

## Chapter 58

# The Development and Analysis of Environmentally Responsible Supply Chain Models

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### ABSTRACT

*Inventory management and supply chain management are integral issues and prime areas of concern in production and operations management, and industrial engineering. There is a drive for businesses and organizations to be accountable for their environmental impacts. Guaranteeing environmentally conscious supply chain operations is strongly linked to an organization's sustainability and overall success. The responsible management of forward and return product flows in production and inventory environments is a rapidly increasing requirement. This can be attributed to economic, environmental and/or regulatory motivations. Mathematical modeling of such systems assists decision-making processes and provided a better understanding of the behavior of such production and inventory environments.*

### INTRODUCTION

Inventory modeling in supply chains is a prime concern for research in production and operations management and industrial engineering. The approach is to have mathematical representations of systems that can be studied and optimized to satisfy dynamic market demands. Most of these inventory models are managed by the classical analysis (profit-maximization/cost-minimization) approach. There has been a push for businesses and organizations to be accountable and responsible for environmental and social impacts of their operations. This drive has been derived from various internal and external stakeholders leading to new regulations being imposed. Such responsibilities have accounted for the introduction and application of various concepts, programs, and efforts (Richards, 1997). Some of these include: environmental management systems, integrated management systems, corporate social responsibility, life

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cycle assessment, design for environment, pollution prevention, sustainable development, environmental indicators and reporting to name a few.

Applying environmental management concepts to supply chains is becoming known as green supply chain management. Relatively, this concept is considered in its infancy and many individual efforts using a variety of approaches and methodologies are existent throughout the literature. In light of the current environmental responsibilities, interest in industrial environmental performance metrics is increasing. The coupling of such measures and their integration into product procurement/purchasing decisions, investment decisions, and their effect on supply chain environmental performance will only increase environmental awareness and the ability of decision makers to reach balanced judgments and achieve sustainable choices.

This chapter addresses the importance of environmental awareness in firms and organizations, and the integration of environmental consciousness into supply chains as a necessity for sustainability and continuous improvement. This chapter will focus on the mathematical modeling of supply chains highlighting research gaps and providing insights to future work that remains to be done to achieve environmental responsibility.

## **SUPPLY CHAIN AND SUPPLY CHAIN MANAGEMENT**

Supply chains are an important element of any business whether it is manufacturing products or providing a service. It is a direct result of differences and discrepancies between supply and demand throughout the different stages of a business. Assume the following scenario of a vendor who supplies products to a buyer: if the demand is more than what the supplier offers, shortages will occur and may lead to possible back-logs or lost sales. Conversely, if the supply available is more than the buyer's demand, excess inventory may incur additional costs. Expanding, there may be more than two parties involved: e.g. many suppliers, multiple products, numerous warehouses, various distributors, etc. The more parties in a supply chain, the more complex it is and the need for careful management is more evident. For a successful supply chain, it should be efficient and responsive. Furthermore, storage and material handling costs in supply chains can be as high as 50% of a product's indirect operating expenses (Rosenblatt, 1986). Consequently, reducing inventory related costs in a supply chain is a priority. The following will provide readers with some of the concepts and definitions.

Supply chains have been defined as "the alignment of firms that bring products or services to market" (Lambert et al., 1998), or as a chain that "consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves . . ." (Chopra et al., 2003). It has also been defined as "a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers." (Ganeshan & Harrison, 1995). Though slightly different, all definitions share a network, active participants in this network, and a goal to bring a service or product to the end customer. It is not uncommon that participants have conflicting objectives, where each participant would like to maximize (minimize) its profit (cost). Accordingly, supply chain management becomes the means to manage these networks.

Mentzer et al. (2001) defines supply chain management as: "the systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular

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