
**Strategic and Tactical
Aspects of Closed-Loop
Supply Chains**

Strategic and Tactical Aspects of Closed-Loop Supply Chains

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Strategic and Tactical Aspects of Closed-Loop Supply Chains

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Abstract

Today's common business practice of extracting non-renewable raw materials from the earth, processing them, turning them into products, selling the products to customers, and then having the customers dispose of the products in a landfill or through incineration is not sustainable. Eventually, the basic raw materials that are used to build most of the products our economy is based on will run out, or become prohibitively expensive to extract more of. Cognizant of this fact, many firms are taking a closer look at their supply chain practices and exploring ways to reduce (or at least prolong the timing of) the amount of their product that ends up in landfills. They do so by finding profitable ways to recover their used products for remanufacturing, refurbishing, or recycling. The study of these efforts has been termed Closed-Loop Supply Chains.

In this monograph, we review some of the recent research in this field, with a particular focus on the strategic and tactical issues. Representative models from each area are presented along with their key managerial insights, providing the reader with both a high-level overview and

an in-depth look at the common assumptions and modeling frameworks that are used. Where appropriate, suggestions for needed research are pointed out. The monograph is not intended to be a comprehensive review of the field, but rather an introduction to some of the more recent developments.

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Introduction

The sustainability movement has gained significant momentum over the last few years as both consumers and corporate managers begin to realize the impact of unsustainable environmental practices on their current and future profits and overall quality of life. The most immediate and direct impact of environmental issues for most people has been the recent dramatic increase in the cost for fossil fuels and raw materials. Not surprisingly, issues regarding energy usage, access to clean water, carbon dioxide emissions, and climate change have received the vast majority of the attention in the popular press. Each of these areas is indeed critically important, but there is at least one additional issue facing countries across the world whose long-term effects may be just as critical and potentially life changing as the ones above. This less publicized issue is the increasing rate of landfilling with manufactured products made of depletable raw materials and resources.

Prior to the early 1900s, very few consumer goods were landfilled or incinerated. Wood and metal from a wagon that had reached the end of its useful life, for example, would be salvaged to build houses or make furniture. The first modern landfill in the United states was not created until 1937. Prior to this time, the small amounts of household waste

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were simply burned. Consumer habits toward waste started to change, however, in 1901, the year King Camp Gillette started his disposable razor company. King Gillette's innovative idea was to create an inexpensive replaceable blade for his razors that could simply be disposed of when they became dull instead of re-sharpened. Thus began the era of the disposable society. Today, advances in manufacturing and supply chain management have brought the cost down on most consumer goods to the point that it has become cheaper to dispose and replace than to repair and reuse. Even with technologically sophisticated items such as DVD players, computers, cellular phones, or microwave ovens, the technology changes so quickly that there is little value in expending effort to extend their useful life for more than a few years from the date of manufacture. Of course, this exponential increase around the world in the amount of solid waste being generated has led to enormous amounts of waste that must be landfilled or incinerated every day.

Eventually, the amount of land available for product disposal will be used up, leading to a significant reduction in the fortunes of pure product-based companies and a lower standard of living for consumers around the world. The numbers demonstrating the problem are hard to fathom. Each household in the United Kingdom generates approximately one ton of waste each year. Even worse, for every ton of products we buy, ten tons of resources are used to produce them.¹ In the United States, each person generates approximately 4.6 pounds of waste per day for a cumulative total of 251 tons of solid waste that were either incinerated or sent to landfills in the year 2006. Of these 251 tons, 16% were categorized as durable goods. The disposal of durable goods is particularly troublesome because they are often manufactured using material from non-renewable resources. The only sustainable business practice for producing durable goods is to reuse or recover the non-renewable materials they are made of. Unfortunately, of the 40.2 million tons by weight of durable goods sold in the United States in 2006, only 18.5% of the material used in their production has been, or is expected to be, recovered.² To reduce waste, the U.S. Environmental

¹ <http://www.wasteonline.org.uk/resources/InformationSheets/HistoryofWaste.htm>

² EPA-530-F-07-030, November 2007, www.epa.gov/osw

Protection Agency recommends adopting a reduce–reuse–recycle hierarchy and resorting to combustion or landfilling only as a last resort (U.S. EPA 2008). Despite this recommendation, 67.5% of the municipal waste went directly to landfills or incineration facilities in 2006 (U.S. EPA 2007). As a consequence, landfills are filling up around the world and waste is being transported (sometimes at great expense) from areas with little available land to areas where land is more plentiful. Incineration is not a good solution either as the process produces toxic pollution and emits gasses that contribute to the global warming problem. Finally, our finite supply of virgin raw materials is being extracted from the earth and chemically processed into alternative forms to make products that are quickly disposed of, then sent to be burned or mixed with other toxic materials in landfills. Simply put, the current business practice of extracting raw materials from the earth, manufacturing them into products, and then disposing of the products into landfills or incinerators after a short period of use is not a sustainable practice.

Most manufacturers of durable goods recognize this fact and are starting to devise strategies for their long-term survival; and strategies that involve dramatic changes in the way they have historically viewed their supply chains. A promising trend in recent years has been the number of firms who proactively provide recycling options for their products at the end of the product's useful life. Some of these efforts have been driven by environmental legislation (or the threat of legislation) such as the WEEE Directive for the electronics industry in the European Union. This directive sets collection, recycling, and recovery targets for all types of electronic goods and holds the Original Equipment Manufacturers (OEMs) responsible for meeting the targets.

While recycling of raw materials is a good first step on the road to sustainability, there are other practices, such as remanufacturing, that have a higher positive environmental impact in most industries. It is encouraging that there is a market for remanufactured products in the United States. According to Hauser and Lund [45], there are at least 2,000, possibly up to 9,000, firms in the United States who claim themselves as remanufacturers; if refurbishing is also included as being remanufacturing, these numbers will be larger. Examples of remanufactured products include automotive parts, cranes and

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forklifts, furniture, medical equipment, pallets, personal computers, photocopiers, telephones, televisions, tires and toner cartridges, among others. These products are put on the market by the OEMs and/or independent remanufacturers. Given the size and growing importance of the remanufacturing market, there is a growing interest in the academic research community to further understand and explore this topic.

The goal in writing this monograph is to provide both researchers and practitioners a concise and readable summary of the latest research in the Closed-Loop Supply Chain (CLSC) field, particularly when there is remanufacturing involved. This monograph is divided into two sections. In the first section, we look at the strategic decisions facing a firm in regards to the secondary market for its products. Examples of strategic questions facing firms of durable and semi-durable products include:

- Is remanufacturing profitable for an OEM?
- Given the capability, should the OEM shut down the secondary market of its products?
- How should the reverse logistics network be designed?
- How are product design decisions influenced by Closed-loop Supply Chains?
- What role does environmental legislation play in a firm's remanufacturing decisions?

In the second section, we address the tactical decisions a remanufacturing firm faces assuming the firm has made the decision to remanufacture/refurbish in-house. More specifically, we explain the key differences between manufacturing new products versus remanufacturing returned products and how these differences require new tools and techniques for production planning and control. Examples of tactical questions facing firms who decide to remanufacture in-house are:

- How many used cores should be recovered?
- What should be done with the cores that are taken back? Should they be landfilled, incinerated, recycled, harvested for parts, sold as-is, refurbished, or remanufactured? (This is referred to as the disposition decision.)

- What is the value of pre-sorting the returned cores into different quality grades based on the amount of effort and/or expense to remanufacture? How many different quality grades are needed?
- How do you create a production plan for a remanufacturing operation? How is it different than a production plan for making new products?

Before exploring the strategic and tactical issues involved in Closed-Loop Supply Chains, we first need to define what a Closed-Loop Supply Chain is. We do so in the next section.

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