

Chapter XIV

System Dynamics Modeling for Strategic Management of Green Supply Chain

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ABSTRACT

Environmental issues are rapidly emerging as one of the most important topics in strategic manufacturing decisions. Perusal of the literature has shown many models to support executives in the assessment of a company's environmental performance. Unfortunately, none of these identifies operating guidelines on how the systems should be adapted to support the deployment of different types of green supply-chain strategies. This chapter seeks to investigate how system dynamics modeling can be supportive for management of feasible green supply-chain strategies. Besides conceptual considerations, we base our arguments on the development of efficient performance measurement systems for remanufacturing facilities in reverse supply chains, taking into account not only economic but also environmental issues. The behavior of the green supply-chain management under study is analyzed through a simulation model based on the principles of the system dynamics methodology. The simulation model can be helpful for green strategic management as an experimental tool, which can be used to evaluate alternative long-term strategies ("what-if" analysis) using total supply chain profit as measure of strategy effectiveness. Validation and numerical experimentation further illustrate the applicability of the developed methodology, while providing additional intuitively sound insights.

INTRODUCTION

Environmental issues are rapidly emerging as one of the most important topics for strategic manufacturing decisions. The scarcity of natural resources and the growing concern in the market for “green” issues have forced executives to manage operations within an environmental perspective (Dimitrios Vlachos, Georgiadis, & Iakovou, 2007). Growing public awareness and increasing government interest in the environment have induced many Chinese manufacturing enterprises to adopt programs aimed at improving the environmental performance of their operations (Vincent, 2006; Zhu & Sarkis, 2004).

In the light of the strategic importance of environmental issues and of their effects on the corporate management system, a growing body of literature is focused on how companies should manage environmental issues. Two major lines of research are evident:

- Studies which analyze feasible green supply-chain strategies available to operations managers and describe how growing environmental concern impacts on the process of strategy formation; and
- General approaches aimed at supporting managers in the assessment of a company’s environmental performance, such as life-cycle assessment methods, or models reporting physical indicators, environmental costs, contingent liabilities, and so forth.

Despite the availability of the various approaches to develop performance measurement systems (PMSs) in respect of distinct green supply-chain strategies, none of them attempted to quantify the effects of various environmentally friendly activities pursued by the manufacturing function. Such a shortcoming is, in our opinion, critical, since environmental behavior results from specific environment-related objectives and has

its own managerial and financial implications on the corporate system.

In response to the issues identified in the above paragraphs this chapter presents a quantitative framework to:

- Define the basic green supply-chain strategies a company can implement and identify factors affecting environmental performance and their relationships for operations management
- Structure environmental performance measures hierarchically
Quantify the effectiveness of a planned environmental strategy on environmental performance
- “What if” analysis on environmental performance and green supply-chain strategy selection

By bringing together existing contributions on strategic environmental management and performance measurement systems, the chapter aims to develop quantitative models for environmental performance measurement systems (QMEPMS) using supermatrix, cause and effect diagrams, tree diagrams, and the analytical network process. It describes how different green supply-chain strategies can be deployed and presents the technique that can be used to identify factors affecting environmental performance and their relationships, structure them hierarchically, quantify the effect of the factors on environmental performance, and express them quantitatively.

The chapter is divided into six major sections. First, we give a taxonomy of green supply-chain management (GSCM) and highlight the problem existing in a company’s strategic management, describe research objectives and methodology to quantify the effect of the factors on an EPMS, and specify a quantitative model on how to structure critical factors hierarchically to support managers in the implementation for an EPMS. Then,

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