

# Chapter 19

## Modeling Closed Loop Supply Chain Systems

**Roberto Poles**  
*University of Melbourne, Australia*

### ABSTRACT

*In the past, many companies were concerned with managing activities primarily along the traditional supply chain to optimize operational processes and thereby economic benefits, without considering new economic or environmental opportunities in relation to the reverse supply chain and the use of used or reclaimed products. In contrast, companies are now showing increased interest in reverse logistics and closed loop supply chains (CLSCs) and their economic benefits and environmental impacts. In this chapter, our focus is the study of remanufacturing activity, which is one of the main recovery methods applied to closed loop supply chains. Specifically, the authors investigate and evaluate strategies for effective management of inventory control and production planning of a remanufacturing system. To pursue this objective, they model a production and inventory system for remanufacturing using the System Dynamics (SD) simulation modeling approach. The authors primary interest is in the returns process of such a system. Case studies will be referred to in this chapter to support some of the findings and to further validate the developed model.*

### INTRODUCTION

Industry in general, and society more broadly, have come to recognize the limited availability of natural resources and are moving towards the manufacture of more environmentally friendly products and the recovery of resources. For this

reason, the modern trend, particularly in developed countries, is to use fewer environmental resources such as water, air and raw materials to manufacture products. Moreover, interest in strategic sustainability is growing among multinational companies, some of whom are developing sustainability reports to demonstrate both their concern for the environment and their commitment to conducting socio-ecological activities in business. In addi-

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tion, sustainability can be used as a competitive strategy to create company branding, comply with government regulations on the environment and optimize the cost of operational processes.

This emerging economic and environmental consciousness within business has increased the focus on reverse logistics activity (company processes that recapture value from product returns) over the last decade (Blumberg, 2005). Indeed, this reverse logistics activity, particularly remanufacturing (the process of reusing returned products in production), can play an important role in sustainability, as well as in developing competitive strategies aimed at reducing the use of natural resources and recovering value from used products. However, several factors make the development of reverse logistics processes difficult. In particular, the complex integration between the forward (from the producer to the consumer) and the reverse (from the consumer to the producer) supply chains can negatively affect operations and logistics management activities such as production planning, inventory control and distribution planning.

According to the Reverse Logistics Executive Council, reverse logistics is the process of moving goods from the point of consumption to the point of origin for the purpose of either recapturing value or proper disposal. Stock (2001) has defined reverse logistics as “the term most often used to refer to the role of logistics in product returns, source reduction, recycling, material substitution, reuse of material, waste disposal, and refurbishing, repair and remanufacturing” (p. 5).

Companies can pursue several methods of recapturing value from returns, and carry out a range of recovery methods (Kulwiec, 2006). For example, products can be reused directly after cleaning or reconstruction. This is a common practice for items such as used pallets, bottles/glass or containers. However, products whose parts or materials need to be repaired or replaced can be reused after repair as rebuilt or used products. Another method of recovery is remanufactur-

ing, a process in which parts and materials from returned products are reused for production. Remanufacturing requires more extensive work, since the returned product must be completely disassembled, its parts and modules examined and either repaired or replaced, and then reassembled into a new product. Remanufacturing is practiced in many industries, including for photocopiers, computers, telecommunications equipment, automotive parts, office furniture and tires. A final recovery option is recycling. In this case, some or all of the parts and materials from returned products can be processed to make different products (Kulwiec, 2006).

The concept of reverse logistics has changed in recent years (Dekker, Fleischmann, Inderfurth, & Wassenhove, 2004). More specifically, the concept of a closed loop supply chain (CLSC) has been developed to refer to the complete loop from the customer, back to the plant, through a reprocessing operation, and then back to the customer (French & LaForge, 2006). Closed loops consist of two integrated supply chains—a forward and a reverse chain—through which a recovered product re-enters the original forward chain (Wells & Seitz, 2005). CLSC is sometimes treated as an extension of the traditional concept of supply chain management. In this case, reverse logistics is not managed independently of forward logistics, but rather both processes form part of a complete supply chain process whereby products start with the manufacturer to reach the customer, then come back to the plant and return to the customer once more. This process has been defined by this new concept of the closed loop supply chain (Eoksu, Sungwon, Haejoong, & Jinwoo, 2004).

The integration of reverse logistics activities within the structure of the original production and distribution systems leads to additional complexity in the closed loop supply chain system. This complexity, which can hinder the integration process, comes from the significant differences between the forward and reverse supply chains. The latter are characterized by operational and business

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