Chapter 6
Multi-Objective Optimization of Economic and Environmental Aspects of a Three-Echelon Supply Chain

Rajaram R.
Tata Consultancy Services, India

Jawahar N.
Ramco Institute of Technology, India

S. G. Ponnambalam
https://orcid.org/0000-0003-4973-733X
University Malaysia Pahang, Malaysia

Mukund Nilakantan Janardhanan
University of Leicester, UK

ABSTRACT

It is very relevant in today’s competitive world for suppliers to ensure that customer-demanded products are made available. Customers expect to obtain a product that has benefits and are available within an acceptable price and time. It is necessary for companies to optimally use their ability to satisfy customers’ specified needs. Researchers and industries are working on developing green supply chain concept in the last few years due to environmental concerns. The objective of this chapter is to propose a three-echelon supply chain model that optimizes economic and environmental objectives simultaneously. The objectives considered are minimizing the total supply chain cost and minimizing CO₂ emission of the supply chain network. The proposed model falls into NP-hard category. Multi-objective genetic algorithm is proposed to solve the proposed model and illustration is provided to explain the use of the proposed model. A procedure that could be followed to find the best possible solution based on user’s choice among the Pareto front solutions is also explained.

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INTRODUCTION

Due to increasing awareness among industries on environmental concerns, lot of researchers and industries are working on green supply chain concept in the last few years (Nurjanni et al., 2014). As defined in supply chain management, for every product reaching the end user there would be a cumulative effort of various elements in the supply chain such as suppliers, manufacturing plants and customers (retailers/distributors). Now-a-days, the main focus in supply chain management (SCM) is to achieve overall competitive advantage (Marinagi et al., 2014). Major focus has been on objectives that are related to economy and many researchers attempted it by means of maintaining optimum inventory level (Ghodsypour & O’Brien, 2001, Reddy et al., 2011), maximizing channel profit (Nachiappan et al., 2007), improving customer service performance (Nozick & Turnquist, 2001) and determining optimal distribution plan (Jawahar & Balaji, 2009, Hamedi et al., 2009). In the last few year’s times, the industries and researchers have understood that competitive advantage cannot be only derived by focusing on economic aspects alone. Sustainability is another aspect which needs to be focused in achieving the global competitive advantage, resulting in both economical advantage and clean environment. This is very much applicable for SCM as well and few research work has been reported focusing on this element (Nurjanni et al., 2014). To be different from each other in market, industries realize the importance of ‘green image’ very seriously and recent research works focus on addressing the environmental aspects such as minimizing carbon emission (Zhang et al., 2015, Aksoy et al., 2014), minimizing energy consumption and maximizing the utilization of eco-friendly resources (Aksoy et al., 2014, Subulan et al., 2015, Abdallah et al., 2013) can be classified under Green Supply Chain Management (GSCM).

The environmental pollution is one of the major issues while transporting goods between the elements of the supply chain (SC). The emission from the vehicle during transportation leads to greater environmental problems. Among the different modes of transportation such as air, sea, rail and roadways, road freight transportation is widely used for movement of goods because of high flexibility, cheaper investment funds and availability. According to Jofred and Öster (2011), 30% to 40% of CO₂ emission are directly resulted from freight transportation in roadways. Hence, every industry working with SC mode aims to be sustainable in the business and attempts to implement plans to reduce the environmental impact as a result of the transportation and processing activities, besides concentrating on the goal of making profit. Many recent work are being reported with models considering both economy and environment aspects (Wang et al., 2011, Govindan et al., 2014, Pop et al., 2015, Validi et al., 2014, Chibeles-Martins et al., 2016, Urata et al., 2015). Within a country, road transportation is considered to the most common and cost effective. In countries
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