ELSEVIER

Optimal manufacturing–remanufacturing policies in a lean production environment

Sergio Rubio [a,*], Albert Corominas [b,1]

[a] *University of Extremadura, School of Industrial Engineering, Avenida de Elvas s/n, 06071 Badajoz, Spain*
[b] *Technical University of Catalonia, Institute of Industrial and Control Engineering, Avinguda Diagonal 647, Planta 11, 08028 Barcelona, Spain*

Abstract

This study analyses a production-management model that considers the possibility of implementing a reverse-logistics system for remanufacturing end-of-life products in a lean production environment (as opposed to models that use EOQ approaches). Decision variables are identified (including manufacturing and remanufacturing capacities and return rates and use rates for end-of-life products) and optimal policies are determined. Moreover, the structure of these optimal policies is analysed. The conclusion drawn is that, in many realistic scenarios, mixed policies (that is, with return rates and use rates strictly between 0 and 1) can be optimal. This conclusion is contrary to results published in earlier studies, which are based on more restrictive assumptions.
© 2007 Elsevier Ltd. All rights reserved.

1. Introduction

According to Dowlatshahi (2005), remanufacturing is a $53 billion industry in the US alone. Costs derived from reverse-logistics activities in the US exceed $35 billion per year. The customer returns rate may be as high as 15% of sales in the coming years, and in sectors such as catalogue sales and e-commerce it could reach as much as 35%. In recent years, research on supply chain management has been paying attention on the recovery processes of end-of-life products for reuse, recycling or remanufacturing. As a result, a new research area called reverse-logistics has emerged by focusing on the management of products once they are no longer desired or can no longer be used by the consumers (Flapper, Van Nunen, & Van Wassenhove, 2005). Without a doubt, reverse-logistics has become a matter of strategic importance – an element that companies must consider in decision-making processes concerning the design and development of their supply chains.

---

* Corresponding author. Tel.: +34 924289600; fax: +34 924289601.
E-mail addresses: srubio@unex.es (S. Rubio), albert.corominas@upc.edu (A. Corominas).
[1] Tel.: +34 934011615; fax: +34 934016605.

The following are the most often-cited reasons (Thierry, Salomon, Van Nunen, & Van Wassenhove, 1995; De Brito & Dekker, 2004; Ravi, Shankar, & Tiwari, 2005) as to why companies establish or participate in reverse-logistics systems:

1. Economic reasons, both direct (consumption of raw materials, reduction of disposal costs, recovery of the added value of used products, etc.) and indirect (an environmentally friendly image and compliance with current and future legislation).
2. Legal reasons, because current legislation in many countries (including, for example, members of the European Union) holds companies responsible for recovering or properly disposing of the products they put on the market.
3. Social reasons, because society is aware of environmental issues and demands that companies behave more respectfully towards the natural environment, especially with regard to issues like emissions and the generation of waste.

The legal reason has traditionally been viewed as having a negative effect on companies' ability to compete, due to the costs involved in adapting processes and industrial operations to comply with regulations. Nevertheless, according to Porter and van der Linde (1995), properly designed environmental laws can spur innovations capable of compensating for the cost of compliance. These "innovation offsets" not only reduce the net cost of compliance but also generate sustainable competitive advantages by reducing overall manufacturing costs and time to market and increasing the value of the product for the consumer. Thus, in addition to companies' legal responsibility, the potential for gaining competitive advantages by complying with environmental legislation is a further reason for adopting environmentally friendly policies such as reverse-logistics systems.

This interest in reverse-logistics has attracted the attention of not only companies and professionals but also academia, which has been tackling this issue in recent years (Prahinski & Kocabasoglu, 2006). Many of the studies published on reverse-logistics have focused on aspects of production planning and inventory management (Rubio, Chamorro, & Miranda, 2008). Some of the most notable works have analysed the effects of the flow of returned products on traditional inventory-management models (see, for example, Fleischmann et al., 1997; De Brito & Dekker, 2003; Minner, 2003; Fleischmann & Minner, 2004, for a review of the same).

However, these studies assume that such a return flow exists, without questioning whether its establishment is appropriate in economic terms and in light of the traditional producer–consumer logistical structure. It seems reasonable to assume that a company considering the development of a reverse-logistics system must first analyse how the introduction of such a recovery system would affect the capacity and resources of its current production system. Traditionally, the studies that have analysed these matters have predetermined the capacity of both the production systems (manufacturing and remanufacturing) and the systems that manage them (for example, EOQ models in constant–demand scenarios), thereby obtaining results that ultimately consist of optimal strategies that call for using all available capacity in either the manufacturing process or the remanufacturing process (Richter, 1996; Dobos & Richter, 2003 and Dobos & Richter, 2004) rather than adopting mixed strategies (manufacturing and remanufacturing).

Our study explores these matters through an analysis carried out in a deterministic environment in which we assume that market demand is constant. Under this assumption, we propose a model that could be described as lean or just-in-time (JIT) production, in contrast to other models covered in the literature that are based on economic order quantity (EOQ) or some variation of this model (Harris, 1913). Lean production is one of the most influential manufacturing paradigm of recent times (Holweg, 2007) that can be considered as a multi-dimensional approach that encompasses a wide variety of management practices, including just-in-time, quality management, work teams, etc., in an integrated system that produces finished products at the pace of the customer demand with little or no waste (Shah & Ward, 2003). One of the early messages of JIT philosophy is related to 'zero inventories' or 'stockless production'; in this sense, Bicheno, Holweg, and Niessmann (2001) indicate that JIT or lean thinking has raised the idea of batches should always be as small as possible, in order to achieve one-piece flow with batches sizes of one.

In addition, Hines, Holweg, and Rich (2004) point out that lean production has been extended considerably over its lifespan, from automotive to manufacturing, and even to services, and indicate, as a need for research,