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Order penetration point in paper supply chains

Abstract

The order penetration point (OPP) of a material flow is the place where a product is assigned to a particular customer. Before this point the material flow is controlled by forecasts and plans, and afterwards as deliveries according to customer orders. This article studies how different OPPs affect the capital bound up in the supply chain. The underlying sample is based on a quantitative study of the OPPs and supply chain inventories at three fine paper mills located in Europe. The general conclusion is that the control principles applied and the order types used are generating more capital-tied-in-inventories in the various stocks and buffers of the supply chain than one would expect if simpler principles and fewer order types were used. One of the cases supports this finding. Unlike the design-to-order industry and many consumer goods industries, in which the OPP is strictly defined by the nature of the process, the paper industry uses several OPPs right from the paper machine throughout each echelon of the supply chain up to the market depots. This article provides guidelines and suggestions as to how OPPs should be managed to improve the flow of materials.

Keywords: demand amplification, supply-chain management, logistics, process industries

Tiivistelmä

Tilauspisteen paikka paperin jalostuksessa ja jakelulogistiikassa

Tilauspistettä tai pikemminkin sitä vaihetta jakeluketjussa, missä tuote nimetään tietylle asiakkaalle ja tämän tilaukselle erottaa tuotannonsuunnittelun tilausten ohjauksesta. Ennen tilauspistettä materiaalivirtaa ohjataan suunnitelmien ja ennusteiden pohjalta, ja kun asiakaskytkentä tuotteeseen on tehty siirtyy prosessi tilausohjautuvaan tilaan. Aineistona olleissa kolmessa hienopaperitehtaassa oli käytössä useita eri tilauspisteitä ja niiden käyttö ei ollut johdonmukaista ja tehokasta toimintaa tukevaa. Tehtaista löytyi vaihtelevasti 8 – 12 tilauspistettä, jotka supistuivat jakeluketjussa noin kuuteen fyysiseen vaiheeseen, joissa tuotteet korvamerkitään asiakkaalle. Havaittiin, että mitä lähempänä asiakasta tilauspiste on, sitä kauemmin tavara on seisonut jakelukanavassa. Tilauspisteen ollessa paperikoneella viipyi tavara keskimäärin kuukauden kanavassa, kun markkinoilla sijaitsevista varastoista jakelu tapahtui kylläkin nopeasti asiakkaan silmissä, mutta sillä kustannuksella että tavara oli odottanut toimitustaan keskimäärin kolme kuukautta, vaihteluvälin olessa muutamasta kuukaudesta vuosiin. Paperissa ehdotettaan neljän tilauspisteen käyttöä vaihdellen arkki- ja rullatilauksille. Pienempi määrä tilauspisteitä mahdollistaa selvempien ohjausperiaatteiden käyttöönoton, sekä tehostaa eri jakeluportaiden pääomakiertoa.

Introduction

Industrial processes can be classified in many ways. One is to measure the ratio between the number of raw materials and the number of end products in the process /1/. According to this classification, the process industries are explosive industries, as they process a small number of raw materials into a vast number of end products. In contrast, the assembly industry can generally be seen as implosive, with a huge variety of inputs to produce just a few end products. The paper industry produces many different grades, dimensions, packages and finishing qualities from basically the same few raw materials. This clearly classifies papermaking as an explosive industry, although there are mills that produce fewer end products than they use raw materials. With other classification criteria, the outcome for the paper industry is not so clear.

Order penetration point (OPP) can also be used to classify industries and in this way to determine on an aggregate level what kind of production management principles, layouts and strategies should be applied to manage operations. By OPP we mean the point in the material flow where a product is assigned to a customer and that customer's order /9/. From the customer's point of view the time from the OPP to reception of the goods is regarded as the customer's order delivery time – the time before OPP is not /8/. This means that there is a fundamental trade-off between delivery time and inventory cost as to where to locate the OPP in the material flow or supply chain. The emphasis in these decision-making criteria varies across different industrial environments /6/. Selling paper only from depots near the markets provides customers with short delivery times, yet the inventory cost of maintaining such a service level, especially with larger product mixes, may not be covered at the prevailing market prices.

Pure customisation to customer order starts right from product engineering and purchasing, i.e. the product is engineered to order and its parts are purchased specially for that order. This works for ships and other large investments like paper mills. At the other extreme is pure standardisation with make-to-stock industries delivering highly unified consumer goods like soft drinks and cereals close to the end customer. In between this spectrum there are many variations, and management scientists tend to argue that the recent trend has not been toward pure customisation, but toward the middle ground that they call customised standardisation /7/. Whatever the situation in other industries, the location of the OPP in the paper industry makes mills very different to run.

In the following the problem setting is further clarified, the methodology applied is discussed, and the underlying sample presented. The empirical findings and results are described with managerial guidelines for better operations management in papermaking. Finally, conclusions are drawn, with some projections for further studies and improvement potential in paper supply chains.

Problem setting, methodology and sample

For the current purpose the paper supply chain is considered to start from the paper machine, the raw material chain back to the forest deliberately being omitted. This leaves several places to position an OPP: it can be placed at the paper machine, cutter, reel stock, sheeted stock, finished goods stock, central warehouse, market depot, wholesaler's stock, and many other places along the chain. From the point of view of efficient operations management, the many OPPs can easily make the process complex, yet on the other hand they do provide operations management with options for managing the flow. This being the case, this article studies the following research questions:

- How are OPPs currently located at paper mills?

- How do different OPPs affect the overall throughput time in the supply chain?
- How should OPPs be located in order to improve operational efficiency in paper supply chains?

Using the methodology of quantitative controllability analysis /2/, tens of thousands of deliveries were studied at three paper mills. For each delivery the throughput times were calculated and analysed according to the order type, i.e. when the customer enters the material flow. The mills in question produce fine paper ranging from standardised office paper to more customised dimensions and grades, yet all data gathered concerned fine paper production. Data from these mills was collected from the production planning and control systems with at least one year's time window to cover seasonal changes and market fluctuations. In practice the data covered all activities taking place in each mill during the sample period. To preserve anonymity, the results are shown in average terms to highlight the phenomenon and not to pinpoint particular mills. Yet, several comments are made which refer the individual mills to clarify the OPP implications in paper supply chains.

It is clear that the sample mills do not represent the whole paper industry, yet the practices they use are similar to many mills that have been analysed earlier /5/. The empirical situation revealed and the results deduced should be reflected separately at each and every mill. It should be emphasised that the mills studied were quite similar and that the results were complementary**.** OPP is a relatively old concept in operations management and it is time to exploit its potential for improving productivity and operational speed in paper supply chains.

Empirical results

For each mill, orders over a period of one year were grouped according to type, which defines the OPP for each delivery. In practice, the OPP indicates whether the order is to be delivered right from the paper machine or from any other buffer or stock along the chain up to the customer. It is a simple matter to find six OPPs in a normal supply chain (Fig. 1). These points are physical points from which the delivery may commence, yet the sample mills also used 'virtual' inventory locations from which to deliver goods. These virtual OPPs were related to budgeting and accounting routines, which could easily be matched with those in Fig. 1. The number of order types used at the mills varied from 8 to 12, and goods were physically assigned to the customer from all six real locations of the supply chains. The division between reel and sheet orders is part of the reason for the large number of order types. The mills also shared different practices for internal ordering, which were made commensurable through the physical OPP at which the goods were assigned to the customer.

Volume-wise, 70% of the deliveries have their OPP before the final depot, i.e. along the supply chain. Some 30% of the deliveries were ordered direct from the paper machine. For sheets, 35% of deliveries had their OPP in the to-be-sheeted reels stock, and some 20% of sheets were delivered direct from the finished goods stock. For reels, various internal replenishment orders were used, which meant that 50% of the orders got their OPP between paper machine and final depot. In all, the overall volume gets divided along the supply chain quite evenly, and no clear policies were found for standard products, which seemed to get their customer earmark in practically any of six physical slots in the supply chain. One would have expected that more customised products would be made more to order, yet they too seemed to catch the customer stamp wherever the best fit with the order had been found in the supply chain. Also, sales personnel seemed to have different ordering habits, one preferring to hold major stock to guarantee good customer service, another relying more on stocks along the supply chain. All this reflects a lack of discipline in the order handling procedures, and a lack of communication between production planning and sales personnel. This means that the OPPs were

not really managed and their potential for improving efficiency was not really exploited.

Order handling processes were basically the same at all mills, and despite the numerous ordering types four to five OPPs were mostly used when assessed in terms of volume. To study the influence of the different customer delivery points on the throughput time, the overall throughput time was calculated on a weekly basis (Fig. 2). This shows that the average throughput time from paper machine to customer varies between about 30 and 60 days. No clear seasonal fluctuation was seen, yet the profiles between the sample mills were more or less the same; the throughput times also varied on similar scales. Figure 3 shows the average weekly throughput times for the four most voluminous OPPs. It shows that when paper is delivered direct from the paper machine to the customer the throughput times vary between 20 and 30 days, while when deliveries begin from a depot the variation is between 50 and 100 days. Delivering sheets from reel stock takes slightly longer than from the paper machine. It should be noted that these numbers are weekly averages, which hide the real variation among paper grades and individual orders. More detailed studies showed no clear fluctuation in throughput times, yet volume played a certain role. High-volume grades seemed to behave in a similar manner, while smaller grades tended to behave randomly.

When paper is delivered from a depot, the delivery time from the customer's point of view is short, yet the paper might have been waiting for the right order for several months – even years – as detailed studies indicated. In all, 60% of the volume was delivered from depots, which raises the overall throughput times to a higher level. In general, the data support the hypothesis that the closer to the customer the OPP is, the longer the overall throughput time. Except for direct paper machine deliveries the time spent before the OPP is time spent in the inventories along the supply chain. For the Scandinavian paper industry, which has long supply chains between mills and customers, this means that maintaining a high standard of customer service in terms of short delivery times is expensive. It becomes even more expensive if no clear operational procedures are used to control the material and order flows. The cases examined here show that there is significant potential for improving performance, especially if different OPPs are applied to the right product families with complementary service strategies. Drawing from the present cases and earlier studies /3/ it is possible to list the following operational guidelines on how to define an OPP for a product family:

- OPP at market depot: Mill brands and other high-volume and standardised grades, with small order sizes. Larger orders with longer reaction times should be delivered direct from the paper machine, thus keeping the size of orders from the depot down to a certain level. Depots are replenished every production cycle, which should be reduced down to one week. This means that the volume delivered the previous week forms the production volume for the current week, thus: sell one palette – produce one.
- OPP at mill stock: First-class sheet customers with special labels. Direct customer deliveries from the mill or in some cases from the depot. The aim is a high standard of customer service with customised products. The same applies to reels, if not bulk from depots with smaller volumes, then deliveries from mill stock.
- OPP at reel stock: All other sheet products with lower and more fluctuating volumes and degrees of customisation. Reels have no OPP at this point.
- OPP at paper machine: Large deliveries such as those based on annual sales agreements, which should not be produced not until the last production cycle prior to punctual delivery.

This leaves only three possible OPPs for reel orders – mainly paper machine and mill stock – and for some cases the depot. For sheet orders all four – paper machine, to-be-sheeted reel stock, mill stock and depots – are used, which requires a closer study as to how to assign them to each order delivery (Table 1). Using past

history data on volumes per customer and paper grade sheds some light on how to proceed. The decisive criteria for defining OPP are the customer, product type, brand, supply channel and service standard. However, reducing the number of OPPs is enough to improve the material flow and to make order handling routines simpler and more efficient. The guideline provided here serves as a general norm on how OPPs can be classified in fine paper production. All paper mills should examine their true OPPs and how they are really assigned to orders. Experience shows that in the worst cases this decision is being made by somewhat outdated computer systems optimising the utilisation of full production capacity.

Reducing the number of OPPs paves the way for simpler order handling routines and more efficient production planning. When routines are clearly stated, their application by all parties in the supply chain becomes more systematic, and gradually the whole chain starts to act in a coherent manner. All this results in better capital turnover in all echelons of the supply chain. Change is taking place at all mills and preliminary results are already being achieved. Loose production with no customer name is being better controlled by limiting stock space for certain customers and paper grades. Methods for controlling material flows have also been changed to illuminate better the true performance of operations management. Physically, only the adopted OPPs are allowed, and paper should not be found at any other place in the supply chain. Paper located at the OPP has been planned, produced and delivered there in accordance with certain principles, which are ultimately based on market demand.

Conclusions

This study of the OPPs in paper supply chains was motivated by the finding that the paper industry is lagging behind other industries in operational efficiency and especially in speed /4/. The fine paper mills studied here used far too many OPPs, resulting in ill-managed material flows with excess buffering and poor control. It became obvious that the closer to the customer the OPP is, the longer the products have spent in the supply chain. Selecting an OPP is based on a trade-off between inventory cost and customer service, where the inventory cost depends on the operational efficiency of the mill. If production cycles are short enough and the product palette fits well with demand, a good standard of service can be maintained with speedy operations and low material stocks. Cutting down the number of real OPPs in the supply chain is a way of simplifying operations management and the control policies on which they are based.

Careful segmentation among paper grades and customers is vital for defining who and what are to be served from each OPP in the supply chain. Volumes should be adjusted according to the real demand within the production and delivery cycle. If not produced to order, paper should be produced for a stock location of limited size serving a well-researched demand that promotes rapid inventory turnover. The study showed that four OPPs are enough (even fewer for reel deliveries) and that implementing them is a simplification measure that should be easy to incorporate within whatever enterprise resource planning system is used in the company.

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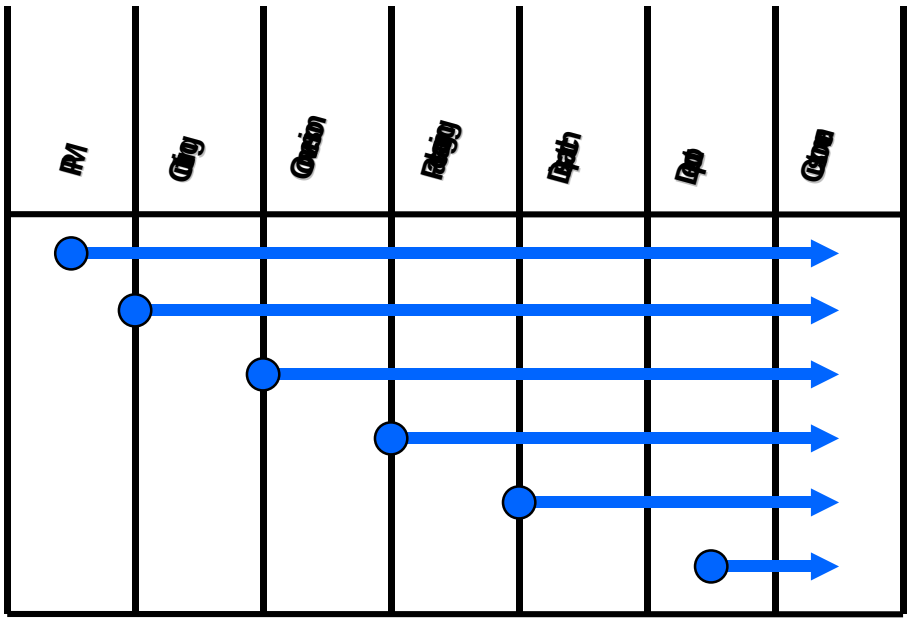

Fig. 1. Possible OPPs for a fine paper supply chain.

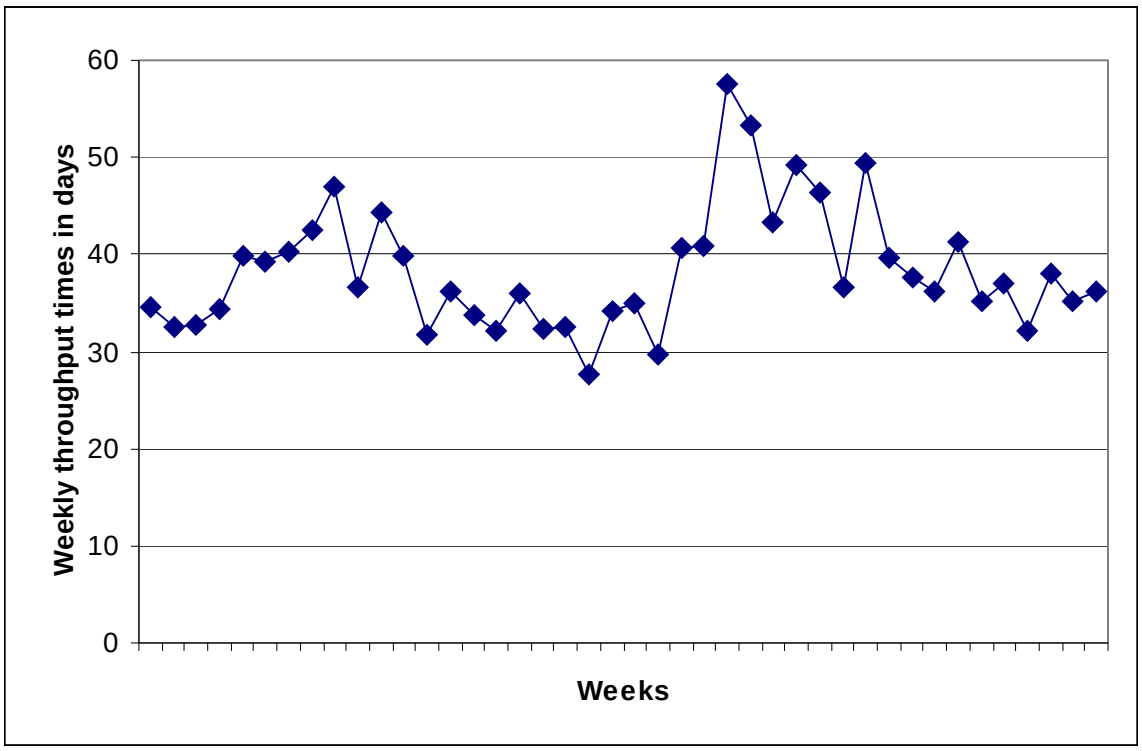

Fig. 2. Average weekly throughput times from paper machine to customer.

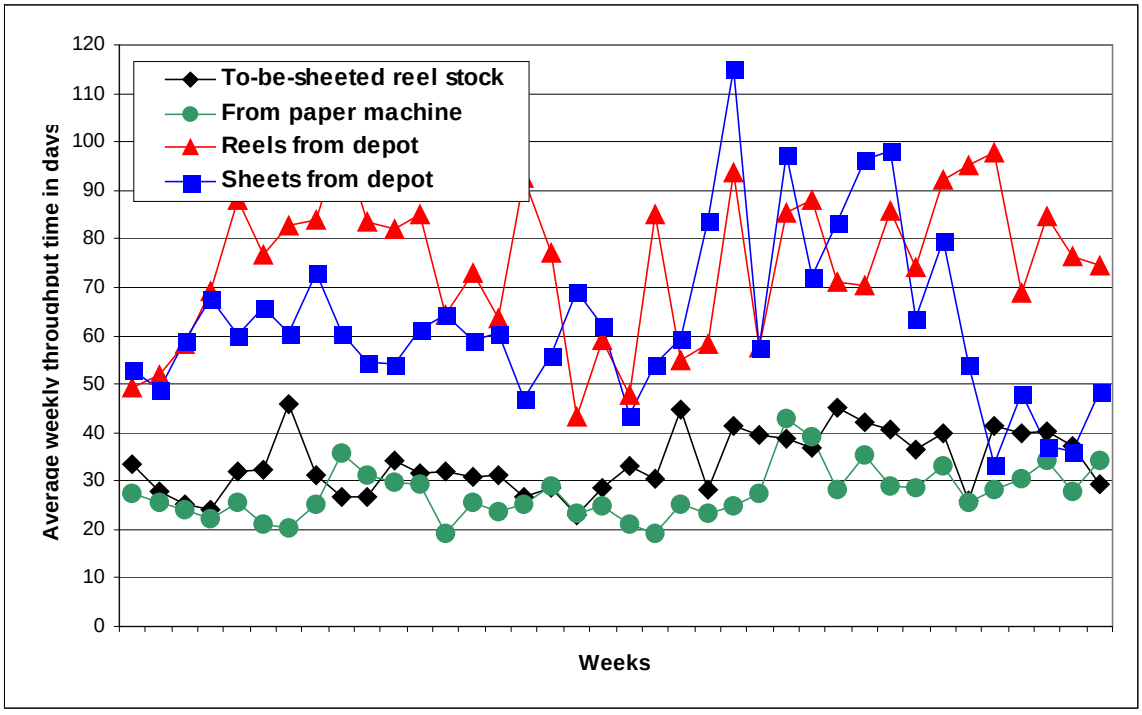

Fig. 3. Average weekly throughput times for the four most voluminous OPPs. Whole throughput time measured by individual order from paper machine to customer.

	OPP_4: Paper machine	OPP_3: To-be-sheeted reel stock	OPP_2: Mill stock	OPP_1: Market depot
Sheets	Really large orders, which are actually rare for sheets.	Larger orders, and other deliveries that are not main grades.	Only for key customers and main grades. Customised sheets, e.g. with special labels. Own inventory place for key customers. Replenished weekly.	Mill brands with large overall volumes and rapid deliveries. Restricted order size, large ones from to-be-sheeted reel stock. Weekly replenishment cycles.
Reels	Large deliveries, which are usually well know in advance.	-	Direct customer deliveries. Weekly replenishment to a level that secures key customer-specific demand fluctuations.	For special cases, or to maintain certain service standard for occasional demand.

Table 1. Selection criteria for assigning OPP to an individual fine paper order.