Integration of design for reverse logistics and harvesting of information: a research agenda

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Abstract: The literature is replete with treatises advocating the immense benefits of reverse logistics (RL) systems for organisations in terms of alleviating environmental concerns and enhancing the level of productivity. Nevertheless, implementing RL in organisations is fraught with complications with its success largely riding on fulfilling the requirements prescribed by the critical success factors (CSFs) of RL. Despite the voluminous body of knowledge on RL in the extant literature, operational aspects of RL have overshadowed some central strategic prerequisites for the success of RL systems. Drawing upon an integrative literature review, this paper provides an insight into different aspects of the implementation of RL practices. The central role of the integration of design for reverse logistics (DfRL) and harvesting of information (HoI) in the effective implementation of RL systems is then established and clarified through developing a conceptual framework. The paper concludes by putting forward an agenda for research.

Keywords: reverse logistics; RL; design integration; information harvesting; knowledge management; supply chain.


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Part of the section of this paper related to review of literature on the ‘Barriers and critical success factor for reverse logistics’ is a revised and expanded version of a paper entitled ‘The crucial role of design for reverse logistics (DfRL) and harvesting of information (HoI) in reverse logistics systems’ presented at the 4th International Conference on Engineering, Project, and Production Management (EPPM 2013), Bangkok, Thailand, 23–2 October 2013.

1 Introduction

Mass production along with mass consumption have revealed the limitations of the built environment in providing raw materials and accepting the wastes generated (Umeda et al., 2000; Abdulrahman et al., 2014). In this context, many organisations in a wide range of industries have shown an increasing interest in implementing reverse logistics
(RL) practices to achieve sustainable development through using resources effectively (Presley et al., 2007; González-Torre et al., 2010) leading to noticeable cost savings in many aspects of supply chain management (SCM) (Srivastava, 2007). RL has been regarded as a key competence in SCM (Brito and Dekker, 2004; Zhu et al., 2008b) and a major business opportunity for the 21st century (Bouzon et al., 2013) reflected in its burgeoning recognition within many industry sectors (Pokharel and Mutha, 2009; Das and Chowdhury, 2012). In addition to business considerations, legislation is increasingly considering the original producers legally responsible for setting up recovery and return systems for their returned products (Fleischmann et al., 1997; Krikke et al., 2003; Turrisi et al., 2013). As a result, implementing RL is gradually becoming a necessity for organisations (Genchev et al., 2011; Bai and Sarkis, 2013; Samir, 2013).

Nevertheless, organisations can reap the benefits of RL only after minimising or suppressing the effects of the associated barriers (Ravi and Shankar, 2005). Furthermore, RL is a highly cross-functional and multidisciplinary phenomenon and many factors should be considered as the prerequisites for its success (Carter and Ellram, 1998). By implementing RL initiatives, organisations will be able to surpass the accomplishment of their competitors in all streams (Govindan et al., 2012). However, harnessing the benefits of RL in today’s business environment will not be possible without carefully planning the system (Guide et al., 2003a; Das and Chowdhury, 2012) in tandem with drawing up strategies to fulfil the requirements of the critical success factors (CSFs) of RL and to overcome the barriers (Turrisi et al., 2013).

The body of knowledge on RL has been progressively growing (Pokharel and Mutha, 2009; Jayant et al., 2012; Ilgin and Gupta, 2013; Qiang et al., 2013) or, as stated by Kannan et al. (2012), is ‘booming’. Nonetheless, most attempts in the relevant literature have been devoted to small areas of RL systems (Pokharel and Mutha, 2009; Jayant et al., 2012) mainly seeking to optimise the operational aspects of RL (Hazen et al., 2012) particularly by considering an objective problem to minimise the costs (see Kannan et al., 2012, for a list of such studies). The literature suffers from a paucity of research when it comes to dealing with strategic managerial aspects of RL (Bernon and Cullen, 2007; Subramoniam et al., 2009; Bernon et al., 2011). In this context, studies have overlooked the decisive role of the design of products and management of knowledge among the involved parties. The findings of the literature review in this study establish the fact that design for reverse logistics (DfRL) and harvesting of information (HoI) initiatives would enable organisations to resolve many of the issues of adopting and implementing RL. In addition, as reflected in the conceptual framework developed by the authors, incorporating DfRL and HoI in an integrated way would make the implementation of RL more viable and more advantageous in several dimensions.

Few studies have investigated the vital role of DfRL and HoI in RL systems. Furthermore, these studies have only addressed one of the aspects (e.g., Lambert et al., 2011) or have used specific contexts and limited case studies to support their discussions (e.g., Umeda et al., 2000; Jayaraman et al., 2008). Moreover, taking an integrative approach to harnessing the synergistic benefits of these constructs has been neglected in the extant literature (Abdulrahman et al., 2014). The above-mentioned gaps of knowledge have provided the primary driving force behind conducting this study to reveal the great influence that integrating DfRL and HoI might have on the success of RL systems. As a result, the objectives of this study are to:
1. clarify the central aspects of RL
2. establish the crucial role that the integration of DfRL and HoI initiatives play in the success of RL systems through developing a conceptual framework
3. direct future investigations on the aforementioned subjects by putting forward an agenda for research.

This study contributes to the body of knowledge by highlighting the overlooked aspects of RL implementation in organisations as well as by supplying investigators with lucrative grounds for future inquiries. Furthermore, the developed conceptual framework presents a new theory to be validated by future empirical inquiries in different contexts.

2. Research methodology

Considering the study’s three main objectives, an integrative literature review approach as described in Russell (2005) and Torraco (2005) was adopted in this study. This literature review method is well able to serve several objectives as described below (Hart, 1998):

1. discovering important variables affecting a concept along with rationalising their vital role
2. identifying the relationships between variables and practices in question
3. distinguishing the areas in the literature that need further research to be conducted.

The above abilities are closely consistent with the previously mentioned objectives defined for this study. Compared to the integrative literature review, other methods would provide less potential for generalisation of the results to fulfil the requirements implied by our objectives. In addition, RL is still regarded as an emerging topic in the literature (Bai and Sarkis, 2013). The novelty of this topic supports conducting studies that deploy integrative literature reviews. The reason for this is that studies integrating the literature on emerging phenomena add value to the corresponding body of knowledge by conceptualising and synthesising the existing information (Torraco, 2005).

Moreover, the research field has not kept pace with the unprecedented interest in RL with many studies calling for further inquiries on many aspects of RL (Bai and Sarkis, 2013). Developing conceptual frameworks would therefore advance the knowledge by systematising the findings of previous inquiries (Rocco and Plakhotnik, 2009). Likewise, conducting integrative literature review studies is the prerequisite for developing conceptual frameworks (Shields and Tajalli, 2006). Furthermore, previous studies have called for synthesising the available information on RL into a broad integrated body of knowledge in response to the paucity of literature on the strategic sphere of RL systems (Dowlatshahi, 2005; Pokharel and Mutha, 2009, Lambert et al., 2011, Bouzon et al., 2013).

It is necessary for stand-alone literature reviews to describe in detail the protocol of conducting the integrative literature review (Torraco, 2005; Okoli and Schabram, 2010). The review deployed in our study falls within the focus category of literature reviews based on the taxonomy introduced by Cooper (1988) in which the researchers mainly concentrate on the outcomes of previous studies.
The sources of the literature were limited to major electronic databases utilised in the review of the literature on RL by Seuring and Müller (2008). Therefore, the databases included Springer (www.springerlink.com), Emerald (www.emeraldinsight.com), Elsevier (www.sciencedirect.com) and Wiley (www.wiley.com) along with library sources, Ebsco (www.ebsco.com) and Scopus (www.scopus.com). The keywords to search the relevant literature comprised ‘reverse logistics’, ‘closed loop supply chain’, ‘green supply chain’, ‘remanufacturing’, ‘sustainable supply chain’, ‘sustainable logistics’, ‘reverse flow’, ‘reverse channel’ and ‘product recovery’. To broaden the literature covered and to assure coverage of the most recent existing studies, publications cited in the treatises found were reviewed to check their relevance to the topic of interest: this was in accordance with the method proposed in Webster and Watson (2002) and utilised in previous reviews of the literature in the RL area (Pokharel and Mutha, 2009). Two of the researchers reviewed the abstracts and introduction sections of identified publications which led to some treatises being excluded from the main review of the study.

To be concise, only publications satisfying the criteria below were reviewed and incorporated in the analyses and discussions in this study:

- Only papers in English that took a managerial approach were included. Therefore, papers with a technical or mathematical focal point were not included in the review process.
- Due to the large number of publications in relevant fields, studies that did not incorporate the closed loop of SCM were removed from the list. Hence, papers focusing only on one aspect of supply chain and manufacturing such as waste management, ecology, energy or green logistics were not on the list for analyses.

Eventually, the reviewed treatises comprised 14 book chapters, 213 journal papers and 12 conference papers.

3 Clarifying the central aspects of RL

In response to the objectives of this paper which determined to shed light on the vital aspects of the RL system, this paper will particularly emphasise the following features:

- RL concept
- drivers for RL
- barriers to adopting RL
- CSFs for implementing RL in organisations.

The reasons for selecting these items as the focal points of the review are described in the following section.

Clarifying the concept of any phenomenon is an indispensable prerequisite for any further inquiries on the subject specifically when it comes to developing theories or frameworks as enunciated by the seminal work of Wacker (2004). The literature has recognised the great potential of RL for bringing about many benefits for organisations. However, to achieve large-scale profits at the industry level, the current situation of implementing RL in organisations should be improved through taking a project approach.
(Pirlet, 2013). As implied by the model developed by Pirlet (2013), the milestones of the proposed project approach are recognising the driving forces, ascertaining the challenges and barriers, and eventually devising the best practices for implementing RL in organisations. The foregoing approach has been advocated in other studies. As an example, the most influential features of RL included drivers for organisations to implement RL, barriers of applying the RL concept, and the necessary processes and activities according to Schultmann and Sunke (2007). This is due to the fact that organisations would proceed towards reaping the benefits of RL only after minimising the effects of or suppressing the associated barriers (Ravi and Shankar, 2005).

As the first focal point, the concept of RL is clarified in the next section.

3.1 Background

One of the initial definitions regarding RL is found in the work of Lambert and Stock (1982) from the early 1980s. This definition was inspired by considering the traditional flow of products in the conventional supply chain as the expected direction. Hence, RL was described as ‘going the wrong way’ [Lambert and Stock, (1982), p.19]. During the 1980s, the concept of RL remained confined to describing the movement of goods from the consumer back to the producer in a distribution channel. Salient examples are the papers by Murphy (1986) and Murphy and Poist (1988) that referred to the concept using the term ‘reverse distribution’ with a focus on warehousing and transportation features of product recalls. As illustrated in Figure 1, the early definitions for the RL phenomenon only considered the direction of the flow of materials and point of origin to demarcate the RL activities. Afterwards, Thierry et al. (1995) coined the concept of ‘product recovery management’ to refer to the activities encompassing the management of used or discarded products and materials. Based on this definition, the main objective was to recover the economic and ecological values of products as much as feasible and in turn to reduce the ultimate quantities of waste, as presented in Figure 1.

In 1998, some studies defined RL from another vantage point with the orientation being the aim of reducing the level of utilisation of resources (Fernandez, 2003). A good example is the definition of RL presented in Carter and Ellram (1998, p.85) describing RL as “a process whereby companies can become more environmentally-efficient through recycling, reusing and reducing the amount of materials used”. At the end of the 1990s, the definitions provided by Rogers and Tibben-Lembeke (1998, 2001) drew upon the concepts of logistics to define RL (Brito and Dekker, 2004). They conceptualised RL as “the process of planning, implementing and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or for proper disposal” [Rogers and Tibben-Lembeke, (1998), p.2].

As is evident from Figure 1, recent studies have regarded RL as a necessary element of SCM as it enhances the efficacy of the processes (Mollenkopf and Closs, 2005; Cullen et al., 2013). The aim of implementing RL is defined as adding value to all the outcomes of the traditional system of the supply chain by complementing the forward logistics system (Govindan et al., 2012). The borders between forward and RL are becoming blurred in modern designs of supply chains as both are the elements of an effective supply chain (Brito and Dekker, 2004). Moreover, Dowlatshahi (2005, p.1) stated that “a RL system defines a supply chain that is redesigned to efficiently manage the flow of
products or parts destined for remanufacturing, recycling, or disposal. The enhanced supply chain is, therefore, capable of effectively using resources that were not previously considered or utilised”.

Figure 1  Evolution of the concept of RL based on fundamental aspects of its conceptual definitions (see online version for colours)

As implied by Figure 1, the concept of RL has evolved during the past decades from a concept reflecting processes that ‘move in the wrong way’ with its focus on the direction of the flow of goods (Brito and Dekker, 2004). Definitions were later based on phenomena such as the point of origin of materials. Afterwards, the concept was delineated drawing upon the targeted objectives such as reducing the amount of waste and raw materials. Nevertheless, the contemporary concept of RL represents a necessary element of effective SCM (Bai and Sarkis, 2013). RL is an element and subset added to traditional SCM to make it more effective (Pirlet, 2013) as is discussed in the section below.

3.2 RL within the CLSC

Products usually move from the supplier or the manufacturer to the end-users. However, large amounts of products and materials with some value move backwards from end-users (Ravi, 2012; Nikolaidis, 2013). As illustrated in Figure 2, the return of products may occur at any point during a product’s life cycle for a wide range of reasons (see Brito and Dekker (2004) and Tibben-Lembke (2004) for detailed discussions on the reasons that make material move in the reverse direction). To recover the value of returned products in an effective manner, organisations should deploy the most attractive option based on the status of the returned products (Guide and Van Wassenhove, 2009).
In addition to the necessity of maximising profitability and competitiveness due to the effects of globalisation (Zhu et al., 2008b), organisations should meet the requirements of recent environmental legislation as well as satisfying their customers (Bai and Sarkis, 2013). Utilising effective systems of logistics and SCM such as RL is an approach to achieve the mentioned objectives in terms of cost reductions and adherence to environmental regulations and requirements (Pagell et al., 2004). Likewise, closing the supply chain loop has been recognised in the literature as the remedial measure to make SCM capable of meeting the foregoing requirements (Krikke et al., 2004; Zhu et al., 2008b; Fahimnia et al., 2013; Qiang et al., 2013). This begot the genesis of the closed-loop supply chain (CLSC) which is defined as “the design, control and operation of a system to maximize value creation over the entire life-cycle of a product with dynamic recovery of value from different types and volumes of returns over time” [Guide and Van Wassenhove, (2006), p.349].

Closing the loop of the supply chain to form the CLSC is fulfilled by adding RL to SCM (El Korchi and Millet, 2011; Bai and Sarkis, 2013). Thus, the CLSC as the enhanced version of the traditional supply chain includes the functions and activities of the traditional supply chain along with the functions and activities of RL (Guide et al., 2003a) as illustrated in Figure 2.

Figure 2  A simplified model for a CLSC and RL (see online version for colours)

As shown in Figure 2, RL closes the loop of the supply chain at different points resulting in reusing the products as an entire product, as modules or as some of its parts (Guide and Van Wassenhove, 2009). The CLSC extracts the value of the returned products by taking different measures. Only returned products and materials with a level of value that does not justify recovery will be regarded as waste as shown in Figure 2. Since RL is an element of the CLSC, most of the driving forces behind using this system of supply chains also apply to RL. The next section of this paper discusses the main benefits of RL which act as the drivers for organisations to use RL in their supply chains.
Table 1  Major drivers for implementing RL for organisations

<table>
<thead>
<tr>
<th>Category</th>
<th>Drivers</th>
<th>Scholarly support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental drivers</td>
<td>Using less raw materials in production process</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Less energy consumption for producing or transport of goods</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Addressing the climate change issues (e.g., CO2 level)</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
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<td></td>
<td>Less pollution (visual, soil, water, weather, etc.)</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Complying with environmental legislation locally or globally to compete in international markets</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
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<td></td>
<td>Pressure from the government or community to accept responsibility for disposal of products due to heightened public awareness of environmental issues</td>
<td>Qiang et al. (2013), Pirlet (2013), Samir (2013) and Umeda et al. (2000)</td>
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<tr>
<td>Economic drivers</td>
<td>Cost saving by using less material and energy</td>
<td>Pirlet (2013), Mafakheri and Nasiri (2013), Presley et al. (2007) and Bouzon et al. (2013)</td>
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<td></td>
<td>Cost saving by lower inventory, equipment maintenance, transportation and procurement expenses, and the costs that stem from tying up assets in stock</td>
<td>Krikke et al. (2003), Mason (2002), Mollenkopf and Closs (2005)</td>
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<td></td>
<td>Higher competitiveness by gaining higher productivity levels</td>
<td>Dowlatshahi (2000), Dowlatshahi (2005), Lau and Wang (2009) and Samir (2013)</td>
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<td></td>
<td>Lower costs for landfill registrations and transportation to disposal facilities</td>
<td>Tibben-Lembke (1998) and Fleischmann et al. (1997)</td>
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<td></td>
<td>Long-term profits by meeting strategic objectives</td>
<td>Presley et al. (2007) and Brito and Dekker (2004)</td>
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<td></td>
<td>Meeting customer requirements and satisfying customers with the service (growing tendency of customers to trade-in old products)</td>
<td>Samir (2013), Ilgin and Gupta (2013), Krikke et al. (2003), Mason (2002), Lambert et al. (2011) and Seitz (2007)</td>
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<td></td>
<td>Opportunity to sell functional sales instead of physical products (e.g., leasing)</td>
<td>Sundin and Bras (2005) and Nikolaidis (2013)</td>
</tr>
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<td>Social drivers</td>
<td>Enhancing the environmental image of the organisation due to demands by communities to protect the environment</td>
<td>Bai and Sarkis (2013), Presley et al. (2007), Brito and Dekker (2004), Fleischmann et al. (1997) and Mollenkopf and Closs (2005)</td>
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<tr>
<td></td>
<td>Unprecedented awareness about environmental issues</td>
<td>Lau and Wang (2009), Blumberg (1999) and Fleischmann et al. (1997)</td>
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</table>
4 Drivers for implementing RL

Generally, RL initiatives are geared towards solving issues pertaining to environmental concerns, durability of products and economic savings (Kannan et al., 2012; Pirlet, 2013). There is a plethora of research studies that set forth the drivers of RL (Cullen et al., 2013); however, all the advantages could be classified under three major headings:

1 economic drivers
2 environmental drivers
3 social drivers (corporate citizenship) according to Brito and Dekker (2004), Presley et al. (2007) and El Korchi and Millet (2011) as illustrated in Table 1.

The list of references that have discussed the drivers and benefits of RL is exhaustive, thus Table 1 only refers to some of the treatises that directly mention each corresponding item.

There is consensus in the literature regarding the strong effects of the drivers in Table 1 to push organisations towards deploying RL. Nevertheless, some researchers (e.g., Seitz, 2007; Lambert et al., 2011) have postulated that the primary motives for organisations to adopt RL largely concern the necessity of meeting after-sales requirements such as warranties to keep the market share by satisfying customers. As a result, the major drivers for implementing RL in organisations are still a matter of debate in the literature.

4.1 Economic drivers

As shown in Figure 2, part of the value of returned products could be achieved by refurbishing or remanufacturing the products which, in some cases, entails only cleaning the products or changing some parts using less equipment and energy. Moreover, RL can bring about cost savings by reducing the costs of procurement, inventory and transportation in a CLSC (Krikke et al., 2003). This means gaining added value using the parts, modules or the entire products by putting in much less effort as opposed to the case of manufacturing using raw materials (Pirlet, 2013). Based on the definitions of productivity and performance, organisations gain the same output by putting in less inputs which equals higher levels of productivity and profitability of products (Dowlatshahi, 2000). This enhances the competitiveness of the organisations that implement RL (Mollenkopf and Closs, 2005) as, according to Lau and Wang (2009), effective implementation of RL could act as a weapon for a firm to defeat its competitors in the industry.

Returned products adversely influence a wide range of economic aspects of a business by increasing inventory costs and affecting cash flow by tying up assets in stock. Alleviating these issues is another economic gain achievable by implementing RL (Mason, 2002). As companies are increasingly obliged to be responsible for their end-of-life products, RL can reduce the costs associated with landfill and the transportation costs for delivering the used products to approved facilities for disposal (Tibben-Leembke, 1998). Other reasons for implementing RL for an organisation might be to prevent competitors from accessing a technology or preventing brokers from entering the market (Brito and Dekker, 2004).
In addition, strategic policies such as preparing for the impact of future legislation in order to remain in the market might be among the economic drivers for RL (Brito and Dekker, 2004). Some changes in customer behaviour also push organisations towards adopting RL such as the expectation of customers to be able to trade in their old products from a company when purchasing new items (Krikke et al., 2003). As stated by Nikolaidis (2013, p.6), RL activities to recover the value of products “should not be considered as a cost centre, but as a profit one”.

It is inferred that the conventional boundaries between manufacturing activities and providing relevant services are increasingly becoming fuzzy. One simple example for selling functional services could be the case in which a company emphasises that it provides the services of washing clothes in lieu of selling washing machines.

4.2 Environmental drivers

In the face of the continuous depletion of raw material and energy resources and the concomitant effects such as deforestation and climate change, taking any measure to reduce the utilisation of resources along with the reduction of waste and disposable materials seems necessary and extremely valuable (Bouzon et al., 2013; Pirlet, 2013). In addition, organisations must increasingly comply with governmental regulations (Fahimnia et al., 2013) on top of responding to consumer pressure to enhance their environmental performance (Bai and Sarkis, 2013). Strict environmental regulations progressively force organisations to become more accountable for the environmental impacts of their activities and make them responsible for disposal of their products (Krikke et al., 2003; Dowlatshahi, 2005). Some studies have even considered RL as a subset of environmental green SCM in seeking to address environmental concerns (Sarkis, 2003).

4.3 Social drivers (corporate citizenship)

Social drivers named by Brito and Dekker (2004) as ‘corporate citizenship’ refer to the values and social values dominant in a community or society which impel an organisation to implement RL to enhance its image in that community or society (see Carroll, 1979, for a broad discussion on corporate social responsibilities). A green image is an effective marketing element for any organisation (Fleischmann et al., 1997). Nowadays, many organisations attempt to enhance their image in their society by showing their success and compliance in addressing environmental concerns (Bai and Sarkis, 2013). Customers and communities loudly demand that manufacturers should lower the level of environmental impacts from their activities (Mason, 2002; Krikke et al., 2003). There is evidence that many customers are even prepared to pay more for products that benefit their community by protecting the environment (Dowlatshahi, 2000; Andel and Aichlmayr, 2002). In addition, companies will make their customers loyal through enhancing their green image (Mollenkopf and Closs, 2005). The heightened awareness of consumers about environmental issues (Blumberg, 1999) has made the environmental performance of organisations a criterion for many customers in selecting products (Mason, 2002). Thus, firms can use an environmentally-friendly image as a strategic tool for generating revenue, promoting their brand, satisfying their customers and reducing costs (Qiang et al., 2013).
Many benefits are associated with implementing RL in organisations. The major barriers obstructing the large-scale implementation of RL in organisations are next described in the following section.

5 Barriers for implementing RL in organisations

Although RL implementation has proved to be advantageous from various aspects, many firms, specifically small and medium-sized companies, are still reluctant to adopt RL due to the existence of some barriers (González-Torre et al., 2010). To be concise, the barriers associated with RL can be categorised into three groups comprised of:

1 organisational barriers
2 operational barriers
3 work/environment-related barriers as illustrated in detail in Table 2.

Organisational barriers are the conditions inside the organisation that hinder the organisation from adopting RL. Operational barriers mostly concern industry-specific barriers such as characteristics of the industry or of other parties in the industry that would comprise the elements of the RL system. Work/environment-related barriers concern the legislation and economic conditions including the attitudes of influential actors in the society towards different aspects of the RL system such as their perception of the recovered products.

Table 2 Major barriers associated with RL

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<tr>
<th>Category</th>
<th>Description</th>
<th>Scholarly support</th>
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<tbody>
<tr>
<td></td>
<td>Restraining organisational policies (e.g., overlooking DfRL)</td>
<td>Abdulrahman et al. (2014), Ravi and Shankar (2005) and Rogers and Tibben-Lembke (1998)</td>
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<td></td>
<td>Lack of awareness within the organisation</td>
<td>Jindal and Sangwan (2011), Presley et al. (2007) and Post and Altma (1994)</td>
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<td></td>
<td>Inappropriate organisational structure (and size)</td>
<td>González-Torre et al. (2010) and Post and Altma (1994)</td>
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</table>
Table 2  Major barriers associated with RL (continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Scholarly support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational</td>
<td>RL is not a priority in the organisation’s investments</td>
<td>Presley et al. (2007), Rogers and Tibben-Lembke (2001) and Rogers and Tibben-Lembke (1998)</td>
</tr>
<tr>
<td>Operational</td>
<td>Deficient structure of the industry for adopting RL</td>
<td>Qiang et al. (2013), Del Brio and Junquera (2003), Rogers and Tibben-Lembke (2001) and Post and Altma (1994)</td>
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<td></td>
<td>Inadequacy of technologies [emphasis on information communications technologies (ICTs)]</td>
<td>Jindal and Sangwan (2011), Ji (2006) and Ravi and Shankar (2005)</td>
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<td></td>
<td>Lack of standardised processes and lack of shared understanding of the best practices</td>
<td>Abdulrahman et al. (2014) and Lau and Wang (2009)</td>
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<td></td>
<td>Perceptions about the low quality of products of RL</td>
<td>González-Torre et al. (2010)</td>
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<td>Lack of support from professional associations, non-government organisations (NGOs), etc.</td>
<td>Hillary (2004)</td>
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<td></td>
<td>Bureaucratic problems in granting of licences and location permits</td>
<td>Zilahy (2004)</td>
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5.1 Organisational barriers

The significant costs associated with the adoption of RL in organisations act as the primary impediment in starting to use RL in the supply chain of an organisation (Lau and Wang, 2009). These include the costs of providing the necessary infrastructure (Abdulrahman et al., 2014) and equipment, of purchasing the technology and of training
and necessary education (Del Brío and Junquera, 2003; Hillary, 2004) which are all central to adopting RL in organisations. On the other hand, high costs are only justifiable when the results are clear and managers are confident about the returns of the investment. Uncertainty about the results is another barrier for investing in RL (González-Torre et al., 2010). This may lead the organisation to invest in other fields with less risks (Zilahy, 2004) and to give low priority to RL (Rogers and Tibben-Lembke, 1998, 2001). Furthermore, some organisational policies act as restraints against the adoption of RL. One example is the case of a company that does not want to compromise on the quality of its products and the image of its brand by using the RL products (Ravi and Shankar, 2005). Another issue within the policies of producers could be overlooking the primacy of design for RL (DfRL) within product design procedures (Abdulrahman et al., 2014).

The above-mentioned barriers all have their roots in organisations’ lack of awareness regarding the potential returns of implementing RL and the levels of risks attached to the implementation process in organisations (Post and Altma, 1994; Presley et al., 2007). In this regard, according to Rogers and Tibben-Lembke (2001), lack of knowledge in organisations stems from the inadequacy of investment in knowledge management. In addition, a successful RL system requires a flexible effective information system that crosses an organisation’s boundaries to facilitate the exchange of data and information in return processes between all parties involved in RL. This is not in place for many organisations for a wide range of reasons (Rogers and Tibben-Lembke, 1998; Ravi and Shankar, 2005). Lack of an effective information system is a serious problem as far as RL adoption is concerned (Ji, 2006).

Many managers might regard returned products as ‘junk’ and do not support the idea of using them through a RL process (Rogers and Tibben-Lembke, 2001). Resistance to change specifically in a logistics structure might result in destructive results for the organisation. This is the case that is mostly observed in small companies (Ravi and Shankar, 2005). Symptoms of resistance to change might be reflected in the lack of commitment to implement RL by personnel including the workforce or management staff (González-Torre et al., 2010). Commitment by the manager of one organisation should be clearly observable by the other parties of the supply chain as a prerequisite to the integration of all parties in adopting RL. Thus, lack of commitment by managers acts as a serious impediment for RL adoption (Ravi and Shankar, 2005). Lack of personnel with qualifications and necessary training to be able to implement and adopt RL has been regarded as another major impediment for adopting RL in an organisation (González-Torre et al., 2010).

Implementing RL successfully requires the use of some advanced technologies to facilitate the exchange of information: these include ‘virtual warehousing’ (Landers et al., 2000) or advanced information communications technologies (ICTs) for tracking product orders and making decisions about returned products in the case of a CLSC. Lack of these technologies and the failure to provide them for RL for any reason at all would be a barrier for RL adoption (Ravi and Shankar, 2005; Ji, 2006).

An inappropriate organisational structure obstructs organisations from making the necessary changes to facilitate adopting RL leading into experiencing inertia in routine organisational processes and activities (Shrivastava, 1995). This might hinder the effectiveness of attempts to forge external and internal communications which, in turn, might dilute the commitment to adopt RL at all levels of the organisation (Zilahy, 2004).
5.2 Operational barriers

Many companies and organisations use wholly separate infrastructure systems for addressing the issues of returned products and materials (Bernon and Cullen, 2007). Developing systems compatible with the requirements of RL needs relationships to be established with other businesses and close cooperation between the groups of parties involved. This could be an issue in many industries specifically those with large numbers of small to medium-sized firms (Del Brío and Junquera, 2003), as many organisations might not be willing to change the nature of their relationships inside the industry or might not have the financial strength to do so (Ravi and Shankar, 2005; Seitz and Wells, 2006). One of the main barriers of RL was identified as the lack of comprehension about the benefits of RL within different industries (Ji, 2006).

Moreover, suppliers and parties that should be involved in the RL practices might barricade the adoption of RL by their lack of cooperation (Jindal and Sangwan, 2011) which would act as pressure on the organisation (Govindan et al., 2012). In addition, lack of standardised processes for implementing RL is another barrier associated with the implementation of RL in organisations according to Lau and Wang (2009).

5.3 Work/environment-related barriers

The lack of support from social factors such as non-government organisations (NGOs), professional associations and other parties that logically should support the adoption of RL in an industry has been regarded as a barrier associated with adopting RL in organisations (Hillary, 2004). Organisations need to receive great support from the government and other social actors when making the decision to adopt RL. This support includes legal incentives as well as raising public awareness about the benefits of RL and the quality of RL products. Thus, lack of support is regarded as a barrier (González-Torre et al., 2010). Moreover, Jindal and Sangwan (2011) stated that major barriers to the adoption of RL are related to lack of support from the government.

Bureaucratic hindrances such as problems in getting approval for RL facilities and locations might also be a barrier in many contexts (Zilahy, 2004). In the paper by González-Torre et al. (2010) which ascertained the barriers associated with RL, perceptions in the community regarding the poorer quality of RL products was among the main barriers from the environment that affected the organisation.

The barriers discussed in the above section are those factors that obstruct the adoption of RL in many organisations. However, in addition to the barriers encountered prior to adopting RL, organisations should be prepared to meet the challenges of RL during its implementation in their SCM processes. The main activities and the process for implementing RL in a supply chain are described in the next section. This is followed by a description of the CSFs for implementing RL in organisations in order to ascertain the different factors that affect the processes of RL.

6 CSFs for implementing RL

As illustrated in Figure 2, the nature of operations and activities in a RL system cuts across many functional areas, for example, transportation, distribution, marketing, operations, designing, quality assurance and finance. Thus, RL is a highly
cross-functional and multidisciplinary procedure that takes a holistic approach (Dowlatshahi, 2005). As stated by Carter and Ellam (1998), organisations should consider many factors for designing and effectively implementing RL by taking an integrative perspective. The following sections clarify the primary items and themes to be considered as CSFs for designing and successfully implementing a RL system largely drawing upon the seminal work of Dowlatshahi (2005) which is advocated by other studies in the literature and is also discussed in the sections below.

6.1 Costs

This category covers all costs associated with the design, inception and implementation of the RL system. The costs include but are not limited to design costs and costs incurred in the acquisition of additional facilities, equipment and plants for any reconditioning procedures; hiring qualified workers and personnel; and the acquisition of storage and warehousing facilities (Dowlatshahi, 2005). Measures should be taken to minimise the capital costs of adopting RL as well as the recurring costs of its implementation as these costs could have a significant effect on the price of the output products as stated in the literature (Stock, 1998; Tibben-Lembke, 1998). On the other hand, recovered products should be sold at prices to compete with virgin products. As the demand is gradually satisfied, the revenue is considered fixed. Hence, cost minimisation is essential for conducting a successful RL system (Mitra, 2007). It should be mentioned that the aforementioned costs depend on the nature of the facilities and the required elements of the designed RL system which, in turn, rest on the type and the nature of the products used as inputs (Dowlatshahi, 2005). Therefore, gearing the basic design of products towards lowering reconditioning costs should be considered as a priority for reducing the costs of implementing RL in organisations. The costs of the RL system will determine whether or not the organisation will include RL in its SCM system as it is one of the formidable barriers of RL. Furthermore, a major part of the costs of implementing the RL system depends on the availability of required information in due course as will be discussed in the following sections.

6.2 Output quality

As is the case for any product, reproduced or recovered materials and products of the RL process should meet some quality levels. The quality of recovered items is usually considered in comparison to the quality level of raw or virgin materials or by taking into account the overall level of quality desired by consumers (Dowlatshahi, 2005). Regardless of the background and nature of products, customers expect the same level of quality from recovered items. Hence, as one of the major criteria expected from the RL system (Thierry et al., 1995), the quality of outputs from the RL system should be designed to be at least equivalent to the quality level of virgin products (Jayaraman et al., 2008). Any negligence that leads to producing items of lower quality might jeopardise the credit of the company brand and also adversely affect the reputation and sales of virgin products.

One dimension of the quality of outputs is the external quality or the perceived quality of recovered items by customers. The issue is that customers might regard recovered products as being of inferior quality. Therefore, marketing policies and
strategies should be considered to elicit the perspectives of potential customers regarding the quality of recovered items (Çorbacioglu and van der Laan, 2013).

All the above items are also somehow related to the basic design of the products as the eventual quality of a product in the recovery process rides on the basic design of the products along with the level to which the product design lends itself to be recovered through the implementation of viable recovery strategies. In addition, the perceptions of customers, and specifically those dimensions concerning the external quality of products, are achievable only by eliciting and processing information from this context.

6.3 Customer satisfaction

There is consensus in the literature that any service provided for the customers of virgin products should be considered for the customers of items recovered during the RL process (Pokharel and Mutha, 2009). However, the studies addressing this issue have presented recommendations regarding the primacy of meeting the expectations of customers of recovered products without expounding on the nature of these expectations (Dowlatshahi, 2005). The nature and the level of expectations from recovered items might be different in different sectors of the industry. Presumably, this relies on the type of products and the type of customers as well. However, there is much evidence in the literature emphasising the necessity of investing in keeping customers satisfied when it comes to recovered items from the RL system due to increased awareness and expectations of customers (Mason, 2002; Trebilcock, 2002). The major items that define aspects of customer satisfaction concerning recovered products are as listed below (Dowlatshahi, 2005):

- Using the same level of standards for customer service as organisations use for virgin products including effective post-sale services and repairs according to Blumberg (1999) and Du and Evans (2008).
- Timeliness of delivering recovered products to customers.
- Meeting the diverse requirements of customers in terms of product functionality. In other words, recovered products should have the same diversity of functions and capabilities.
- Locating the customer service centre in the main customer service area of the organisation to show the primacy of recovered products for the organisation.

Organisations should fulfil the requirements of customers and communities in designing and implementing their RL systems and any reconditioning options (Mason, 2002). However, environmental concerns in RL concern the costs of the system and the expectations of the community and customers. In some communities, paying more for a more environmentally-friendly product is acceptable (Andel and Aichlmayr, 2002). However, these aspects of RL should take into account a deep appreciation of consumers’ perceptions and expectations (Blumberg, 1999). The primacy of incorporating the perceptions of customers and consumers in order to devise strategies to keep them satisfied and interested in the products of the RL system reveals the importance of eliciting information and knowledge continuously regarding the expectations governing the market. This could be translated into the necessity of constantly harvesting relevant information.
6.4 Pricing strategy

Defining the appropriate price of the recovered products in any RL system is complicated and could be a challenge (Liang et al., 2009; Jayant et al., 2012). Generally, recovered products should be sold at lower prices compared to virgin products (Dowlatshahi, 2005). Therefore, the pricing of recovered items would be an effective strategy to control the inventory and increase revenue from the RL system. In addition, demand is affected by changing the selling price of the recovered items (Guide et al., 2003b). As a result, the pricing processes in RL tend to determine the optimal prices of the outputs from the reconditioning phases by considering different quality levels for the returned items to maximise the total revenue with this having been the subject of many studies (e.g., Mitra, 2007; Vadde et al., 2007).

Presumably, the price of products relies primarily on the costs of the RL system. Thus, any variable determining the costs of the RL system will directly influence the price of the recovered products in the market.

6.5 RL arrangement

The costs, required efforts and environmental impacts of a RL system vary greatly based on the design of its structure. The design of the RL system encompasses the incorporation of a wide range of factors including optimisation of the geographical location and layout of the facilities and centres. The optimal layout of RL systems has been the focus of investigation by many studies (Fleischmann et al., 2001; Krikke et al., 2003). The objective in designing the RL system is to define the optimal number and locations of the centres (collection, recovery) and the transportation routes between these centres. Different designs vary in terms of the variable and fixed costs of the facilities and the variable costs of various transportation methods between these facilities (El Korchi and Millet, 2011).

Another dimension of the design of the RL network concerns determining the actors to be involved in the organisation’s RL system to conduct the necessary operations (Meade and Sarkis, 2002; Brito and Dekker, 2004). These actors could be forward logistics actors such as the original manufacturer, suppliers, wholesaler and retailers. In some cases, the activities of the RL system are performed by entities specialised in RL activities who are named as third-party RL service providers or by a combination of the actors previously mentioned (Fleischmann et al., 1997). In other cases, opportunistic actors, namely, entities with their own businesses but who become involved to benefit from RL, such as brokers or charities, are involved in the RL processes.

Defining the best option in terms of the actors of the RL system is a matter of concern in the organisation’s decision about the separation of the forward and RL structures. Some researchers have maintained that RL activities should be designed and implemented separately from that of forward logistics (Rogers and Tibben-Lembke, 2001). Likewise, many studies have supported the outsourcing of RL and the use of third parties as the service providers of RL for organisations (Meade and Sarkis, 2002; Ravi, 2012; Pirlet, 2013) due to successful experiences of deploying third parties for conventional logistics systems (Gunasekaran and Ngai, 2004a; Manzini et al., 2007). On the other hand, some studies have stated that one of the main success factors for implementing RL is to utilise the current facilities of an organisation as much as possible to reduce the investment costs and make the products of RL more affordable.
Some also consider that overcoming the stochastic nature of returned items and the lower demand for recovered products as the main reasons justifying the necessity of combining forward and RL facilities (Aras et al., 2004). However, other researchers have maintained that the decision to outsource RL activities rides on the level of variety of returned items. Hence, RL systems dealing with high variability of returned items should use third party service providers (Serrato et al., 2007).

The controversy regarding this matter is evident in the literature as Pokharel and Mutha’s (2009) paper presents a lengthy list of studies either opposing or proposing each of the above-mentioned viewpoints regarding the actors in the RL system. Nevertheless, regardless of the actors and the design of the RL system, the efficiency of accomplishing the required activities and the eventual costs strongly rely on the key affecting factors of the RL system. The availability of required information is one of the most influential variables as mentioned previously. In addition, the design of products plays a vital role in the success of the RL system as explained in the following section.

6.6 Acquiring information in due course (HOI)

As inferred from Figure 2, any decision about the fate of returned products should be made as soon as possible and based on accurate information about the quality and state of the returned items as pointed out in Jayant et al. (2012). Moreover, some studies have conjectured that this decision should be made before transportation of materials to the collection centre in order to prevent the delivery of huge amounts of unrecoverable materials to the centre (Dowlatshahi, 2005). This could save large amounts of money in terms of the costs of the RL system as mentioned previously. Another challenge facing RL systems is the wide variety in the quality of returned items (Nikolaidis, 2013). The difference in the quality of returned items imposes high levels of uncertainty on RL activities and processes. High levels of uncertainty and perceptions about the low quality of some products were regarded as major barriers in adopting RL in organisations (see Table 2). Continuous access to on-time information regarding the different features of products has positive effects on modifying the risks of uncertainty and accordingly enhances the efficiency of RL systems with this having been widely acknowledged in the literature (e.g., Umeda et al., 2000; Chouinard et al., 2005; Jayaraman et al., 2008).

The crucial role of implementing knowledge management practices in increasing the efficacy of SCM and the competitiveness of an organisation through improving the coordination between the different parties involved has been frequently postulated (Gunasekaran and Ngai, 2007). Accordingly, much evidence attests to the great advantages of systematic sharing, processing and exchanging of information intra- and inter-organisationally for parties involved in a supply chain (Gunasekaran and Ngai, 2004b; Yu et al., 2013). All these propositions apply to RL as an enhanced form of supply chain as, according to Chouinard et al. (2005, p.122), “to benefit from the complementary nature of material and information flows of the supply chain and reverse logistics, a total network vision should be used to improve the coordination and collaboration among the various actors.” Likewise, the seminal work of Dowlatshahi (2005) which comprises a major part of the literature has treated the availability of on-time information as one of the prerequisites for an efficient RL system.

Building upon the concept of supply chain integration (Yu et al., 2013) and harvesting of knowledge (Snyder and Wilson, 1998), HoI in regards to RL could be termed as:
Integration of design for reverse logistics and harvesting of information

“an integrated set of processes in a RL system geared towards on-time capturing of any intra- and inter-organisational available information regarding the nature, quality, amount, flow, locations and relevant aspects of logistics of returned products from main performers and convert this knowledge into actionable awareness that can be transferred and shared with others within the RL network to maximise the benefits of the RL system.”

It is contended that the positive outcomes envisaged for HoI and its vital role in RL systems’ efficiency elevate its role to that of a key element for any RL system as will be discussed further in the following sections.

6.7 Product design (design for RL)

As is evident from Figure 2, and as postulated by Dowlatshahi (2000, p.152), reconditioning activities and operations are ‘at the heart of RL’. There has always been consensus in the literature that an organisation’s ability in using the design of products to facilitate the reconditioning activities determines the level of the organisation’s success with the RL system (Ginter and Starling, 1978; Giuntini and Andel, 1995; Sarkis, 1995; Thierry et al., 1995; Pokharel and Mutha, 2009; Ilgin and Gupta, 2010; Nikolaidis, 2013).

This strategy for designing products based on reducing the environmental impacts along with attempting to facilitate the value recovery of products has been referred to by different titles in the literature, for example, design for environment (DfE), design for remanufacturing and design for recycling (DfR) (Ilgin and Gupta, 2010). Considering the RL system, the objectives of such a design system could be encapsulated in the concept of DfRL which will be discussed in the following sections.

Design for X (DFX) refers to various design specialties as the objective of the design process such as design for manufacture, design for quality, etc. (Ilgin and Gupta, 2010). Drawing upon the definitions presented for DfE (Fiksel, 1996; Giudice and Fargione, 2007), design for disassembly (DfD) (Veerakamolmal and Gupta, 2000) and DfR (Masanet and Horvath, 2007) and based on the direct relationship between RL and environmental aspects, disassembly and recycling of products as illustrated in Figure 2, the following is considered to be the definition for DfRL:

Design for reverse logistics (DfRL) focuses on the products’ design attributes that support the implementation of cost-effective reverse logistics practices for the returned products and the materials embodied in the products.

DfRL is built on the idea that products should deliver some value to customers as well as retaining a ‘return value’ that must be extracted with minimal uncertainty and effort (Çorbacıoğlu and van der Laan, 2013). This idea directly addresses the economic aspects of the RL concept. Presumably, the environmental aspects must be fully incorporated in the DfRL conceptual definition as RL is the underlying aspect of DfRL and "environmental issues are at the core of RL” [Dowlatshahi, 2005, p.3471].

7 Effects of DfRL and HoI on the RL system

The main effects of DfRL and HoI are described in the next sections and also reflected in Figure 3.
7.1 Harvesting of information

- **Costs:** Lack of knowledge about the quantity, quality, timing, collection point locations and features of transportation of used products from the typical points of consumption has been mentioned as the ‘fundamental problem’ of implementing RL in organisations (Jayaraman et al., 2008; Asif, 2011). As a remedial solution to this problem, acquiring information about different aspects of returned items as soon as possible could bring about many advantages for the RL system (Fleischmann et al., 2001; Krikke et al., 2008). Implementing RL for organisations would be economically attractive as long as knowledge about the history of returned products is available (Klausner et al., 1998). Concerning the availability of knowledge about the quality of returned products, the most important impact would be on the cost of implementing RL. This is because availability of information leads to making the best decisions regarding the fate of returned products in terms of selecting the most profitable recovery option based on awareness of their quality (Jayaraman et al., 2008). In addition, having adequate knowledge will prevent the loss of any recoverable value due to selection of an unfavourable recovery option. Furthermore, knowledge about the quality of products will prevent the delivery of large amounts of low value or unrecoverable products to incompatible recovery points (Dowlatshahi, 2005).

Other variables affecting the cost of the RL system concern the large number of collection points and the time of collection which make the collection procedure demanding and costly (Guide et al., 2000). Using information disseminated by monitoring equipment at waste generation sites enables RL planners to foresee the time of collection and to optimise the planning of collection trips, thus reducing the overall cost of the RL process from many aspects such as transportation costs (Krikke et al., 2008). This also increases the amount of available returned items which is a determinant for the viability of implementing RL systems. RL is profitable providing there is the availability of large amounts of returned recoverable items (Tan and Kumar, 2008). Collection planning will be optimised by implementing the best collection routes and the most efficient collection planning drawing upon reliable information (Jayaraman et al., 2008). From another vantage point, available information on the supply and demand of returned products facilitates sending larger amounts of products directly to demand points. This will reduce the costs of warehousing the products and lowers the probability of damage to products during handling and storage (Kriwet et al., 1995; Krikke et al., 2003). In other words, the remaining value of products will be preserved. Moreover, faster delivery to demand points will prevent the product being regarded as obsolete due to new technologies arriving at the market (Rogers and Tibben-Lembke, 2001).

Another feature of the cost reduction gained from HoI concerns reduced inventory costs due to lowering the level of demand variability resulting in the potential to decrease the safety stock of recovered items based on the same case put forward for logistics activities (see Rabah and Mahmassani, 2002).

- **Quality of output/pricing/consumer satisfaction:** From another perspective, information about the remaining service life of products should be gained through
Integration of design for reverse logistics and harvesting of information

awareness of the design consideration of the products which facilitates the assessment of the quality of returned items (Ferguson and Browne, 2001). This will determine the costs of the recovery process as well as the quality of outputs of the RL process. Presumably, the knowledge about the design criteria of products would play a vital role in determining the quality of returned products (Fleischmann et al., 2001). Therefore, some studies have maintained that organisations should take measures to gain relevant information about the history of products (Klausner et al., 1998), particularly information concerning the earlier utilisation of products (Ferguson and Browne, 2001). Accurate pricing based on the remaining service life of recovered items will increase the level of consumer satisfaction with the products. This is due to the fact that selling recovered items with any defects or errors or priced higher than is warranted by their functionality will result in customer dissatisfaction with the brand (Jayaraman et al., 2008). Taking measures to easily disseminate information and knowledge will increase the level of customer satisfaction through utilising tools that simplify procedures for ordering products and that track the order status in exactly the same way as used in forward logistics procedures (Rabah and Mahmassani, 2002). Effective information systems will reduce the risks for customers when shopping as they are aware that they can easily return the products to the manufacturer thus increasing the manufacturer’s competitiveness in the market (Rogers and Tibben-Lembke, 2001). For the above-mentioned reasons, the use of ICTs to increase customer satisfaction with RL systems has been recommended in Daugherty et al. (2005).

- **RL arrangement:** To make the RL arrangement more efficient, some studies have highlighted the necessity of establishing effective communications between the parties involved to effectively coordinate the procedures and tasks (Fleischmann et al., 2000; Yalabik et al., 2005). By having accurate information about different aspects of returned items, parties would collaborate to have the most efficient RL process by devising strategies such as pooling the collection and sorting procedures or sharing some activities (Jayaraman et al., 2008). Closer cooperation gained from effective exchange of information might increase the commitment of parties that eventually will increase the level of effectiveness of the procedure (Kumar, 2001).

As per the above discussions, implementing a good RL system requires the collection of relevant data and effective dissemination of related knowledge (Ferguson and Browne, 2001; Jayaraman et al., 2008; Asif, 2011). The primacy of HoI for RL systems is acknowledged in many studies that have emphasised the necessity of deploying supportive information systems in order to facilitate and expedite the HoI procedures (Rogers and Tibben-Lembke, 2001; Daugherty et al., 2005; Asif, 2011; Nikolaidis, 2013; Samir, 2013). As a result, there is much evidence in the literature supporting the proposition of regarding HoI as a pillar of the RL system as it can improve the effectiveness of all the CSFs of the system (as shown by the green arrows in Figure 3).

7.2 Design for reverse logistics

- **Costs:** According to Krikke et al. (2003), the building blocks of the RL system consist of two main elements:
  1. the location-allocation issues
The authors of that paper contended that optimisation of the system should consider different scenarios for the reconditioning system with different types of product design. They underpinned their assumptions by referring to previous studies that had incorporated product design as one of the central variables affecting optimisation of RL systems (e.g., Daniel et al., 1999; Umeda et al., 2000). The thrust of this discussion is that products with the same functionality might be designed in a way that reduces the costs and efforts of the RL system by increasing the feasibility of cost-effective recovery options (Park and Tahara, 2008; El Korchi and Millet, 2011). This will be achieved by considering a suitable modular structure, appropriate components and materials for designing the product (see Pokharel and Mutha, 2009, for a list of studies advocating the incorporation of modularity in order to make RL more efficient). As enunciated by Krikke et al. (2003), the design of products is a determinant of the costs, energy consumption level and residual wastes in a RL system.

- **RL arrangement**: Product design affects many aspects of the RL process as products with different designs need different levels of expertise and recovery technologies (Thierry et al., 1995) which directly changes the level of expertise required of personnel and actors involved in the RL system arrangement (Das and Chowdhury, 2012). In addition, using an appropriate product design such as modularity can avoid the futile return of items in a RL system and increase the revenue (Das and Chowdhury, 2012). Incorporating DfRL in a RL system would reduce lead times and make the overall recovery process easier (Mikkola and Gassmann, 2003; Mukhopadhyay and Setoputro, 2005) that, in turn, leads to more efficient RL arrangements. In addition, some studies have claimed that, by utilising DfRL initiatives, organisations can optimise the structure of the RL system. As an example, Das and Chowdhury (2012) pointed out that the returned parts of modular products could be collected by the original retailers to form a cost-effective user-friendly RL arrangement.

- **Pricing/quality of output**: Presumably, anything influencing the cost of the procedure can make the prices more attractive for customers. This idea has been endorsed in some studies (e.g., Pokharel and Mutha, 2009) in which authors asserted that, by changing the design of products, many aspects of the RL system could be improved including the pricing, demand patterns and remanufacturing processes that indirectly affect time, cost, the RL arrangement and the training required for the actors involved. RL planners would use the potential provided by DfRL as the measure to overcome the challenges of the RL system mainly due to the uncertainty stemming from the high variability of the returned items (Nikolaidis, 2013). Moreover, designers could make the necessary amendments to the basic design of products to make any product wear resistant (Sundin and Bras, 2005) in order to present higher quality recovered products.

- **Customer satisfaction**: The idea of developing products with design attributes that require minimal recovery costs while fulfilling environmental requirements along with meeting customer expectations has been advocated in many studies (Cristofari et al., 1996; Zhang, 1999; Yüksel, 2010).
It is evident that the literature regards DfRL as one of the primary elements of planning the RL system affecting all the strategic decisions about the CSFs of the RL system (as shown by the green arrows in Figure 3).

**Figure 3** The primacy of integrating DfRL and HoI on different aspects of the RL system (see online version for colours)

8 **Integrating DfRL and HoI**

Some of the most cited works in this sphere (Rogers and Tibben-Lembke, 1998, 2001) have defined the flow of information as an inseparable element of the RL system or even a cornerstone of the RL system (Lambert et al., 2011). On the other hand, the discussions presented previously would justify treating DfRL as one of the prerequisites for the success of RL practices (Krikke et al., 2003). Nonetheless, an effective RL system takes into consideration all the affecting factors holistically (Dowlatshahi, 2000). It is inferred that integrating HoI and DfRL practices in RL will enhance the overall efficiency of the RL system as well as expediting the achievement of the hoped-for benefits and modifying the adverse effects of the major barriers as implied in Chouinard et al. (2005).

As reflected in Figure 3 and highlighted in Umeda et al. (2000) and Chouinard et al. (2005), designing products effectively requires the acquisition of precise information about the life cycle of the products including the practical lifetime of products, customer
behaviour, reuse patterns and rates, and collection and recycling rates. Therefore, incorporating HoI practices and DfRL processes within a unified system of management will enhance every aspect of the effectiveness of the RL system.

The necessity of integrating DfRL practices and HoI initiatives has been implied by other studies in the literature. As an example, Kriwet et al. (1995) stated that designers should rely on the findings from processing the information to incorporate the perceptions of all parties active in the recovery process to design the best possible products compatible with the recovery procedures. On the other hand, in an integrated system composed of DfRL and HoI constructs, designers would release the information about their future designs within the network of the RL system. The feedback from the parties involved will revise some aspects of the product design as illustrated in Figure 3.

On the other hand, designers in the integrated RL network will determine the best methods for recovering the products and can share information regarding the quality, quantity and estimations about the availability of returned products based on the criteria considered for design which determine the potential life cycle of products. The designer thus plays the key role in making products consistent with the requirements of a RL system (Kriwet et al., 1995). As supported by the conceptual framework proposed by Lambert et al. (2011), we contend that all decisions about any aspect of the RL system would be made based on the knowledge exchanged between the integrated system of DfRL and HoI with the coordinated actors involved in the RL process (see Figure 3). The actors, in turn, share their knowledge and experience regarding practical fulfilment of the RL process within the integrated system, which enhances the quality of designs and would positively improve the quality of later decisions.

From a broader vantage point, the benefits of integrating DfRL and HoI are supported by many studies that advocate the positive outcomes of integrating generic management systems. This is due to the consensus in the literature that integration of different management systems can result in significant benefits including cost savings and/or a noticeable reduction in the use of limited valuable organisational resources. In addition, an integrated management system ensures that routine activities are being effectively completed without asking for high-level management input. This, in turn, saves a significant amount of organisational resources such as managerial supervision and the necessity of continuous audits and paperwork as opined in Douglas and Glen (2000) and confirmed by Zutshi and Sohal (2005a, 2005b). One can find much empirical evidence on the integration of different aspects of management systems with the aim of reducing incompatibilities, lead times, overloaded resources and, consequently, overtime costs (Samaranayake and Toncich, 2007). As a salient example, Rajkovic and Aleksic (2009) presented a broad literature review on empirical works advocating the benefits of integrating management systems of corporations. Against the backdrop of the pivotal role of integrating DfRL and HoI in the success of RL systems, the fertile grounds for future investigations are outlined in the following sections.

9 Drawbacks of previous studies

The primacy of HoI and DfRL has been frequently stated in previous studies. However, the relevant literature in its current form is incapable of providing the sphere with sufficient knowledge in order to harness the achievable advantages of HoI and DfRL. Moreover, the extant literature has neglected the enormous potential of reaping the
benefits of integrating HoI and DfRL initiatives. To be concise, the pitfalls of the existing literature can be summarised as follows:

1. Most of the research publications concerning RL system have been devoted to limited areas of RL systems (Pokharel and Mutha, 2009; Hazen et al., 2012; Jayant et al., 2012). These studies have largely focused on optimising the RL system by defining the optimum location of facilities and transportation routes (Jayant et al., 2012). These results might be the best alternatives in the absence of DfRL and HoI initiatives in the system. Nonetheless, the most profitable arrangement is only achievable after incorporating DfRL in the initial stages of developing products along with deploying the principles of HoI in organisations and among their partners. The existing body of knowledge on RL has overlooked this matter.

2. Many studies have attested to the great benefits of DfRL in terms of enhancing the performance of RL systems (see the recent work by McGovern and Gupta, 2013 for a comprehensive list of relevant references and findings of a quantitative study acknowledging the benefits of DfRL). Furthermore, the crucial role of harvesting relevant information to facilitate the implementation of RL has been advocated in the extant literature (e.g., Chouinard et al., 2005; Shi et al., 2012) which has recommended integrated systems for information harvesting in RL. Yet, only a handful of studies have been devoted to quantitatively investigating the effects of DfRL and HoI on the outcomes of the RL system as most studies have deployed intuitive or qualitative approaches as reported by McGovern and Gupta (2013). Therefore, the above-mentioned aspects of RL systems suffer from a paucity of research. This should not be the case taking into account the vast potential of the mentioned constructs to improve the performance of RL systems.

3. In terms of the methodology, we did not locate any studies that used any method other than case study to investigate different aspects of RL systems in organisations. However, many features of RL systems are reliant on large-scale perceptions of the practitioner and customers of products (Umeda et al., 2000; Çorbacıoğlu and van der Laan, 2013). Hence, limited case studies drawing upon analyses of a few cases in some specific contexts and industries could not provide this sphere with theories and knowledge applicable to generic industries and products. The findings of case studies should not contradict each other and the existing literature in order to develop generalisable valid theories (Eisenhardt, 1989). However, concerning the fundamental aspects of RL (e.g., drivers, third party deployment), the findings of case studies have been contradictory. This reveals that the RL literature is not mature enough to provide theories which can withstand the scrutiny of large-scale empirical investigations.

4. Few studies have referred to the envisaged potential of integrating different operations associated with RL. This is a well-attested premise in the literature because the lack of awareness on integrative approaches towards implementing RL arrangements has been regarded as a major barrier to RL implementation in organisations (Abdulrahman et al., 2014, citing Jindal and Sangwan, 2011; Gunasekaran and Ngai, 2012). Moreover, Jayant et al. (2012) called for more research to develop integrated models by incorporating all the processes pertaining to RL. Presumably, this is the case when it comes to the integration of DfRL and HoI
initiatives to enhance the effectiveness of RL systems. Hence, it is construed that the extant literature has hitherto ignored the benefits achievable through integrating DiRL and HoI principles.

5 Some key issues concerning RL are still a matter of controversy in the literature. A salient example of this is the controversy concerning the outsourcing of RL activities and utilising third parties as pointed out in Rogers et al. (2012) and discussed previously (see Section 6.5). On the one hand, some studies have recommended outsourcing the performance of RL tasks to third parties as the most efficient option for organisations (e.g., Meade and Sarkis, 2002; Ravi, 2012; Pirlet, 2013). On the other hand, many seminal studies have opposed the foregoing premise and urged organisations to deploy the organisations’ own resources (Dowlatshahi, 2000; 2005). Presumably, a deep appreciation of such aspects of the RL system is necessary for practitioners and academia to harness the benefits of RL in organisations.

Drawing upon the above-mentioned drawbacks revealed by the existing literature, this study sets forth in the following section an agenda for research to address the identified gaps of knowledge in the RL field.

10 Agenda for research

In response to the identified gaps in the body of knowledge, the following research questions provide a lucrative ground for further investigations of RL.

1 What are the main drivers and barriers for organisations in adopting RL and, accordingly, DiRL in their SCM systems? (see item 5 in the above section)

The answer to this question might be largely context-based and determined by the nature of products, the idiosyncrasies of the industry in question and the perceptions, the culture and even the dominant religion in a community as pointed out in Mahmoudzadeh et al. (2013). This might be the main reason behind the debate on this topic witnessed in different studies. We are of the view that future investigations on this subject should draw upon large-scale data collection approaches if the results are to be generalised in one context as suggested by recent studies (Bouzon et al., 2013). The necessity of validating the barriers identified in the literature for various industries and other countries has also been emphasised in González-Torre et al. (2010).

2 What are the best practices and procedures for developing an effective integrated system composed of HoI and DiRL to enhance the efficiency of RL systems?

The knowledge created by answering this question might result in promoting the drivers of RL, suppressing the barriers and increasing the efficacy of RL for organisations. Yet, the best answer for each context might be context-based and heavily dependent on the conditions and the dominant culture in one industry and community as noted above.

3 What are the major variables within each of the constructs (HoI and DiRL) that affect the integrated system and accordingly the RL system?
The answer to this question might provide researchers with an array of variables that could be incorporated in equations and algorithms to optimise the RL system for any case. One example to optimise the system could be the level of maturity of one organisation in terms of knowledge management initiatives as an affecting variable.

4 How can we utilise the advancement in ICTs and virtual teamwork to enhance the effectiveness of the proposed integrated system in RL arrangements?

Some studies in the literature have recommended the utilisation of ICTs to enhance the effectiveness of the exchange of information between parties involved in the RL system (e.g., Chouinard et al., 2005). It seems that the technology and infrastructure for deployment of ICTs to exchange RL-related knowledge between parties are available even in laggard industries such as construction (Hosseini et al., 2012). However, the best methods to utilise the vast potential of ICTs and virtual teamwork to make the RL system more effective remain a fertile ground for investigation. As suggested by Hong et al. (2008), studies that focus on the potential of establishing central information facilities to supply the involved parties with updated data on the supply and demand of returned products via a RL network would enormously contribute to the RL body of knowledge.

5 How can we promote the coordination and exchange of information between different actors involved in the RL system by utilising the principles of partnering between different actors?

This investigation would require the identification of the barriers and drivers of partnering between different parties involved in the RL system in any context and industry. The answer could resolve the controversies around defining the best alternatives in terms of actors involved in the RL system. By establishing partnering arrangements, most issues regarding the exchange of information or the incorporation of DfRL by designers might be resolved to a great extent.

11 Conclusions

HoI and DfRL will bring about many advantages for RL even if separately incorporated into the RL system. Furthermore, integrating HoI and DfRL will facilitate reducing the costs of the RL system, simplifying the procedures, overcoming the barriers of the RL system and promoting the driving forces for organisations to implement RL. Therefore, given the above-mentioned drawbacks in the existing literature, the necessity for concentrating on the following aspects of RL systems in future inquiries seems necessary and a prerequisite for promoting the implementation of RL in organisations. Thus, it is construed that promoting the integration of DfRL and HoI principles should be the overarching objective of future inquiries. Furthermore, the robustness of future studies should be augmented by strengthening the links between the subjects of interest and the established theories and models. In this regard, the existing established theories applicable to the subjects of interest would include:
• knowledge management regarding different aspects of HoI
• change management regarding adopting DfRL and HoI due to the necessity of making substantial changes in the operational processes of organisations
• innovation diffusion models stemming from the novelty of RL-related discussions in many organisations on topics such as DfRL and HoI to facilitate adoption of these initiatives by organisations
• integration of management systems’ principles to facilitate the integration and unification of the principles of HoI and DfRL.

In addition, as previously discussed (see item 1 of ‘agenda for research’), many features of RL are heavily context-based and might differ glaringly between communities, industries, products and locations. As a result, it is necessary to conduct research studies in different contexts and triangulate and compare the results to further establish the field.

This study opens the door for future investigations on the subject of interest. However, the limitations of the study should be mentioned as this study is building its discussion on a conceptual framework that has not been validated empirically. Therefore, validating the proposed framework or making appropriate modifications will be another area for future investigations on the topic.

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References


Integration of design for reverse logistics and harvesting of information


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