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An inventory model for delayed customization: A hybrid approach

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Abstract

We present a variant of the delayed customization problem in which the company considers using both regular production and postponement. We determine the optimal inventory levels for the generic product (to be used for postponement) and the regular products. Even when the use of the generic product is significantly more expensive than other products, maintaining an inventory of the generic product significantly increases profits. We present an algorithm to optimally solve the single period and heuristically solve the infinite horizon problems for any number of products, and present computational results.

Keywords: Inventory; Postponement; Distribution; Logistics

1. Introduction

In this paper, we present and solve a variant of the delayed customization problem. We assume a manufacturer that produces N final products. The manufacturer faces a long production lead time, and as a result, raw materials are ordered to a forecast much before the actual demand is observed. Due to the long production lead time the demand forecast is not very accurate and the manufacturer is likely to experience shortages of some products and at the same time excess inventory of other products. The manufacturer may use a different technology in which the first production steps are identical for all products and all use exactly the same raw material. Using this technology it is possible to perform the final production steps (the steps that actually customize the product) very late and even after the actual demand is observed. The advantage of this technology is that it enables the manufacturer to use an aggregate forecast and to pool the risk over all products; as a result, the total inventory level in the system is reduced, while serviceability is maintained at the same level. On the other hand the new technology is more expensive than the

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standard technology. It may be optimal to use a mixture of the two technologies: produce ahead of time some quantity of the final products and wait with the rest and use the new technology (at a high cost) only after the demand is observed. In what follows we present a model in which the objective is to determine the optimal inventory levels (produced ahead of time) of all products so that the expected cost is minimized.

There are many industries and instances in which this model is a relevant one. For example, the fashion company Benetton is known for producing colorful sweaters, for which the production lead time may be as long as 9 months [23]. Forecasting the demand for fashionable goods is extremely difficult [11]. As a result, Benetton designed a new production process in which the dyeing of the products is performed at the end of the process, only after the demand is actually observed. Goods are produced from non-dyed material (generic material). Due to the high production cost of the delayed customization, Benetton produces only a fraction of the products as generic products; the rest are produced using the old technology.

A similar structure could be observed in the computer industry, where a company may produce different types of similar computers. Here it is possible to either produce finished computers, ahead of time to a forecast, or to customize the computers very late in the production process, possibly after the demands for the computers are observed. The customization can be as simple as putting different labels on the computers, but it also can be more complex, like assembling different electrical components [8,26].

Three features are common in such systems: (1) Major savings can be realized by keeping generic product in inventory, due to the risk pooling effect. (2) The final operation (the customization) takes place only after the demand is observed. This additional information about the demand results in a reduction in holding and shortage cost. (3) Since the customization takes place only after the demand is observed it must be performed very quickly. The high-speed operation may be expensive in comparison to performing the same task at a slower pace.

These trade-offs must be considered when designing the manufacturing and distribution system. In many cases it is possible to re-sequence certain operations in such a way that the final operation takes place only after the demand is observed, so that risk pooling effects results in a substantial savings. Examples of designing processes to utilize the above benefits can be found in [6,12,13,27,28,36].

Fisher [10] suggests that the ideal supply-chain for stable-selling products is very efficient, while for harder-to-predict fashion items, responsiveness is most important. The current paper applies this split approach to each individual item: efficient production (traditional, low-cost technology) is used for some minimum quantity which is very likely to sell, and responsive production (higher cost, delayed customization) is used for the additional sales which cannot be as accurately forecasted.

This problem can be interpreted as a substitution problem. In a complete downward substitution model, each product faces demand and can serve as a substitute for all products below it. The present model is a special case of the complete downward substitution model, because there is one product which faces no demand, which can substitute for any of the products, and substitution by other products is not allowed. Bassok et al. [2] present structural results for the complete downward substitution model which we will use in studying our model. Hsu and Bassok [21] also study downward substitution.

This model can be viewed as mathematically similar to the one warehouse, N retailer inventory problem. In this case each of the final products is equivalent to demand at a retailer, and the generic product is equivalent to inventory at the central warehouse. A few of special relevance to our study include [5,7,22,24,33,30]. Common to these studies is the assumption that the retailers cannot order directly from the external supplier. We, on the other hand, assume that it is possible to order finished goods (orders are shipped directly to the retailers) as well as generic products (orders shipped to the warehouse).

Gerchak and Zhang [16] consider a problem which has some similarities to ours. They use as a