Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 61 (2017) 257 – 262

www.elsevier.com/locate/procedia

The 24th CIRP Conference on Life Cycle Engineering

Key activities, decision variables and performance indicators of reverse logistics

Kuldip Singh Sangwan*

[a]Department of Mechanical Engineering, Birla Institute of Technology and Science, Pilani 333031, India
* Corresponding author. Tel.: +911596515205; fax:+91-1596-242-183.*E-mail address:*kss@pilani.bits-pilani.ac.in

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

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
*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

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.11.185

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.

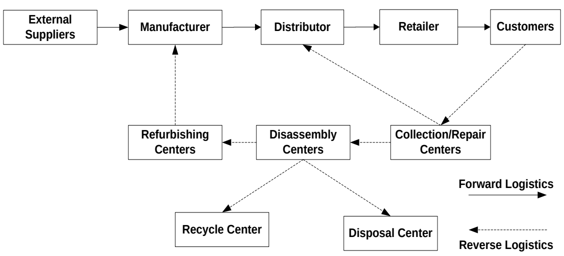

Fig. 1. A generalized framework for closed-loop supply chain (Jindal and Sangwan 2014)

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 collection system is having the advantage of economies of scale and it does not complicate a company's forward supply chain. However, an individual company has limited control over this type of collection system. Proprietary collection system is particularly beneficial when the company has a strong direct relationship with its customer such as a lease-return relationship, or when there is high customer trade-in behaviour. However, transportation costs may be higher, because a company-specific system cannot take advantage of economies of scale. Jindal and Sangwan (2015) evaluated three alternate collection methods proposed by Savaskan et al (2004) using fuzzy mathematics and found that the most suitable collection method depends upon the type of industry and size of collection in addition to the criteria of initial investment, value added recovery, return volume, operating cost, degree of supply chain control, and level of customer satisfaction. The KPIs used for taking collection decisions in RL are given in table 2.

Table 2. KPIs for collection decisions in RL

S. No.	KPIs
1.	Initial investment
3.	Return volume
4.	Operating cost
5.	Supply chain control
6.	Customer satisfaction
7.	Environmental impact
8	Health and safety issues

2.2 *Inspection and sorting*

2.2.1 Centralized or decentralized

The products are inspected and sorted after collection. Inspection and sorting consists of operations that determine whether a given product is reusable or not, and if yes, then to what extent. Barker and Zabinsky(2008) identified that sorting/testing can either be done at centralized location or decentralized location and discussed the trade-offs considerations. Owing to efficiencies from higher volumes, a centralized site is common for a commodity-type product, such as construction sand recycling (Barros *et al.*, 1998) or carpet recycling (Louwers *et al.*, 1999). A centralized site is desirable for high-cost testing procedures as it minimizes the cost of testing equipments and specialized labor. One drawback of centralized sorting and testing is that in this system the waste will be identified after its transportation to the testing facility therefore transportation cost will be higher. Distributed sort/test sites are often used if low cost testing procedures are available, such as for paper recycling (Bloemhof-Ruwaard *et al.*, 1996), machine refurbishing (Thierry *et al.*, 1995), or reusable containers and equipment (Kroon and Vrijens, 1995). In this system scrap is identified early and shipped to waste disposal center, thus reduces the transportation costs. However, testing procedures must be consistent and reliable at all centers. The network may be more complicated because scrap and usable return product are shipped in separate streams. Srivastava and Srivastava(2006) also discussed that inspection/sorting may be carried out either at the point/time of collection or afterwards (i.e. at rework facilities). Inspection/separation may encompass disassembly, shredding, testing, sorting, and storage steps (Fleischmann *et al.*, 1997). The centralization or decentralization of inspection and sorting facilities depends upon the seven measures as given in table 3.

Table 3. KPIs for inspection and sorting facilitylocation decisions in RL

S. No.	KPIs
1.	Testing cost
2.	Product reliability requirement
3.	Availability of skilled labour
4.	Location of waste disposal sites
5.	Labour cost
6.	Volume of collection
7.	Waste handling, storage and transportation cost

2.2.2 Degree of Disassembly

Disassembly is a systematic method of separating a product into its constituent parts, components, subassemblies or other groupings and it is also used to remove the toxic elements. It may involve dismantling, demolition or reprocessing (Sasikumar and Kannan, 2008). Most of the literature in disassembly is related to find out the degree of disassembly or to improve the efficiency of disassembly. Brennan *et al.* (1994) discussed the operational planning issues in assembly/disassembly environment. de Ron and Penev (1995) proposed an approach to determine the degree of disassembly at a single point of time. The KPIs identified for the degree of disassembly are given in table 4.

Table 4. KPIs for degree of disassembly decisions in RL

S. No.	KPIs
1.	Value recovery
2.	Disassembly cost
3.	Processing cost
4.	Landfill cost
5.	Incineration cost
6.	Environmental impact of processing
7.	Environmental impact of landfill
8.	Environmental impact of incineration

2.3 Product recovery

Product recovery is an important activity of reverse logistics to manage the flow of products or parts destined for remanufacturing, repairing, or disposal and to effectively use the resources (Dowlatshahi 2000). It is generally carried out to recover hidden economical value, to meet market requirements or to meet Government regulations (Sasikumar and Kannan 2008).

Sometimes resource recovery is not economically viable for the industry. In such cases, governments can resort to a wide range of policy tools to facilitate achievement of their targets. Mandatory take-back legislation, such as Germany's packaging recycling law implemented via the well-known Green Dot program, constitutes the most radical approach but typically difficult to enforce. Price-based policies constitute a less challenging option in terms of implementation and monitoring. Examples of such policies include taxes on the use of virgin materials, recycling subsidies, disposal fees and deposit-refund requirements (Fullerton and Wu, 1998). Economics literature provides evidence that deposit-refund is the most preferable policy (Wojanowski *et al.*, 2007). A deposit-refund system requires consumers to pay a certain deposit at the time of purchase, which is refunded upon the return of the used product. Such systems have been commonly used in promoting return and reuse of product packages and containers, e.g. aluminum cans, glass bottles, car batteries, tires, etc.

2.3.1 Product recovery processes

Some of the product recovery processes include repair, reuse, refurbish, remanufacture, cannibalize, recycle or disposal.

Once a product has been returned to an organization, it has many recovery options. Jayaraman(2006) has identified seven recovery options as reuse, repair, refurbish, remanufacturing, retrieval, recycle and disposal. The first option is to sell the product as a used product if it meets sufficient quality levels. The second option is to clean and repair the product to working order. Product repair involves fixing and replacement of failed parts. Repair operations can be performed at the customer's location or at a manufacturer controlled repair centre. The third option is to sell the product as a refurbished unit. In this the product does not lose its identity and is brought back to a specified quality level. Sometimes, refurbishing is combined with technology upgrading by replacing outdated modules and parts with technologically superior ones. The fourth option is to remanufacture. In this option the product will enter the reverse channel at the fabrication stage where it would be disassembled, remanufactured, and reassembled to flow back through the retail outlet back to the consumer as a remanufactured product. The purpose of remanufacturing is to bring the used products up to quality and reliability standards that are as rigorous as those for new products. The fifth option is to retrieve one or more valuable parts from the product. The sixth option is to recycle. In this option the product will most likely enter the reverse value channel in the raw material procurement stage where it may be reutilized with other raw materials to produce the virgin materials after some initial processing. In recycling, the identity and functionality of products and components is lost. The main purpose of recycling is to recover materials from used components and products. The seventh option is to recover the energy in the product through incineration. If the product is of no use even after re-processing the last option is waste disposal. The various alternate product recovery options suggested by different authors are listed in table 5.

Remanufacturing is an environmentally and economically sound way to achieve many of the goals of sustainable development. It closes the material use cycle and forms an essentially closed-loop manufacturing system. The aim of remanufacturing is to bring the product into 'as new' conditions by carrying out the necessary disassembly, overhaul, and replacement operations to get value-added recovery, rather than just materials recovery.

Table 5. Alternative product recovery processes

Citation	Alternative Product Recovery Processes
Thierry et al. (1995)	Repair, refurbish, remanufacture, cannibalize and recycle
Johnson and Wang (1995)	Combination of remanufacture, reuse, and recycle
Rose and Ishii (1999)	Reuse, service, remanufacture, recycle and disposal
Guide et al.(2000)	Repair, remanufacturing and recycling
Ferguson and Browne (2001)	Reuse, remanufacture and recycle
Lee et al. (2001)	Reuse, remanufacture, recycle, landfill, and incineration
King et al. (2006)	Repair, recondition, remanufacture, and recycle
Sasikumar and Kannan (2008)	Direct reuse, recycling, remanufacturing, and repair
Skinner et al. (2008)	Destroying, recycling, refurbishing, remanufacturing, and repackaging
Srivastava (2008)	Repair & refurbish, remanufacturing, and secondary market
Lambert et al. (2011)	Repair, reuse, remanufacture, upgrade, repackage, recycle, reconfigure, and revaluation
Jindal and Sangwan (2016)	Repair, refurbishin, remanufacturing, cannibalising, and recycling

Lund (1983) defined remanufacturing as ''an industrial process in which worn-out products are restored to like-new condition. Through a series of industrial processes in a factory environment, a discarded product is completely disassembled. Useable parts are cleaned, refurbished, and put into inventory. Then the new product is reassembled from the old and, where necessary, new parts to produce a fully equivalent and sometimes superior-in performance and expected lifetime to the original new product. The KPIs for product recovery decisions are given in table 6.

Table 6. KPIs for product recovery decisions in RL

S. No.	KPIs
1.	Operating cost
2.	Environmental impact
3.	Market demand
4.	Technical feasibility
5.	Green image
6.	Value recovery
7.	Health and safety issues
8.	Employment generation opportunities
9.	Level of national importance

4. Summary

This paper provides key activities, decision variables involved in each activity and the key performance indicators required to take informed decisions. The novelty of this paper is that the KPIs and decision variables are provided for all the major activities involved in reverse logistics. The researchers in the area of RL have not thought of KPIs along the activity lines. The non availability of KPIs and decision variables is effecting the research direction in the area and also the justification of RL activities to the top leadership in the organizations. It is expected that now, with the identified KPIs, the managers will be able to take effective decisions in the design of reverse logistics activities. However, further research is required to fine tune the KPIs for the different type of industry segments as the volume of collection and importance of collection depends upon the type of products.

References

[1] Aras, N. and Aksen, D. 2008. “Locating collection centers for distance- and incentive-dependent returns.” International Journal of Production Economics 111(2): 316-333.

[2] Barker, T. J. and Zabinsky, Z. B. 2008. “Reverse logistics network design: a conceptual framework for decision making.” International Journal of Sustainable Engineering 1(4): 250-260.

[3] Barker, T. J. and Zabinsky, Z. B. 2011. “A multicriteria decision making model for reverse logistics using analytical hierarchy process.” Omega 39(5): 558-573.

[4] Barros, A. I., Dekker, R. and Scholten, V. 1998. “A two-level network for recycling sand: A case study.” European Journal of Operational Research 110(2): 199-214.

[5] Bloemhof-Ruwaard, J. M., Van Wassenhove, L. N., Gabel, H. L. and Weaver, P. M. 1996. “An environmental life cycle optimization model for the European pulp and paper industry.”Omega 24(6): 615-629.

[6] Brennan, L., Gupta, S. M. and Taleb, K. N. 1994. “Operations planning issues in an assembly/disassembly environment.” International Journal of Operations & Production Management 14(9): 57-67.

[7] Chanintrakul, P., Mondragon, A. E. C., Lalwani, C. and Wong, C. Y. 2009. “Reverse logistics network design: a state-of- the-art literature review.” International Journal of Business Performance and Supply Chain Modelling 1(1): 61 - 81.

[8] Daugherty, P. J., Autry, C. W. and Ellinger, A. E. 2001. “Reverse logistics: the relationship between resource commitment and program performance.” Journal of Business Logististics 22(1): 107-124.

[9] De Brito, M. P. and Dekker, R., 2002. A framework for reverse logistics. In: Dekker, R., Inderfurth, K., van Wassenhove, L., and Fleischmann,M. ed. Reverse Logistics. Quantitative Models for Closed-Loop Supply Chains. Springer-Verlag, Berlin, Germany.

[10]De Ron, A. and Penev, K. 1995. “Disassembly and recycling of electronic consumer products: an overview.” Technovation 15(6): 363-374.

[11]Diabat, A. and Kannan, G. 2011. “An analysis of the drivers affecting the implementation of green supply chain management.” Resources, Conservation and Recycling 55(6): 659-667.

[12]Dowlatshahi, S. 2000. “Developing a Theory of Reverse Logistics.” Interfaces 30(3): 143-155.

[13]Ferguson, N. and Browne, J. 2001. “Issues in end-of- life product recovery and reverse logistics.”Production Planning & Control 12(5): 534-547.

[14]Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., van der Laan, E., van Nunen, J. A. E. E. andVan Wassenhove, L. N. 1997. “Quantitative models for reverse logistics: A review.”European Journal of Operational Research 103(1): 1-17.

[15]Fleischmann, M., Krikke, H. R., Dekker, R. and Flapper, S. D. P. 2000. “A characterisation of logistics networks for product recovery.” Omega 28(6): 653-666.

[16]FrotaNeto, J. Q., Bloemhof-Ruwaard, J. M., van Nunen, J. A. E. E. and van Heck, E. 2008.”Designing and evaluating sustainable logistics networks.” International Journal of Production Economics 111(2): 195-208.

[17]Fullerton, D. and Wu, W. 1998. “Policies for green design.” Journal of Environmental Economics andManagement 36(2): 131-148.

[18]Guide Jr, V. D. R. 2000. “Production planning and control for remanufacturing: industry practiceand research needs.” Journal of Operations Management 18(4): 467-483.

[19]Jayaraman, V. 2006. “Production planning for closed-loop supply chains with product recovery andreuse: an analytical approach.” International Journal of Production Research 44(5): 981-998.

[20]Jayaraman, V., Patterson, R. A. and Rolland, E. 2003. “The design of reverse distribution networks: Models and solution procedures.” European Journal of Operational Research 150(1): 128-149.

[21]Jindal, A. and Sangwan, K. S. 2014, “Closed loop supply chain network design and optimization using fuzzy mixed integer linear programming model.” International Journal of Production Research 52(14): 4156-4173.

[22]Jindal, A. and Sangwan, K. S. 2015. “Evaluation of collection methods in reverse logistics by using fuzzy mathematics.” Benchmarking: An International Journal 22(3): 393-410.

[23]Jindal, A. and Sangwan, K. S. 2016. “A fuzzy based decision support framework for product recovery process selection in reverse logistics.” International Journal of Services and Operations Management. DOI: 10.1504/IJSOM.2016.10000346.

[24]Johnson, M. R. and Wang, M. H. 1995. “Planning product disassembly for material recovery opportunities.” International Journal of Production Research 33(11): 3119-3142.

[25]Kapetanopoulou, P. and Tagaras, G. 2011. “Drivers and obstacles of product recovery activities in the Greek industry.” International Journal of Operations & Production Management 31(2):148 - 166.

[26]King, A. M., Burgess, S. C., Ijomah, W. and McMahon, C. A. 2006. “Reducing waste: repair, recondition, remanufacture or recycle?” Sustainable Development 14(4): 257-267.

[27]Kroon, L. and Vrijens, G. 1995. “Returnable containers: an example of reverse logistics.”International Journal of Physical Distribution & Logistics Management 25(2): 56-68.

[28]Kumar, V. and Dao, A., 2006. Reverse supply chain management: an integrated research framework. Administrative Sciences Association of Canada. Alberta, Canada 47-63.

[29]Lambert, S., Riopel, D. and Abdul-Kader, W. 2011. “A reverse logistics decisions conceptual framework.” Computers & Industrial Engineering 61(3): 561-581.

[30]Lee, D.-H., Dong, M. and Bian, W. 2010. “The design of sustainable logistics network under uncertainty.” International Journal of Production Economics 128(1): 159-166.

[31]Lee, S. G., Lye, S. W. and Khoo, M. K. 2001. “A Multi-Objective Methodology for Evaluating Product End-of- Life Options and Disassembly.” The International Journal of Advanced Manufacturing Technology 18(2): 148-156.

[32]Louwers, D., Kip, B. J., Peters, E., Souren, F. and Flapper, S. D. P. 1999. “A facility location allocation model for reusing carpet materials.” Computers & Industrial Engineering 36(4): 855-869.

[33]Lund, R. T., 1983. Remanufacturing, United States experience and implications for developing nations. Center for Policy Alternatives, Massachusetts Institute of Technology.

[34]Min, H., JeungKo, H. and SeongKo, C. 2006. “A genetic algorithm approach to developing the multi-echelon reverse logistics network for product returns.” Omega 34(1): 56-69.

[35]Mutha, A. and Pokharel, S. 2009. “Strategic network design for reverse logistics and remanufacturing using new and old product modules.” Computers and Industrial Engineering 56(1): 334-346.

[36]Rose, C. M. and Ishii, K. 1999. “Product end-of- life strategy categorization design tool.” Journal of Electronics Manufacturing 9(01): 41-51.

[37]Sasikumar, P. and Kannan, G. 2008. “Issues in reverse supply chains, part I: end of life product recovery and inventory management – an overview.” International Journal of Sustainable Engineering 1(3): 154-172.

[38]Schwartz, B. 2000. “Reverse logistics strengthens supply chains.” Transportation & Distribution41(5): 95-100.

[39]Seuring, S. and Müller, M. 2008. “From a literature review to a conceptual framework for sustainable supply chain management.” Journal of Cleaner Production 16(15): 1699-1710.

[40]Skinner, L. R., Bryant, P. T. and Richey, R. G. 2008. “Examining the impact of reverse logistics disposition strategies “International Journal of Physical Distribution & Logistics Management 38(7): 518-539.

[41]Spengler, T., Püchert, H., Penkuhn, T. and Rentz, O. 1997. “Environmental integrated production and recycling management.” European Journal of Operational Research 97(2): 308-326.

[42]Srivastava, S. K. 2008. “Network design for reverse logistics.” Omega 36(4): 535-548.

[43]Srivastava, S. K. and Srivastava, R. K. 2006. “Managing product returns for reverse logistics.”International Journal of Physical Distribution & Logistics Management 36(7): 524-546.

[44]Thierry, M. C., Salomon, M., Nunen, J. A. E. E. v. and Wassenhove, L. N. v. 1995. “Strategic issues inproduct recovery management.” California Management Review 37(2): 114-135.

[45]Tibben-Lembke, R. S. and Rogers, D. S. 2002. “Differences between forward and reverselogistics in a retail environment.” Supply Chain Management: An International Journal7(5): 271-282.

[46]Vedpal and Jain, V. 2011. “A conceptual framework for modelling reverse logistics networks.”International Journal of Business Performance and Supply Chain Modelling 3(4): 353 -363.

[47]Wojanowski, R., Verter, V. and Boyaci, T. 2007. “Retail–collection network design under deposit–refund.” Computers and Operations Research 34(2): 324-345.