Closed-Loop Supply Chain Networks: an Overview

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Abstract- In recent decades, global economy pressures and developments force companies to make new competitiveness advantages to come up them. Not only companies are encouraged by environment regulation to be cautious to reuse used product but also they have understood that could be economic and beneficial if they can reuse product in end of life cycle. Closed-loop and reverse logistics network make an infrastructure to collect and recover, assess, remanufacture and recycle used products to achieve the objective. Therefore, developing an effective closed-loop and reverse logistics network are more interesting by scholars and industrial researcher that to design supply chains to be more competitive. The main issue in designing reverse logistics is which and where facility should be considered in networks and how they have to relate together .In this research, we explain green supply chain concept and elements then discuss about reverse and closed-loop network.

Keywords: Reverse Logistics; Closed-loop Logistics; Green Logistics; Logistic Network Design Green Supply Chain.

1. INTRODUCTION

Global warming is a real threat to our world. Two main figures have been reported by Intergovernmental Panel on Climate Change (IPCC) in 2007 (Intergovernmental Panel on Climate Change 2007); namely linear warming trend over the 50 years from 1956 to 2005 (0.13°C per decade) is nearly twice that for the 100 years from 1906 to 2005, and that global average sea level rose at an average rate of 1.8 mm per year over 1961 to 2003 and at an average rate of about 3.1 mm per year from 1993 to 2003. Today people, government, and business units are more cautious to environment and climate change and there are an increasing concerned on the role of organizations in society (McWilliams and Siegel 2000), so that there are an increasing concerned on role of business and manufacturing organizations in society and ecology (McWilliams and Siegel 2000).

Supply Chain is a system of managing activities and facilities beginning with purchasing raw material, moving to producing goods, and finally distributing product to customers. All vendors and manufacturers, service providers, distributors, warehouses and retailers are linked in Supply Chain Management (SCM). The main objective of SCM is minimizing costs and maximize profits simultaneously to reach service level requirements [3,4].
The supply chain concept has been changed by environmental concerns so that, not only is an efficient supply chain based on economic conditions, but also interest is growing in integrating environmental issues into the entire supply chain such that they are more “green” and produce zero waste and pollution. The concept is aimed at the reduction of several elements: energy, materials, the all kinds of pollution and emission, waste in production and logistics processes or promoting the usage of recyclable materials and renewable energy sources are introduced in various segments of supply chains [5]. It is often defined as integrating environmental thinking into supply chain management [6].

2. GREEN SUPPLY CHAIN

In business, some conflict derivers note that some theories encourage practitioners in supply chain management to “be green” and some not only do not encourage greening the supply chain, but also force and emphasis to run it throughout the supply chain. In other words, from one perspective, customers’ concern for the environment leads them to be satisfied with green products and the manufacturer uses this opportunity to be agile and produce environmentally friendly products. On the other hand, the increasing severity of environmental damage such as decreases and limits in raw material resources increases in air pollution and CO₂ emission push practitioners to adopt a green supply chain. From this perspective, green supply chain can help companies reach a more competitive position, higher profitability, and better performance by satisfying their customers more effectively (Sarkis 2003).

To achieve green supply chain objectives and competitiveness, as well reducing costs and protecting the environment, manufacturers try to implement various initiatives throughout the entire in supply chain. Such activities include recycling, reusing, reworking, remanufacturing, refurbishing, reclaiming, reducing to designing reverse logistics (Srivastava 2007) or using closed-loop logistics. In this latter case, closed-loop and reverse logistics networks are used for re-using recycled materials along with virgin materials and can protect the environment by collecting used products and re-using them. Many initiatives should be considered for greening supply chains. Eltayeb et al. reviewed literatures on green supply chain and categorized them into; eco-design, green purchasing, supplier environmental collaboration, customer environmental collaboration, and reverse logistics (Eltayeb, Zailani et al. 2010). Furthermore, Srivastava et al. classified green supply chain literature into three main branch based on problem context in supply chain design(Srivastava 2007) that is shown in Fig. 1.

![Fig.1. Classification based on problem context in green supply chain design](image-url)
Besides cost that should be optimized in supply chain, green supply chains deal with environment and ecology concerns, waste management and optimization, green and reverse logistics, recycling, remanufacturing and green design. These issues and related variables and limitations should be included concurrently while the model and network are being developed in green supply chain.

Regarding to the variety of variables and limitations, most of the green supply chain problems have been known to have characteristics of being combinatorial and NP-hard. As a result, all possible combinations of the decisions and variables must be explored to find the optimum solution. The time required to solve the problem becomes extremely long as the number of variables increase to more than hundreds.

3. CLOSED-LOOP AND REVERSE LOGISTICS

Traditionally, supply chains have been designed with unidirectional logistics, also called forward logistics with the need to decrease waste and reuse products at the end of the life cycle. However, the concept of reverse logistics has been considered in supply chains. Currently, reverse logistics as a greening tool has become increasingly interesting to a large number of companies based on environmental concerns and regulations. The term reverse logistics has been used and defined differently by many authors. For example, some have noted that reverse logistics is the opposite of forward logistics (Fortes 2009). Reverse logistics is a mechanism a manufacturer may use to collect products at the end of the life cycle from the point of the consumer for possible recycling and re-manufacturing. The main application of reverse logistics is to improve reclamation of products when they are at the end of the life cycle (Meade and Sarkis 2007). Wang and Bai (Wang and Bai, 2010) believed that the main task of RL could be considered collecting used products based on the balance of environment affects and cost. Products that are collected using reverse logistic can be used in four forms: direct reuse, repair, recycling, and remanufacturing (Srivastava 2007) and (Thierry, Salomon et al. 1995).

Reverse logistics can be accomplished through the original forward channel, through a reverse channel, or through a combination that uses both the forward and reverse channels. Fig. 2 illustrates a generic concept model of a reverse and forward network.

![Fig.2. A generic forward and reverse logistic (Closed-loop network)](image-url)
Collecting and transporting used products is the main task of reverse logistic. The mutual relationship between the reverse and forward channels led by managers and engineers to design them concurrently. Therefore, the concept of a closed-loop network or an integrated network refers to the mutual transactions between reverse logistic and forward logistic. This integration helps avoid sub-optimization results versus designing them separately. The first quantitative model for a closed-loop network in supply chain management was developed by Fleischmann, Beullens, Bloemhof-Ruwaard, and Van Wassenhove (2001), who tried to optimize forward distribution and recovery using product flow simultaneously.

4. PROBLEMS AND CASE STUDIES

In supply chain management, all facilities locations and logistics networks specifications such as: how many raw material suppliers and partners should be selected and which ones are best?, what kind of physical structure should be use for the supply chain?, how many manufacturers should be included in the supply chain and where should be they established?, and how many products should be produced by each factory? and when and where should those products be stored? should be considered to minimize cost entire the supply chain.

In addition to cost which should be optimized in the supply chain, logistics and transportation system in green supply chains deal with environment and ecology concerns, waste management, fossil fuel consumption, recycling and remanufacturing requirements. These issues, along with related variables and limitations, should be considered concurrently when networks elements are being developed for a green supply chain.

Regarding the variety of variables and limitations, most logistics networks in green supply chain problems have been known to have characteristics of being combinatorial and NP-hard (Krumwiede and Sheu 2002). As a result, all possible combinations of decisions and variables must be explored to find the optimum solution. Notably, the time required to solve the problem becomes extremely long as the number of variables increases to more than hundreds.

Due to the complexity of reverse logistics network, many researchers have studied reverse logistics network design for several different industries/products such as carpet recycling (Louwers, Kip et al. 1999; Realf, Ammons et al. 2004), sand recycling (Barros, Dekker et al. 1998; Listes and Dekker 2005) electronic equipments (Krikke, Van Harten et al. 1999; Shih 2001; Walther and Spengler 2005), paper recycling (Pati, Vrat et al. 2008) and Automotive industry (Schultmann, Zumkeller et al. 2006; Cruz-Rivera and Ertel 2009; Kannan, Sasikumar et al. 2010; Cao and Zhang 2011) Some of case studies tabulated in table 1.

5. CONCLUSION AND FURTHER RESEARCH

In the paper, we discussed about green supply chain importance and concept. Then, we categorized main issues in the field and explained reverse and closed-loop logistics as one of most effective tool for greening supply chain. it has been argued that due to the complexity of reverse logistics network, many researchers have studied reverse logistics network design for several different cases not for general fields. The research can be explored by considering social problems such as jobless as one of dimension of sustainability in green supply chain. It is hoped that the study sparks further interest in green supply chain and reverse logistics.
Table 1. Case studies in reverse logistics

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<thead>
<tr>
<th>Reference</th>
<th>Case</th>
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<tr>
<td>(Krikke, Kooi et al. 1999; Schultmann, Zumkeller et al. 2006; Cruz-Rivera and Ertel 2009; Olugu and Wong 2011; Hamzah, Yusof et al. 2012) (Schultmann, Zumkeller et al. 2006; Cruz-Rivera and Ertel 2009; Kannan, Sasikumar et al. 2010; Cao and Zhang 2011)</td>
<td>Automotive parts industry</td>
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<tr>
<td>(De La Fuente, Ros et al. 2008)</td>
<td>Metal-mechanic company</td>
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<tr>
<td>(Barros, Dekker et al. 1998; Listes and Dekker 2005)</td>
<td>Sand recycling</td>
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<tr>
<td>(Krikke 2011) (Krikke, Van Harten et al. 1999)</td>
<td>Copier machine and Electronics part</td>
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<td>(Tsai 2012)</td>
<td>suitcase</td>
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<tr>
<td>(Listes and Dekker 2005)</td>
<td>product recycling</td>
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<td>(Sheu 2008)</td>
<td>Nuclear power generation</td>
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<td>(Pati, Vrat et al. 2008)</td>
<td>Paper recycling</td>
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6. REFERENCES


