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On the comparison of inventory replenishment policies with time-varying stochastic demand for the paper industry

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Abstract

The aim of this paper is the development of a mathematical model to compute the optimal inventory mix to face stochastic demand at minimum cost in a two-level supply chain. The paper addresses a multi-product dynamic lot-sizing problem under stochastic demand subject to capacity and service level constraints. This model is executed to compare a Make To Order (MTO) strategy to a Vendor Managed Inventory (VMI) partnership between the supplier and their customers. Both strategies provide the demand order to be produced. A schedule of production orders is determined over the planning horizon in order to minimize the inventory holding costs of the supply chain, taking into consideration that the supplier is also responsible of initiating the replenishment orders and deliveries of their customers according to the VMI partnership. The simulation model is illustrated empirically using a real case study: a paper manufacturing company that pursues to improve customer service level and supply chain inventory costs through a proper production planning of their paper machines and a suitable VMI order replenishment schedule.

Keywords: lot-sizing problem, Vendor Managed Inventory, simulation, optimization, paper industry

1. Introduction

Production lot-sizing has a great impact on inventory, particularly under seasonal fluctuations of demand and constrained production capacity. Many companies adopt the MTO (Make To Stock) policy in which products are not built until a confirmed order for products is received by the manufacturer. Other companies maintain high levels of inventory (stock) to face periods of uncertain demand. However, a production schedule which does not adjust accurately the real demand may lead to overstocks for some products and stock-outs for other. Inventory sizing by product is especially important under uncertainty, when the inventory is necessary to guarantee a service level in a stochastic environment. One of the integration practices that can contribute to reduce inventory in the supply chain is Vendor Managed Inventory (VMI). VMI programs allow for consumer demand information to be disseminated up the supply chain, thus mitigating upstream demand fluctuations due to the bullwhip effect [6] and [8] . Due to this demand anticipation, VMI may allow to reduce logistics and manufacturing costs, reduce overall lead-times, improve service level and reduce transportation costs.

The aim of this paper is the development of a mathematical model to seek the most effective inventory mix to face stochastic demand at minimum cost in a two-level supply chain. We focus on a multi-product dynamic lot-sizing problem under stochastic demand subject to capacity and service level constraints. Unlike previous studies, this model is executed to compare a MTO strategy to a VMI partnership between the supplier and their customers [4]. Both policies are developed within the model, and their results are compared within the numerical application. The work presents some forecasting nonlinear optimization models that can be brought from Applied Science as done in [7], [9] and [10].

In the problem, a schedule of production orders is determined over the planning horizon in order to minimize the inventory holding costs of the supply chain, taking into consideration that the supplier is also responsible of initiating the replenishment orders and deliveries of their customers according to the VMI partnership. The model also considers features such as service level required, the production capacity at machine level, set up time or product-machine allocation. The integration of stochastic demand in the production/inventory model is performed through the statistical distribution of the forecast accuracy. Historical data are analyzed to select the most suitable forecasting model for each reference (also called SKU). The selected model is triggered to forecast the demand during the rolling horizon.

The applicability of the proposed model is illustrated empirically using a real case study: a paper manufacturing company that pursues to improve customer service level and supply chain inventory costs through a proper production

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