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Strategic safety stocks in reverse logistics supply chains

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Abstract

In the last few years growing interest has been dedicated to supply chain management. Modeling complexity is added to the supply chain coordination problem by accounting for reverse logistics activities. An increasing number of ecological constraints, together with economic incentives, allows product recovery become an interesting field in supply chain management. Limitations, enormous waste and by-product disposal cost, the duty for manufacturers to take back used products from customers and the fact that returned products might have a positive economic value are some of the reasons. The objective of this paper is to combine the problem of safety stock planning in a general supply chain with the integration of external and internal product return and reuse. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The presence of substantial cost reduction and service improvement potential provides an incentive for designing planning techniques and to coordinate the various partners that are involved in the logistic chain. The presence of several sources of original uncertainty, i.e. timing and size of customer orders, variable processing times, yield of production processes, timing, and quantity of replenishment order deliveries, requires for an adequate implementation of buffers in order to realize sufficient cost and service performance results. Safety stock being generated as an additional inventory in order to smooth delivery and demand variations coupled with timing and quantity deviations is one (beside others) buffering technique. The challenging research question is where to place which amount of safety stocks in a complex supply chain.

Modeling complexity is added to the supply chain coordination problem by accounting for reverse logistics activities. An increasing number of ecological constraints together with economic incentives allows researchers and practitioners put more interest towards return and reverse logistics. The reasons are limitations or enormous waste and by-product disposal costs, the duty for many manufacturers to take back used products from the customers and the fact that the returned used products might have a positive economic value to be unlocked by recovery operations. After disassembly and remanufacturing, parts of the returned product components can be used in new products (e.g. copiers) or be sold as spare parts in service logistics (e.g. motor engines).

The objective of this paper is to combine the two problem areas mentioned above. It provides a safety stock planning approach for general network supply chains with integrated reverse logistics return and reuse materials flows. Safety stocks are regarded from a strategic planning perspective. The buffers established by the approach are meant to

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cover against a maximum reasonable amount of variation. From an operative point of view, the size of these stocks may be insufficient because extraordinarily large variations, that exceed the maximum reasonable level, are not taken into account. Nevertheless, from a practical point of view not all variations are covered by stocks. There are additional opportunities summarized under the term operating flexibility, e.g. expediting orders, external supply, assumed to be available if such extraordinary variations occur. As a first step, only safety stock requirements with respect to uncertain customer demand and returns are considered. Other sources of uncertainty in a supply chain are a matter of necessary extensions.

Integrated reverse logistics material flows can be classified into external product returns and internal by-products. As a matter of legislation or marketing strategy for selling new products, a manufacturer may be obliged to take back used products. Instead of disposing them, the products are disassembled where some parts can – after undergoing some remanufacturing activities – be used as substitutes for produced or procured materials in the regular manufacturing process. A second topic is provided by merchandise returns where final products are sent back by customers due to several reasons. In the catalogue seller business an amount of up to 30% of sold products are returned. These products undergo some quality check within the take-back process and can afterwards be sold again as regular products. Internal reverse flows occur if a production process yields several outcomes. Especially in chemical and pharmaceutical industry, processes yield one major desired output and one or several jointly generated by-products. After some processing, these by-products can either be used as a substitute for materials at an upstream processing stage (which creates a cyclic backward reuse flow in the supply network) or they can be used as input material substitutes in different product lines which will be regarded as a forward reuse activity. Besides the effect of saving disposal and raw material purchasing cost by investing in remanufacturing operations, the main interest of this analysis is how these additional external and internal material flows impact the required amount of supply chain safety stock. The contribution of this paper is that it provides a safety stock planning methodology that applies for general networks and in addition allows for cycles that are induced by return and recovery flows.

Thierry et al. [1] present an overview on strategic product recovery and remanufacturing issues and their impact on the supply chain. The different product recovery options repair, refurbishing, remanufacturing, cannibalization, and recycling are discussed. A state of the art review on quantitative models developed for the different problems in reverse distribution, recovery production planning and inventory control is given by Fleischmann et al. [2]. For the purpose of materials coordination in product recovery systems the available research material follows the two well-known streams of stochastic inventory control (SIC) [3–5] and material requirements planning (MRP) [6,7].

In the following section, the strategic safety stock planning approach for general network supply chains without product recovery is introduced as a base for the integration of external and internal return reuse in the third chapter. Some implications resulting from the recovery integration are illustrated by a numerical example. The last section summarizes the approach with its managerial implications and discusses further extensions.

2. Safety stock placement in supply chains

The safety stock planning approach followed in this paper refers to the model of Simpson [8]. It was developed for a serial production/inventory environment to provide a framework for safety stock planning under random demand from a strategic buffering point of view. The model is quite robust and can be extended to more general divergent and convergent supply chains (see [9]) as well as to general networks as described in this section.

2.1. Model assumptions

The supply chain is given by a network. The nodes represent the stocking points i for purchased ($i \in A$), in-process ($i \in P$) and final product ($i \in E$) goods. Every process i yields a unique product outcome. Therefore, each stockpoint i characterizes