Chapter 4
Supply Chain Design Including Quality Considerations: Modeling and Solution Approaches based on Metaheuristics

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ABSTRACT

This chapter introduces the reader to Supply Chain Network Design (SCND) models that include the Cost Of Quality (COQ) among the relevant costs. In contrast to earlier models, the COQ is computed internally as a function of decisions taken as part of the design of the supply chain. Earlier models assume exogenously given COQ functions. Background information is provided on previous COQ modeling and on supply chain network design models. The authors' COQ modeling is described in detail as is the SCND model that incorporates COQ. The COQ modeling includes prevention, appraisal, and both internal and external failure costs. Solution methods based on metaheuristics such as simulated annealing and the genetic algorithm are provided, including details on parameter tuning and computational testing. A genetic algorithm was found to yield the best results, followed by the simulated annealing approach. Topics for further research are provided as well as an extensive list of references for further reading.

1. INTRODUCTION

Cost Of Quality (COQ), or quality cost, represents a powerful measurement system that translates the implications of poor quality, the activities of a quality program, and quality improvement efforts into a monetary language for managers. COQ is a language that every stakeholder can understand; it affects operating costs, profitability, and consumer needs (Srivastava, 2008). Although COQ has been applied mostly within enterprises, it is crucial to extend COQ as an external measure and integrate these costs into Supply Chain (SC) modelling.

This chapter shows how to model a supply chain design problem that incorporates the COQ (SC-COQ model). It is a strategic-level model

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that internally computes the Cost of Quality in a single-product, multi-stage, serial Supply Chain Network Design (SCND) problem. The model selects from among several potential suppliers, several manufacturing plants, and several potential retailers to generate a logistic route that maximizes profit while attaining a required quality level. Two heuristic procedures are presented that can be used to solve the resulting nonlinear mixed-integer optimization problem. The heuristics are based on Simulated Annealing (SA) and the Genetic Algorithm (GA). The procedures followed for tuning the heuristics' parameters is documented for readers wishing to implement similar procedures.

The chapter is organized as follows. The background section covers the concept of the supply chain, supply chain management, supply chain network design, the concept of Cost of Quality, the modelling of the Cost of Quality, a review on strategic SCND problems, and concludes a discussion of the motivation and contributions of the proposed model for supply chain design including the COQ. In section 3, the supply chain design model including COQ is presented. Computational experiments and results are presented in sections 4 and 5, respectively. A discussion of the impact of the COQ on supply chain design is provided in section 6, followed by suggestions for future research and conclusions.

2. BACKGROUND

2.1. Supply Chain

The concept of the Supply Chain (SC) appeared in the eighties as a result of changes in the manufacturing industries and their environments. According to Kurt Salmon Associates, Inc. (Lummus & Vokurka, 1999), the early history of the supply chain initiative can be traced to the textile industry when, in 1984, leaders in the US apparel industry created the Crafted With Pride in the USA Council to study ways to achieve quick response time in the supply chain for general merchandise retailers and suppliers. Later, in 1992, a group of grocery industry leaders formed the Efficient Consumer Response (ECR) working group, whose objective was to improve the supply chain. The improvement was reflected in a reduction of inventory of 37% and overall cost reduction in the range of $24 to $30 billion (Lummus & Vokurka, 1999).

A supply chain is a set of facilities (suppliers, manufacturing plants, retailers, distribution centers, among others), supplies, customers, products, and methods for controlling inventory, purchasing, and distribution (Sabri & Beamon, 2000). The flow of goods between a supplier and customer in a supply chain passes through several stages, and each stage may consist of many facilities (Sabri & Beamon, 2000). Beamon (1998) defines the supply chain as an integrated process of various business entities working together to acquire and transform raw materials and deliver value added products to customers. Business entities can be defined as suppliers, manufacturers, distributors, and retailers.

According to Beamon (1998), in general, a supply chain comprises two basic, integrated processes: the Production, Planning and Inventory Control Process, and the Distribution and Logistics Process. This classification is similar to the one presented by Min and Zhou (2002); these authors divide the supply chain into business processes: material management or inbound logistics, and physical distribution or outbound logistics. The inbound logistics include the acquisition and storage of materials. On the other hand, the outbound logistics are all the activities oriented to provide the product or service to the customer. Since the purpose of the supply chain is to enhance a competitive advantage, efficiency and effectiveness in the operation, and profitability for the whole chain, including its partners, special attention is placed on the flow of information and goods. The supply chain can be seen as the integration