

Migrating the fair share algorithm from a distribution to a production planning environment

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Abstract

This paper investigates the ability to migrate the fair share algorithm from a distribution to a production planning environment. In a semi-process-based production system, such as that of the photographic film producer Agfa, the availability of the intermediate product is then the limiting constraint steering the fair share algorithm for the end-product lotsizing decision process. The manufacturing model of Agfa is typically semi-process, where a first stage produces a limited number of intermediate products. The second stage is flow oriented and converts the intermediates into many distinct end-products. The planning method currently implemented within Agfa is a two-level scheduling approach. First, it establishes a cyclical volume plan at the intermediate product level, which is then used as an input constraint for the secondary problem of determining end-product lotsizes. As an alternative to the traditional model, where the end-product lotsizes are determined based on the standard EOQ formula, this investigation suggests the end-product mix decisions to be governed by a tuned fair share algorithm. The paper discusses this algorithm with its parameter settings, the impact on stock values, on service levels, and on set-up and inventory holding costs. The results of both algorithms are compared. This investigation proves that the combination of a cyclical volume plan, at the intermediate product level, combined with fair share mix decisions for the end-product lotsizes, delivers the needed service level with lower inventory levels and reduced operational costs. The main benefit of the model integrating volume planning and mix decisions is its ability to reduce demand amplifications, prohibiting market demand nervousness (amplified by the Forrester effect) from entering into upstream operations. The reduced nervousness allows a major reduction in needed safety stock at the intermediate product level.

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1. Introduction

The task of production planning is to get supply and demand in balance. Within the planning process a company should treat volume and mix problems separately. If volume planning is handled effectively, it will be less difficult to deal with mix problems. If on the other hand volume is not planned well, then mix issues become substantially more difficult to cope with. Therefore questions of volume precede those of mix. Volume

planning should be done upfront and a company should spend enough effort to do it well.

The typical X-type shape of product structure flow within the semi-process industry, having a large number of components and end-products but a small number of intermediates, has an advantage for volume planning. A two-stage hybrid production model is still dominant in the semi-process industry. The first production stage is process-like, using a lot of raw materials, having large production batches and costly set-ups, and produces a small number of intermediate products. The second stage is flow-shop oriented and transforms the intermediate product into many distinct end-products. Volume planning should be done on the intermediate product level, which is typically the smallest segment of the product structure. Within this two-level scheduling approach, the first level

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generates a volume plan on the intermediate product level. The second scheduling level decides on the finished end-products coming out of the intermediate material flow. Furthermore, the product pareto rule is valid in most companies, stating that 20% of the stock keeping units (SKU's) correspond with 80% of the production volume. On transferring this to the volume planning on the intermediate product level, a company can establish a volume plan for a limited number of intermediate products and cope with the major part of the production volume. Agfa, the company involved in this research project, is a multinational producing imaging systems (graphical film, printing plates, X-ray film). At the intermediate product level Agfa uses cyclical scheduling. The benefits of a repetitive cyclical production plan are numerous. The predictability of the schedule allows synchronisation between different production stages. The technique used for establishing this repetitive nominal schedule, on the intermediate product level, is based on solving the economic lotsizing and scheduling problem (ELSP). The resulting cyclical volume plan is then used as the target volume plan for operational use, which can then use a fair share logic policy for lotsizing the end-products.

This investigation will focus on the problem of determining end-products quantities fulfilling market demand, using the intermediate product volume plan as an input constraint. These end-product mix decisions will be governed by a tuned fair share algorithm. This paper examines the possibilities of migrating the fair share algorithm from a distribution environment towards a production environment. The results, of the fair share-based end-product planning, will be compared with the traditional end-product lotsizing, which uses the standard the EOQ model. Section 2 describes the semi-process production environment. Section 3 gives feedback on previous research. Section 4 illustrates the synchronised planning concept and the logic of the fair share algorithm. Section 5 lists the cyclical volume plan and relevant article data. Section 6 describes the experimental design and Section 7 brings the results of the simulation experiments, gradually tuning the fare share algorithm. This section ends with a comparison of results and estimates the benefits when using the proposed algorithm. Section 8 concludes the paper.

2. Description of semi-process production environment

The considered semi-process environment consists of two production stages out of a photographic film production

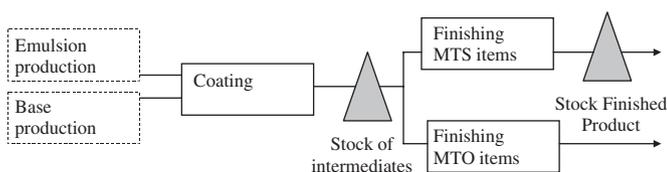


Fig. 1. The film production process.

process (Fig. 1). The first stage is a coating process, where a photographic emulsion is coated on a base roll. This stage is process oriented and produces a limited number of intermediate products (masterrolls). The preceding stages producing the emulsions and base rolls are not included in the research model. The intermediate products feed the second production stage (finishing plants) converting the masterrolls into a large number of end-products, different in size and packaging formats.

Agfa has some 200 different coating types, each with their distinct photographic properties. The finishing departments convert these intermediate products into approximately 10,000 different end-products. The major volume (85%) of the end-products are produced based on a make-to-stock (MTS) policy. Still quite a large number of articles, but small in volume (15%), are produced on a make-to-order (MTO) policy.

3. Previous research

The paper of Aghezzaf and Van Landeghem [1] dealt with two-level scheduling and proposes a step-wise solution approach in establishing an optimal inventory and production plan for a two-stage hybrid production system. They first establish a common cycle model for the process with the highest set-up costs, which is typically the process oriented part of production. The resulting volume plan of intermediate products is then taken as an input constraint for the secondary problem dealing with the determination of end-product quantities. Their research proves that when the involved products have a low lumpiness in demand the solution, based on a common cycle techniques equals the optimal solution. The method for implementing this common cycle approach within the Agfa planning process, is described by Van den Broecke and co-workers [2]. Viswanathan and Piplani [3] demonstrate that common replenishment periods establish a co-ordinated inventory policy and bring substantial savings for the total system, in comparison with the independent cycle approach, on the condition that set-up costs are above a certain threshold level. The cyclical volume plan has the advantage that the sequencing and scheduling problem of the intermediate products is solved first and the solution influences the end-product lotsizing. Solving the aggregated lotsizing decision first has an important influence on the mix decisions for the end-products [4]. Since the cyclical volume plan predicts the availability of intermediate products, this info can be used as an input constraint. The mix decision process fair shares the available intermediate product towards the end-products, depending on their actual demand and stock position.

The fair share mechanism originates from a distribution planning environment, fair sharing central inventory towards different destinations. Little research has been conducted on the possibility of using these fair share techniques within a production environment to guide the mix decisions for the end-products. In the semi-process

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