THE CRUCIAL ROLE OF DESIGN FOR REVERSE LOGISTICS (DfRL) AND HARVESTING OF INFORMATION (HoI) IN REVERSE LOGISTICS SYSTEMS

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Abstract

The mounting environmental concerns along with the fierce competition prevailing in today's business environment have called for utilising new paradigms in the Supply Chain Management (SCM) of organisations. As a remedial solution to the foregoing issues, organisations have started to add Reverse Logistics (RL) practices to their SCM systems encompassing the systematic process of managing the flow of materials from the point of consumption back to the point of origin. There are voluminous amount of treatises in the literature advocating for the benefits of RL for organisations specifically in terms of facilitating fulfilling the environmental concerns and enhancing the productivity level. Nevertheless, implementing RL in organisations is fraught with complications and its success largely rests on meeting the requirements prescribed by the Critical Success Factors (CSFs) of RL practices. The body of knowledge on RL in some sectors of the industry such as manufacturing is voluminous. However, operational aspects of RL have overshadowed some central strategic prerequisites of the success of RL systems in the extant literature. Drawing upon an exhaustive literature review, this paper will highlight the aforementioned gaps of knowledge in the relevant literature. Afterwards, the central role of Design for Reverse Logistics **(**DfRL) and Harvesting of Information (HoI) in resolving the issues of implementing RL systems for organisations will be established and clarified. The paper will conclude by presenting the lucrative grounds for future research studies on RL field putting forward an agenda for research.

Keywords: Reverse Logistics, Design, Information, Supply Chain Management, Knowledge

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management

1. INTRODUCTION

Due to the stated intention of many organisations to achieve sustainable development, to use the resources effectively, and producing affordable products, RL field has experienced a notable growth in a wide range of industries (González-Torre et al., 2010). RL has been regarded as a major business opportunity for 21st century backed by the burgeoning recognition of RL within academia as well as many sectors of the industry (Pokharel and Mutha, 2009, Das and Chowdhury, 2012). Apart from profit-oriented advantages of implementing RL in many industries, legislations are progressively considering the original producers legally responsible for setting up a recovery and return system for their returned products (Krikke et al., 2003, Fleischmann et al., 1997).

The great benefits of implementing RL practices in organisations in terms of alleviating the environmental concerns and generating cost savings has been widely acknowledged in the literature (Pirlet, 2013). Nevertheless, many barriers hinder the adoption and implementation of RL in organisations, which make many firms reluctant to adopt RL (González-Torre et al., 2010). Organisations can proceed towards reaping the benefits of RL only after minimising or suppressing the effects of 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).

As the result of all the above, promoting RL in organisations will not be possible without drawing up strategies to facilitate meeting the requirements of critical success factors of RL and overcoming the barriers. The findings of the review of the literature in this study will establish the fact that DfRL and HoI would act as the strategies that enable organisations to tackle the issues of adopting and implementing RL in organisations. As will be discussed in the following sections, incorporating the DfRL and HoI in integration would make the implementation of RL viable in many aspects. Nonetheless, hitherto most of the research studies have been preoccupied with optimisation of the process of implementing RL rather than working out effective strategies to enhance the viability and effectiveness of implementing RL practices for organisations.

The aforementioned gaps of knowledge have provided the primary driving force behind conducting this study to spot the drawbacks of the relevant literature and discuss the great influence that integration of DfRL and HoI might have on the success of RL systems. This will contribute to the body of knowledge by highlighting the overlooked aspects of implementing RL in organisations as well as supplying the investigators with lucrative grounds for future inquiries.

2. RESEARCH METHODOLOGY

All the discussions and the findings of this study are built on analysing the existing literature. This seemed rationale in terms of the robustness of the methodology taking into account the necessity of integrating the available literature to develop a comprehensive understanding of the RL field (Bouzon et al., 2013, Hazen et al., 2012),which is replete with case studies (Pokharel and Mutha, 2009). Likewise, drawing upon the results of reviews of the literature as the sole method to present strategies has been widely experienced previously in seminal studies in RL field e.g.(Fleischmann et al., 1997, Guide and Van Wassenhove, 2009). To assure the comprehensiveness of the literature considered, the review covered the treatises introduced in the broad review of the literature studies conducted by Pokharel and Mutha (2009) and Bouzon et al. (2013).

3. REVERSE LOGISTICS CONCEPT

The definition for RL proposed by Rogers and Tibben-Lembke (1998, 2001) drew upon the goal, the process, and the concepts of the *logistics* concept to define RL. The mentioned authors 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-Lembke, 1998, page 2).

As another prominent definition proposed for RL, we can refer to the definition presented by the European Working Group on Reverse Logistics (REVLOG) cited in (Brito and Dekker, 2004, page 5). The mentioned definition described RL as “the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal”.

Currently, the concept of RL is regarded as a central element of an effective supply chain system (Bai and Sarkis, 2013). Contemporary definition of RL refers to a blanket term that includes a wide range of activities or procedures aiming at enhancing the effectiveness of supply chain by complementing the forward logistics process (Dowlatshahi 2005). Concisely, the aim to implement RL is to add value to the whole system of the traditional SCM by reversing the flow of materials to extend the forward logistics processes (Govindan et al., 2012).

By adding RL to the traditional system of SCM, the system will be a closed loop, titled as Closed Loop Supply Chain (CLSC). CLSC as the enhanced version of traditional supply chain includes the functions and activities of the traditional supply chain along with the functions and activities of the RL system (Guide et al., 2003a) as illustrated in Figure 1.

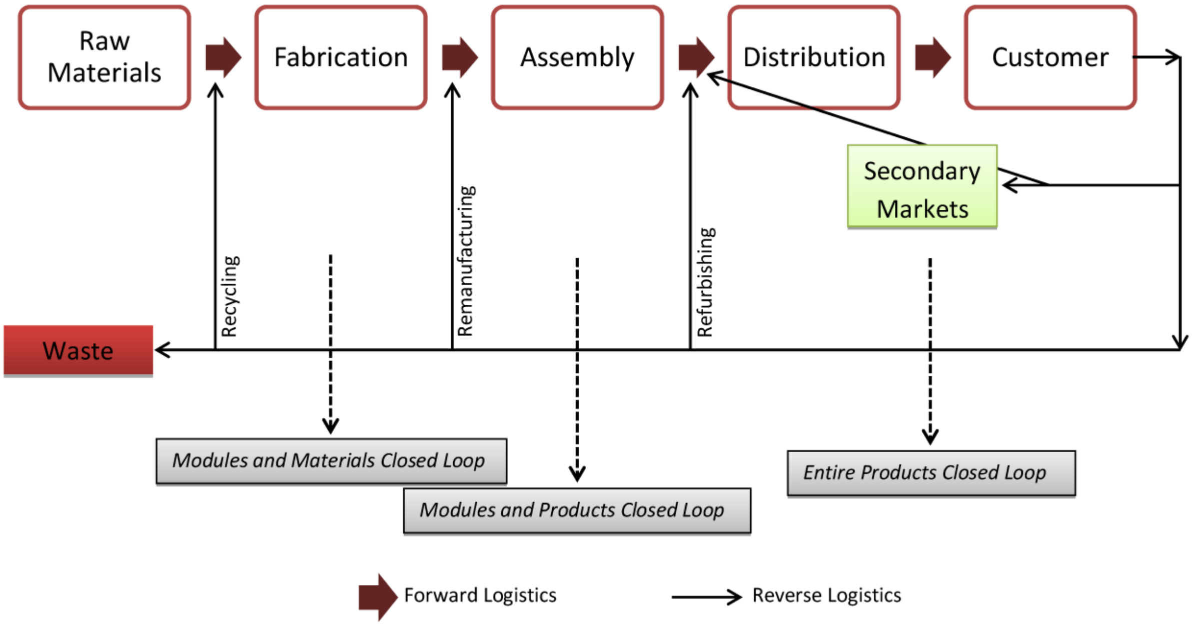

Figure 1: The simple model for a CLSC and RL

As shown in Figure 1, RL closes the loop of supply chain in different points offering the potential for reusing the products as an entire product, as modules, or only some of constituent materials (Guide and Van Wassenhove, 2009). The CLSC extracts the value of the returned products by taking different measures. Only returned products and materials with very low values will be regarded as waste as shown in Figure 1.

Some caveats should be notes based on the clarification of the concept of RL as the below items:

- RL does not add value to the system by itself. Thus, it should be considered in integration with all the other activities during the lifecycle of materials in a SCM.
- The definition of RL proposed by Rogers and Tibben-Lembke (1998, 2001) as stated in the above is one of the most widely accepted definitions of RL (see (Sarkis et al., 2010, Lambert et al., 2011, Govindan et al., 2012)). This definition has maintained that RL is comprised of the flow of material and products in the system as well as the flow of necessary information. Hence, information is central to the processes of the RL and an inseparable element of it.
- Literature wholeheartedly has acknowledged that implementing RL would bring about many advantages for organisations by enhancing the effectiveness of SCM. As a result, using RL as a part of SCM should be promoted by sensitising the benefits and suppressing the barriers as well as identifying the critical success factors for the RL system.

To address the abovementioned aspects of RL the following sections of the paper will be devoted to expounding on the drivers, barriers, and critical success factors of RL.

4. MAIN DRIVERS OF RL

There is a plethora of publications setting forth the advantages and the drivers of RL, however all the advantages could be pigeonholed in three major headings including: (1) economic drivers, (2) environmental drivers, and (3) social drivers (corporate citizenship) as pointed out in (Brito and Dekker, 2004, Presley et al., 2007, El Korchi and Millet, 2011).

4.1. Economic Drivers

As shown in Figure 1, a part of the value of the returned products could be retained by refurbishing or remanufacturing of the products, which in some cases might only entail cleaning the products or changing some parts using much less equipment and energy. 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 virgin materials (Pirlet, 2013). In doing so, organisations gain the same outputs by putting in less inputs. This enhances the competiveness of organisations implementing RL, as according to Lau and Wang (2009), effective implementation of RL could act as a weapon for a firm to defeat the competitors in the industry. The economic benefits of RL could be underpinned by the quotation from Nikolaidis (2013, page 6) stating that RL " should not be considered as a cost centre, but as a profit one".

4.2. Environmental Drivers

Organisations should comply with governmental, regulatory, and consumer pressures continuously asking corporations to enhance their environmental performance (Bai and Sarkis, 2013). As companies are increasingly obliged to be responsible for their end-of-life products, implementing RL can reduce the amount of waste sent to landfills, reduce the adverse effects of transportation activities, and use recovered products instead of raw materials. This way RL would greatly contribute to resolving issues such as climate change and built-environments pollution (Umeda et al., 2000, Pirlet, 2013) . Hence, some studies have considered RL as a subset of environmental green supply chain management to address the environmental concerns (Sarkis, 2003).

4.3. Social Drivers (corporate citizenship)

Social drivers titled by Brito and Dekker (2004) as *corporate citizenship* refer to the social values dominant in a community, which impel an organisation to implement RL to enhance its green image in the 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). Therefore, many organisations attempt to enhance their image in the society by showing their success in addressing the environmental concerns

(Bai and Sarkis, 2013).

The drivers seem to be persuasive enough for organisations to start implementing RL. However, there are major barriers that impede the procedure of adopting RL in SCM of organisations as will be discussed in below.

5. MAJOR BARRIERS OF IMPLEMENTING RL

As implied by Pirlet (2013), the starting point for promoting the current situation of RL in organisations should be clarifying and ascertaining the barriers and difficulties hampering the implementation of RL. Concisely, the major barriers associated with RL could be categorised in two main groups comprised of (1) organisational barriers, and (2) operational barriers as discussed in the following sections.

5.1. Organisational Barriers

The significant costs associated with adoption RL in organisations acts as the primary impediment of starting using RL in the supply chain of an organisation (Lau and Wang, 2009). This includes the costs for providing the necessary infrastructure (Abdulrahman et al., 2012), equipment, and purchasing the technology as well as the costs of training and educations for personnel (Del Brío and Junquera, 2003, Hillary, 2004). Uncertainties about the results is another barrier for investing in RL (González-Torre et al., 2010).

5.2. Operational Barriers

Developing systems compatible with the requirements of RL takes establishing relationships with other businesses and close cooperation between the groups of parties involved. Ineffective cooperation among the suppliers and parties involved in the RL practices might barricade the adoption of RL (Govindan et al., 2012). Hence, organisations should try available avenues to enhance the effectiveness of cooperation between the parties involved.

6. CRITICAL SUCCESS FACTORS FOR IMPLEMENTING RL

As stated by Carter and Ellam (1998), organisations should take into account many factors for designing and implementing RL through taking holistic and integrative approaches. The below items clarify the primary factors to be considered as the CSFs of implementing a RL system with input from the seminal work of Dowlatshahi (2005).

6.1. Costs of Implementing the System

Any measure should be taken to minimise the capital costs of adopting RL as well as the recurring costs of implementing it as these costs might have a significant effect on the price of the output products (Tibben-Lembke, 1998, Stock, 1998). Hence, conducting a successful RL system exclusively relies on cost minimisation during adopting and implementing the RL system (Mitra, 2007).

6.2. Output Quality

The quality of recovered items is considered usually in comparison to the quality level of the raw or virgin materials. Besides, the level of the desired quality of the consumers should be taken into account (Dowlatshahi 2005). Hence, the outputs of the RL system should be designed to be at the least equivalent to virgin products with regard to quality aspects. This is one of the major requirements expected to be met by the RL system (Thierry et al., 1995).

6.3. Pricing Strategy

Defining the appropriate price of the recovered products in any RL system might be a challenge and a complicated matter (Liang et al., 2009). Generally recovered products should be sold in lower prices compared to virgin products (Dowlatshahi 2005). Therefore, pricing of recovered items would be an effective strategy to control the inventory and increase the revenues out of the RL system. Besides, demand is affected by changing the selling price of the recovered items as well (Guide et al., 2003b).

6.4. RL System Layout

The costs, required efforts and the environmental impacts of a RL system varies greatly based on the design for the layout of the RL system. The design of the RL system encompasses incorporating a wide range of factors including optimisation of the geographical location and layout of the facilities and centres. The optimal layout of the RL systems has been the focus of investigation by many studies (Fleischmann et al., 2001, Krikke et al., 2003). The objective for designing the RL is to define the optimal number and locations of the centres (collection, recovering), and the transportation routes between these centres.

6.5. Harvesting of Information (HoI)

As illustrated in Figure 1, the decision about the fate of the returned products should be made as soon as possible and based on accurate information about the quality and the status of the returned items. Even some studies have conjectured that this decision should be made before transportation of materials from the point of consumption in order to prevent delivering huge amounts of unrecoverable materials to recovery centres (Dowlatshahi 2005). One of the challenges facing RL systems is the wide variety in the quality of returned items (Nikolaidis, 2013). Some studies have stressed the value of acquiring information about the quality of returned as soon as possible and the significant advantages of acquiring such knowledge by information communication technologies (Fleischmann et al., 2001, Krikke et al., 2008). From another perspective, valuable information about the remaining service life of products could be achieved by being aware of the designing considerations of the products that facilitates assessing the quality of returned items precisely (Ferguson and Browne, 2001), as will be discussed in following.

6.6. Design of Products (DfRL)

As illustrated in Figure 1, reconditioning activities stand at the centre of RL systems (Dowlatshahi 2005). The capabilities of an organisation in taking advantage of the design of products to facilitate the reconditioning activities determines the level of the success of the organisation with the RL system (Ginter and Starling, 1978, Giuntini and Andel, 1995, Thierry et al., 1995, Sarkis, 1995, Pokharel and Mutha, 2009, Ilgin and Gupta, 2010, Nikolaidis, 2013).

This strategy for designing the products by the aim of reducing the environmental impacts along with attempting to facilitate the value recovery of products has been referred to by different titles in the literature e.g. *design for environment*, *design for remanufacturing*, and *design for recycling* (Ilgin and Gupta, 2010). This paper summarises this strategy as the *Design for Reverse Logistics (DfRL)*, as will be discussed in the following parts of this paper.

7. DISCUSSIONS

Figure 2 aggregates the discussions of the above sections by illustrating the elements of the RL system and the relationships between the factors affecting the system.

As discussed in the above, to alleviate the operational barriers of the RL system, there is dire need for close cooperation between different actors in the RL system. In this context, many studies have highlighted the benefits of constant communications between the involved parties to coordinate the procedures and tasks effectively (Fleischmann et al., 2000, Yalabik et al., 2005).

Besides, acquiring information from the consumption points enables the RL planners of foreseeing the time of collection and optimising the planning of collection trips, thus reducing the ultimate costs of the RL processes (Krikke et al., 2008). As a result, many advantages could be achieved by deploying information harvesting systems that facilitate extracting and exchanging of information in RL systems (Daugherty et al., 2005, Nikolaidis, 2013).

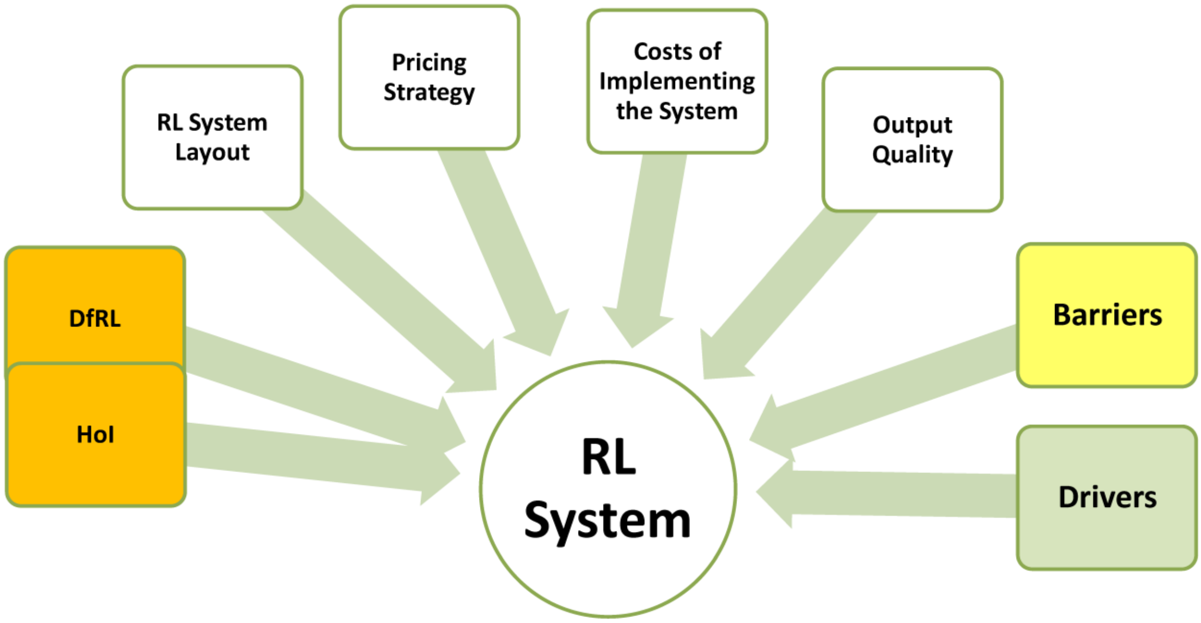

Figure 2: The effects of the DfRL and HoI on different elements of the RL system

As implied by Figure 2, deploying an effective strategy for harvesting the information and management of knowledge could modify the effects of a major part of the barriers impeding the promotion of RL system in organisations. Moreover, availability of rich information regarding the status of returned products will facilitate optimising the RL layout that in turn reduces the costs and will lower the prices of recovered items.

Krikke et al. (2003) asserted that design of the products is the building block of the RL system. It is because, products with the same quality and functionality might be designed in a manner to reduce the costs and efforts of the RL system by increasing the feasibility of more recovery options (Park and Tahara, 2008). This will be achieved by considering a suitable modular structure, appropriate components, and materials for designing the product, which would need lower levels of know-how and recovering technologies (Thierry et al., 1995). Obviously, associated costs and many other CSFs of the RL system are also affected by the design of the products (Das and Chowdhury, 2012). Pokharel and Mutha (2009) asserted that by changing the design of products many aspects of the RL system could be improved including the pricing, demand patterns, and the remanufacturing processes that accordingly would affect time, cost, layout of the RL system, and required training of personnel.

The consensus in the literature regarding the primacy of DfRL and HoI in the success of RL systems is comprehensible. On the other hand, Umeda et al. (2000) stated that designing products effectively takes acquiring accurate information about the lifecycle of the products including practical lifetime of products, customer behaviour, reusing patterns and rates, and collection and recycling rates.

As a result, authors are of the view that deploying an integrated system that incorporates the synergistic abilities offered by DfRL and HoI might be one of the best approaches to promote implementing RL system in organisations. The proposed Synergistic approach facilitates fulfilling the requirements of the RL system, and modifies the effects of major barriers impeding reaping the benefits of RL by organisations as illustrated in Figure 2.

8. CONCLUSIONS

Based on the review of the literature, it is not an overstatement to claim that there are compelling evidences advocating for the great benefits of the RL system for organisations. In other words, the drivers are strong enough for leading the corporations towards adopting and implementing RL is their SCM systems. Nonetheless, as stated in the previous sections, the barriers and some strict requirements prescribed by CSFs of RL system act as impediments making many organisations steer away from utilising RL in their SCM systems. Given the sufficiency of drivers for RL, any attempt to promote RL in organisations should be geared towards facilitating fulfilling the requirements of CSFs of RL along with suppressing the barriers.

It was established that deploying a system integrating the capabilities offered by HoI along with potential benefits of DfRL would fulfil the most of the requirements that should be met according to the major CSFs of the RL system (see Figure 2). Even more, major barriers of implementing RL in organisations including costs would be overcome utilising the aforementioned integrated system.

The consensus regarding the primacy of the DfRL (referred to with other titles) and HoI is prevailing in the relevant literature. However, major parts of available treatises have only mentioned the aforementioned items as the critical success factors of RL system. The lack of studies focusing specifically on investigating different aspects of these items is evident in the extant literature. Except for a mere handful of papers, studies expounding on the mentioned concepts are scarce. Most of the available treatises have been devoted to investigating other CSFs particularly layout of the system and optimisation of the design of the RL system. It seems the literature has confirmed the vital role of DfRL and HoI in RL without any attempt to acquire a comprehensive appreciation of the mentioned matters. To the best of our knowledge, there is no study in the existing literature aimed at developing or validating any theory concerning an integrated system of HoI and DfRL. Hence, this study opens the door for future investigations on the subject to answer the research questions including but not limited to the following items:

- What are the main barriers, drivers, and best practices associated with adopting and implementing an integrated system of DfRL and HoI in different sectors of the industry for enhancing the effectiveness of RL systems?
- What should be the criteria and affecting factors for developing an effective system integrating DfRL and HoI to promote RL in organisations?

- How the best practices for implementing the aforementioned integrated system would be affected by the specific idiosyncrasies of different sectors of the industry and different contexts?

ACKNOWLEDGMENT

This paper provides a background to the successful Zero Waste SA Sustainable Design and Behaviour (sd+b) Centre Research Funding Scheme 2013 program: Designing for reverse logistics (DfRL) within the building life cycle: practices, drivers and barriers. The project team comprises Dr Nicholas Chileshe, Prof Steffen Lehmann, Dr Raufdeen Rameezdeen and Mr M.Reza Hosseini.

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