Chapter 34
Selection of Transportation Channels in Closed-Loop Supply Chain Using Meta-Heuristic Algorithm

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ABSTRACT

This article presents a closed-loop supply chain (CLSC) network design problem consisting of both forward and reverse material flows. Here, a four-echelon single-product system is introduced in which multiple transportation channels are considered between the nodes of each echelon. Each design is analyzed for the optimum cost, time and environmental impact which form objective functions. The problem is modeled as a tri-objective mixed integer linear programming (MILP) model. The cost objective aggregates the opening cost (fixed cost) and the variable costs in both forward and reverses material flow. The time objective considers the longest transportation time from plants to customers and reverse. Factors of environmental impact are categorized and weighed using an analytic network process (ANP) which forms the environmental objective function. A genetic algorithm (GA) has been applied as a solution methodology to solve the MILP model. Ultimately, a case problem is also used to illustrate the model developed and concluding remarks are made regarding the results.

INTRODUCTION

Closed Loop Supply Chain (CLSC) network design includes the establishment of an effective and efficient system for the flow of all materials or products in the Supply Chain (SC) considering social and environmental concerns (Özkır & Başlıgil, 2013). The transportation channels can be seen as transportation modes (e.g., rail, air, truck, ship, etc.) and these modes play an important role in the design of any supply chain model (Kiesmüller et al., 2005). Proper selection of transportation channels in SC is important for reducing the cost and time. It considers the location decision, selection of transportation channels, calculation of flows between nodes, and the trade-off between time and cost. Olivares-Benitez et al. (2013) described a meta-heuristic approach for the selection of transportation channels in SC design problem based on a two-echelon single product system through which transportation channels are selected at minimum cost and time.

In the modern world scenario, every manufacturer is focused on environmental sustainability. The success of any enterprise depends on its location or distribution decisions, but due to the globalization of SC; the distance between the nodes of the SC and distribution locations is being considerably increased (Elhedhli & Merrick, 2012). More the distance means more the environmental impact due to pollutions like air pollution, noise pollutions and greenhouse gas emissions pollute the ozone layer and human health hazard will also increase. As such, we have presented a model for the selection of transportation channels in CLSC by considering the environmental impact of the transportation channels. A set of manufacturing plants assembles the products which are transported to the distribution centers, and from there, products are moved to customers. The products which are returned by the customers are collected in recollection centers and from there it is sent back to the manufacturing plants. Since the selection of transportation channels is a Combinatorial Optimization (CO) and NP-hard (Nondeterministic Polynomial-time hard) type problem (Olivares-Benitez et al., 2013); a meta-heuristic algorithm has been proposed which has the advantage to solve the problem in limited time windows. There are many algorithms in this category like GA, simulated annealing, particle swarm optimization and ant colony optimization. GA is one of the broadly applicable meta-heuristics techniques based on Darwin's evolutionary theory. It was first introduced by Holland (1975) and is now considered as an effective and efficient algorithm for CO and NP-hard problems (Gen & Cheng, 2000). GA has been used by many authors' such as for solving balanced allocation problem of third party logistics providers (Rajesh et al., 2011), for inventory levels and routing structure optimization in two stage SC by Sivakumar et al. (2013). In this paper, ANP is used to find the environmental impact on transportation channels and GA has been applied as a solution methodology for selection of optimal transportation channels.

LITERATURE REVIEW

Supply chain designs have been studied by many authors (Beamon, 1998; Melo et al., 2009; Thomas & Griffin, 1996; Vidal & Goetschalckx, 1997). In the Recent past, we can find that reverse logistics and CLSC are not only a cost minimization approach but also a revenue opportunity for the manufacturers and supply chain partners (Guide & Van Wassenhove, 2009). CLSC design has been the subject of study of many authors (Georgiadi et al., 2006; Atasu et al., 2008; Amin & Zhang, 2013; Chen et al., 2015; Giovanni & Zaccour, 2014; Ramezani et al., 2014; Shi et al., 2016; Tsao et al., 2016; Yang et al., 2009; Zohal & Soleimani., 2016; Chen et al., 2016; O'Reilly & Kumar, 2016).

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