental laws (Akdoğan & Coşkun, 2012).

Different free trade agreements are now in place in Colombia, so the industrial sector is concerned about the unfair competition and free markets that discourage solid waste management (EB5, 70%). This is because producers consider it unfair to manage the life cycle of materials that are not even from the national industry. The Colombian

tendency is to adopt extended producer responsibility that hopefully will cause RL to be mandatory (Monroy & Ahumada, 2006).

Responders regarded weak information systems for solid waste management (EB4, 69.8%) as an external barrier directly related to the lack of reliable data, which is very common in developing countries (Harraz & Galal, 2011). Finally, the absence of secondary markets (EB2, 65.5%) was scored of medium importance because recovering activities were mainly performed to acquire raw materials that were often used within the same company (Monroy & Ahumada, 2006). None of the total set of barriers was of low importance (0-33%), which confirms that all of them represent barriers for the local context.

Facilitators and barriers may vary according to the sector, region, and size of the organization; for instance, profitability from RL is a facilitator in developed countries. However, according to Lau & Wang (2009) and Zoeteman et al. (2010), this arises from recycling in economies of scale, which is hardly found in developing countries due to infrastructure and technological constraints. In spite of the variation, a strong regulatory framework is required for all RL programs (Lau & Wang, 2009; Subramanian et al., 2014).

Finally, it has been shown that barriers depend, in a major basis, on economic and legal issues, and therefore the early stage of the development of RL is critical to face both internal and external barriers, in a balanced way. As stated by González-Torre et al. (2010), at SMEs, the greater the perception of the barriers, the less implementation of RL programs; and the higher the impact of the external barriers, the less attention on the internal barriers. Usually, SMEs are capable of approaching internal barriers; however, there are limitations to address the external barriers such as the lack of power, connections and resources.

## Conclusions

A comprehensive revision of facilitators and barriers facing SMEs in different sectors and countries was provided. A set was selected and assessed across SMEs managers and directors in the plastic sector in a region of Colombia. These issues were suggested in a broad basis and, on average, the whole set of facilitators and barriers proposed were assessed as of high importance.

The economic and legal issues are key for the success of RL in the plastic sector in Colombia. Additionally, understanding RL benefits and environmental awareness are relevant, and hence the role of the government is significant in approaching the poor coordination between economical and environmental goals and the fact that economic sectors are not accountable for their environmental performance. Based on the experiences reported and the support of regulations, it can be argued that SMEs should focus on internal facilitators to improve their performance and promote external participation of government, academia and community to strengthen the external facilitators.

This research is expected to contribute to the progress of the RL field in an early stage development country such as Colombia. It is recommended to perform a study in a larger scale, address different size of companies and sectors, and assess the mutual influence of facilitators and barriers.

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