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Key activities, decision variables and performance indicators of reverse logistics

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Abstract

Reverse logistics is a great enabler for sustainable production and resource circulation. Its definition and scope are still evolving since early 1980s. But, collection, sorting/testing, recovery and redistribution are assumed as the basic four activities in reverse logistics. Unfortunately, many researchers assume reverse logistics by its literary meaning and plan the reverse logistic activities and take decisions based on the forward logistics or supply chain principles. There is hardly any academic research on the performance evaluation and decision variables for reverse logistics. This paper aims at developing the various activities, decision variables and performance indicators based on the four basic activities under reverse logistics. The three basic questions – who will collect from the customer, what is to be done on the collected products and where to send after recovery – interlinked with the activities at collection, sorting/testing and recovery centres will provide the basic activities, decision variables and key performance indicators of the reverse logistics. The location and capacity of various centres, types of networks, various recovery options, various methods of collection, and seamless integration with the forward logistics are the key decision variables. The performance indicators will be developed based on the activities and actions between the activities so that the performance indicators can be associated with the reverse logistics. It is expected that this conceptual framework of activities, decision variables and performance indicators will help the managers working in reverse logistics to take better and informed decisions

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*Keywords:*Reverse logistics; performance indicators; closed loop supply chain; collection methods; recovery options

1. Introduction

Reverse logistics (RL) has gained increasing attention among researchers and practitioners of operation and supply chain management because of growing green concern, sustainable development, fierce global competition, future legislation, increased product return, environmentally consciousness of customers and so on. It is 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(De Brito and Dekker 2002). Design and implementation of reverse logistics is very different from forward logistics. The forward logistics include series of activities in the process of converting raw materials to finished products. Whereas reverse logistics is concerned about the recovery of returned products from customer to recovery point. The major differences between forward and reverse logistics are in term of quality, transportation, cost, inventory, packaging, pricing, routing, forecasting, etc.

Reverse logistics starts with the collection of returned products from customers. Out of the returned products, the products which can be reused after minor repair are sent to distributor and the rest are forwarded to disassembly center to disassemble into parts. To check reusability of parts, sorting and testing is done parallel to disassembly. Here the parts are divided into different categories depending on their residual quality and different end-of-life options available, like refurbishable parts, recyclable parts and disposable parts. The parts which can be refurbished are sent to refurbishing center. The parts which have no value recovery, but can be used for material recovery are sent to recycling center and the rest of parts are disposed off. Therefore, the reverse logistics

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activities can be divided into three main stages, i.e. collection, inspection and sorting, and product recovery. A generalized framework for closed-loop supply chain (Jindal and Sangwan 2014) is shown in Fig. 1.

The importance of the reverse logistics can be judged from the fact that the average reverse logistics costs are 9.5% of total logistics costs (Daugherty *et al.* 2001). The changing technology, decreasing product life cycle and liberal return policies are increasing the volume of returned products. In a study of US market, Rogers and Tibben-Lembke(1998) found that returns in reverse logistics are 50% for magazine publishers, 20–30% for book publishers, 18–35% for catalogue retailers and 10–12% for electronic distributors. Effective handling of reverse logistics transactions can result into economic and strategic benefits (Chanintrakul *et al.* 2009; Vedpal and Jain 2011). Many companies have realized that reverse logistics practices can be combined with source reduction processes to gain competitive advantage and at the same time can achieve sustainable development (Diabat and Kannan 2011; Frota Neto *et al.* 2008; Lee *et al.* 2010; Seuring and Müller 2008).

Reverse logistics is mainly regulatory driven in Europe where governmental regulations are compelling businesses to address recovery and disposal of end-of-life products; profit driven in USA where value is recovered where ever possible; and in incipient stage in developing countries of the world including India (Srivastava and Srivastava 2006). The implementation of reverse logistics is a highly complex task.

Reverse logistics may have a narrow or broad scope. The narrow scope of reverse logistics refers to the actual movement and management of reverse flows of products/parts/materials from customers to suppliers (Tibben-Lembke and Rogers, 2002). The focus then is on logistics issues such as transportation modes and routing, pick-up scheduling, and the use of third-party logistics providers to optimize the logistics capability (Kumar and Dao, 2006). The broader scope of reverse logistics include activities that support the management of used products including picking them up, sorting them out, and reusing them in different ways (Dowlatshahi, 2000). These days the focus has shifted from the value recovery to environmental management to social management. More and more organizations have started to think RL activities on the line of the three pillars of sustainability – economical, environmental and social.

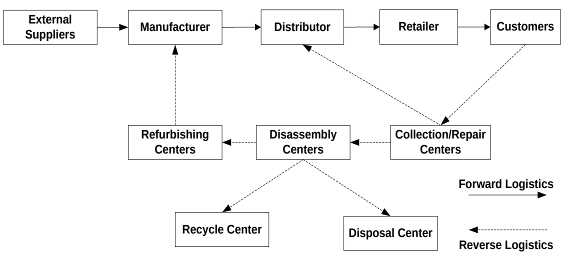

Fig. 1. A generalized framework for closed-loop supply chain (Jindal and Sangwan 2014)

2. Reverse logistics activities

The three major activities of reverse logistics are collection, inspection and sorting, and product recovery.

2.1 Collection

Collection is the first and an important element of the reverse logistics (Schwartz, 2000; Wojanowski *et al.*, 2007). It refers to all activities rendering used products availability and moving them physically to some point where further treatment is conducted for product recovery (Sasikumar and Kannan, 2008). It is to be noted that collection, to some extent, is imposed by legislation, e.g. Directive 94/62/EC for packaging material in Germany (Kapetanopoulou and Tagaras, 2011), white and brown goods in Netherland (Fleischmann *et al.*, 2000).

2.1.1 Decision variables

2.1.1.1 Location-allocation of collection centers

Most of the literature in the field of collection in reverse logistics is related to location-allocation of collection centers. Spengler *et al.*(1997) developed a multi-stage, multi-product and a multi-level mixed-integer linear programming (MILP) model for location of warehouses in German steel recycling industry. Jayaraman *et al.*(2003) formulated a mixed integer programming (MIP) model to determine optimal number of collection and refurbishing centers and their location for hazardous products. Min *et al.* (2006) proposed a MILP model and a genetic algorithm to determine the location and allocation of collection centers and centralized return centers. Aras and Aksen (2008) formulated a mixed-integer nonlinear facility location-allocation model to determine both the optimal locations of the collection centers and the optimal incentive values for each return type so as to maximize the profit from the returns. Mutha and Pokharel (2009) proposed a mathematical model for the design of an RL network handling product returns. The key performance indicators (KPIs) identified for the location-allocation decisions in RL are given in table 1.

Table 1. KPIs for location-allocation decisions in RL

S. No.	KPI's
1.	Collection cost
2.	Processing cost
3.	Value added recovery
4.	Energy use
5.	Waste generation
6.	Product reclamation
7.	Level of social acceptability
8.	Customer satisfaction
9.	IPR information

2.1.1.2 Methods of collection

Literature suggests three methods of collection – collection by original equipment manufacturer (OEM), collection with retailers and collection with third party logistics providers.

Barker and Zabinsky (2008, 2011) in their conceptual framework for decision making in reverse logistics network design categorized collection into two types - proprietary collection and industry-wide collection. Both the categories have their own benefits and drawbacks. Industry-wide