CUSTOMER-DRIVEN MANUFACTURING IN THE FOOD PROCESSING INDUSTRY

Dr. Dirk Pieter van Donk

Som-thema A Primary processes within firms

Abstract

Food processing industry copes with high logistical demands from its customers. This paper studies a company changing to more customer (order) driven manufacturing. In order to help decide which products should be made to order and which made to stock, a frame is developed and applied to find and balance market and process characteristics. The frame is based on the well-known Decoupling Point concept and adapted to the needs of the food processing industry. The application in the company helped management in deciding and implementing customer-driven manufacturing. The main results were lower inventories and less obsolescence, while dependability remained the same. Further research should develop the frame, along with general decision rules for locating the Decoupling Point.

Keywords: competitive response, decoupling point, make-to-order, production management, food processing

INTRODUCTION

The last decade has shown a remarkable amount of interest in a variety of aspects of food processing and food processing industry. More specifically, the changes in information technology and the power-balance of the supply of food (Meulenberg and Viaene, 1998), have been catalysts for changes in supply chain management towards new concepts such as Efficient Consumer Response (Kurt Salmon Associates, 1993) or category management (Hutchins, 1997). As a result, these new themes have been further explored and researched (e.g. Coopers & Lybrand, 1996). Cachon & Fisher

(1997) provide an illustrative example reflecting the actual implementation of these new concepts. To date, it seems that most changes have dealt with supply chain management issues like faster replenishment, the use of scanning, inventory planning and Electronic Data Interchange, which are usually initiated by the (large) retail chains. In fact, within the context of this renewed attention to supply and delivery, the attention has been dominantly drawn towards the last part of the chain from producer to consumer. The actual processing and production of foods and the consequences for food processing industries of these changes have, to a large extent, been ignored. Traditionally, food processing industries have organised their production systems in such a way that they were able to produce in large quantities. In order to be as inexpensive as possible, full use of capacity was necessary and as a result, production was made to stock. Fast delivery from such stock is easy. However, given the changes described and demands posed upon the industry, it is problematic to maintain this production policy. Greater product variety, higher demands on quality and best-before date, smaller quantities and new products can be barriers to proceeding with the current way of producing.

Many of the above-mentioned developments are present in the recent business situation we studied. The management of an industrial supplier in the food processing industry found themselves in a situation of a growing variety of products, fast delivery, and relatively high capacity utilisation. The immediate reason to start this research in the company was twofold. On the one hand, the number of stock keeping units and the amount of inventory grew faster than the total turnover, and on the other hand, there was an occasion to obtain a number of silos for stocking intermediate, semi-manufactured products. The aim of the study is to reduce the amount of inventory of finished products and find which products should and could be stored in the silos, from which the products can be further produced to order.

We found that there is little theory on guiding this type of decision. However, the frame of Hoekstra & Romme (1992) could be transformed into one suitable for the food processing industries. More importantly, the frame developed supported actual decision-making in this case.

The paper is organised as follows: First the case is introduced. Next, the theoretical background is developed. Subsequently, the frame is applied in the case-study. Some conclusions and general remarks are made in the concluding section.

ORGANISATIONAL BACKGROUND

The company under study is relatively small and employs around fifty people. Its share of the Dutch market is about thirty percent, mainly in a price sensitive part of the market. A growing share of turnover is realised in the higher price segments of the market for which a European market exists. During the previous years total volume has constantly risen.

The production process is relatively easy and consists of three main steps: processing, granulating and packaging, as depicted in *Figure 1*.

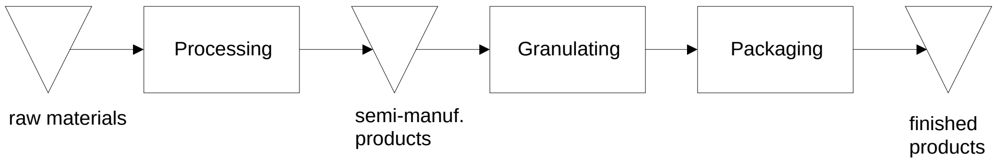

Figure 1. Production process

The first stage (Processing) consists of several strongly related steps: raw materials are mixed according to recipe and pre-processed; then the product is processed in ovens, followed by an operation that breaks up the product as a preparation for the second stage. Now, the product can either be stored in one of the silos as semi-manufactured product or be directly granulated. Granulation means that a product from one recipe is separated into several fractions of different sizes of granule. Next, the product is packaged into different packaging forms, which are stored or delivered to clients directly. Due to cleaning and set-up times, minimal batch-sizes are present in all stages. Average throughput time for a batch is two hours for processing and half an hour for granulating. The production speed (in tons/hour) of granulation is twice as much as the production speed of the processing stage. The product can be kept for about half a year, but customers demand a shelf-life of at least four months. Although management aims at low inventory in all storage points, the physical dimensions of the intermediate storage in silos are restricted: total storage is less than a week's volume.

The company has a large number of customers, and demand is stable on an aggregate level. However, the forecasting on the level of the specific products is not that simple. The variety is great: 200 different products, varying in recipe (40 recipes), granule (30 sizes) or packaging (type and/or amount). Five recipes (bases of several finished products) account for about 70% of total demand. The largest customer has a share in total volume of less than 10%. Lead times have a standard of 5 days, but tend to become shorter. Some customers actually demand a very short delivery, in combination with the wish to maintain a dedicated amount of inventory for immediate supply to them. On the other hand, some customers order in a relatively regular way with a lead time of two weeks.

THEORETICAL BACKGROUND

The main concept used in analysing the above problem is the Decoupling Point, which Hoekstra & Romme (1992) define as "the point that indicates how deeply the customer order penetrates into the goods flow" (see also Wortmann et al., 1997). Determining the location of the decoupling point aims at finding a balance between the costs of procurement, production, distribution and storage, on the one hand, and the customer service to be offered, on the other. In principle, each product-market combination can have its distinct decoupling point. There are three important aspects associated with the Decoupling Point (DP):

- The order-driven and forecast-driven activities are separated by the DP.
- The DP is the main point of inventory from which the customers are delivered.
- The forecast-driven activities can be optimised in some way, as they are not directly influenced by the irregularities of the market.

Figure 2 illustrates the above in a simple production process consisting of two stages, separated by a Decoupling Point.

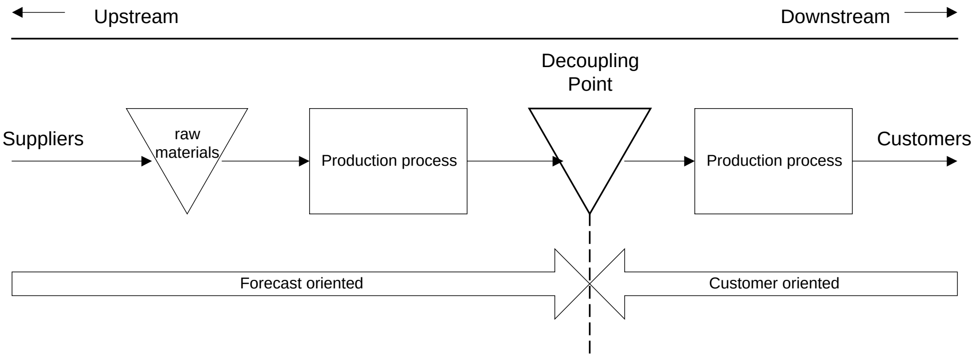

Figure 2. The Decoupling Point Concept (adapted from Hoekstra & Romme, 1992, p.6).

The main determinants of the DP are divided into two groups: product and market characteristics, and process and stock characteristics. These determinants are summarised in *Table I.*

Product and market characteristics	Process and stock characteristics
• Required delivery reliability • Required delivery time • Predictability of demand • Specificity of demand	• Lead times and costs of steps in the (production) process • Controllability of manufacturing and procurement • Costs of stock-holding and value added between stock points • Risk of obsolescence

Table I. Determinants of the Decoupling Point (adapted from Hoekstra & Romme, 1992)

Each of the factors in *Table I* influences the location of the DP. For example, the shorter the required delivery time, the more the DP will be located towards the customer (downstream), while, e.g., a great risk of obsolescence will force the DP to be located more towards the supplier (upstream). Both examples hold only if all other factors remain stable. Hoekstra & Romme distinguish five basic logistical structures (five basic locations for the Decoupling Point): make and ship to (local) stock, make to stock, assemble to order, make to order, and purchase and make to order.

Usually, this frame is an excellent tool to describe and analyse an actual situation, but the literature shows little evidence that this frame is also useful or suitable for redesigning a situation. We will show that by adding some of the specific characteristics of food processing industry to this frame, it is possible to use the frame for that aim as well.

DEVELOPING THE CONCEPT FOR FOOD PROCESSING INDUSTRY

This section briefly develops a frame for the food processing industry. A detailed description can be found in Van Donk (2000). Before the Decoupling Point concept is elaborated upon for the food processing industry, it is necessary to describe this type of industry from the point of view of production and logistical management. Because of the type of industry we are interested in, given our case, we exclude from our description the types of industry, that process agricultural raw materials into basic food ingredients (such as mills, abattoirs, and sugar refineries).

Table II shows an enumeration of characteristics of food processing industry compiled from the literature (Bolander, 1980; Taylor et al., 1981; Van Dam et al., 1993; Fransoo & Rutten, 1994)

Plant characteristics
• Expensive and single purpose capacity coupled with small product variety and high volumes. Usually, the factory shows a flow shop oriented design. • There are long (sequence dependent) set-up times between different product types.
Product characteristics
• The nature and source of raw material in food processing industry often implies a variable supply, quality and price, due to unstable yields from farmers. • In contrast with discrete manufacturing, volume or weights are used. • Raw material, semi-manufactured products, and end products are perishable.
Production process characteristics
• Processes have a variable yield and processing time. • At least one of the processes deals with homogeneous products. • The processing stages are not labour intensive. • Production rate is determined mainly by capacity. • Food industries have a divergent product structure, especially in the packaging stage. • Factories that produce consumer goods can have an extensive, labour intensive packaging phase. • Due to uncertainty in pricing, quality and supply of raw materials, several recipes are available for a product.

Table II Characteristics of food processing industry (cf. Van Wezel & Van Donk, 1996)

In most cases, a limited number of these characteristics is present. An example can be found in the case described by Van Donk & Van Dam (1998). The list above is used for examining, describing and analysing real-life situations. Whenever one of the characteristics is present, it has consequences for the lay-out of the equipment, control and planning of activities and thus (as we will explore in the next sections) on the location of the Decoupling Point. High set-ups and an orientation to use capacity as much as possible, for example, cause planning of long production runs and stocks of end products.

Market characteristics

Delivery times tend to be short and delivery reliability needs to be consistently high in food processing industry. The effect on the Decoupling Point is downstream. While the retail-chains demand short deliveries, they usually pass all the uncertainty onto the producers who experience a kind of lumpy demand, which can hardly be forecasted. Although scanning data and Point-Of-Sale data are available to the retailers, these are seldom shared with the producer. Here, a better co-operation could be beneficial and open up possibilities for longer lead-times. The last important point in relation to the market is the specificity of demand. As noted, food processing companies have a large diversity of products, originating from differences in packaging size, labels and brands. The best-before-date adds to the specificity in two ways. Firstly, because the best-before date is a technical, safety limit to sell the product. Secondly, because retailers do not accept the same best-before date on subsequent deliveries. As such, the commercial best-before is much shorter than the technical best-before suggests. The above discussion is summarised in *Table III*.

Process and stock characteristics

Food processing industries process natural materials, which vary in quality and composition. Therefore, processes might be uncontrollable in their yield or the quality of the output. The result is a downstream effect on the Decoupling Point: delivery is buffered against the unpredictable production by placing a certain amount of inventory after that process. Cleaning times and set-ups are another important factor in the processing of food. Large (sequence-dependent) set-ups especially have a downstream effect on the location of the Decoupling Point. We already mentioned the perishability of food; products might easily become obsolete, due to the limited shelf-lives of food products. As mentioned, products might become obsolete even if the best-before date is not reached. The last point to consider is the value of stock to which two factors are relevant: the value added in the process and the value of purchased materials. A high value added stimulates an upstream movement of the Decoupling Point, as it is more profitable to stock low-value materials instead of high-value finished products. However, if the value of the raw materials is relatively high (e.g. tobacco, coffee beans) and purchase of the raw materials can not be postponed, then the location of the Decoupling Point is not relevant for this aspect. We summarise this discussion in *Table III*.

Market characteristic	Presence/Value in Food	Effect on DP
Delivery reliability	High	Downstream
Delivery time	Short	Downstream
Predictability of demand	(rather) Unpredictable	Downstream
Specificity of demand	High, through great variety and best-before	Upstream
Process characteristic	**Presence/Value in Food**	**Effect on DP**
Lead times and costs	High set-ups/cleaning times and costs	Downstream
Controllability	(sometimes)Low	Downstream
Value added and costs of stock-keeping	Unclear (in general)	-
Risk of obsolescence	High	Upstream

Table III. The influence of Market and Process characteristics on the Decoupling Point

Other characteristics

There are two points of interest for the location of the Decoupling Point that are not directly covered in the above characteristics. The first is that in many food processing industries there is a bottleneck capacity in either the packaging or the processing stage. In general, it will be problematic to produce to order on a bottleneck capacity, except for situations in which variability in orders is very limited. Locating the Decoupling Point upstream from the location of the bottleneck will thus be virtually impossible. The second point to pay attention to is the recent introduction of the concept of ECR (Efficient Consumer Response). The concept of continuous replenishment is especially relevant for the above discussion. There are potential ways to improve communication and co-operation in a supply chain. Through information sharing on actual sales, the Decoupling Point can move upstream and more production to order seems possible.

LOCATING THE DECOUPLING POINT IN THE CASE

The description of the case makes clear that there are three possible locations for the Decoupling Point (DP): the stock of raw materials, the stock of semi-manufactured products (in silos), and the stock of finished products. The silos, especially, have a limited capacity.

With respect to the market characteristics, it is evident that the company is in a situation in which delivery should be very reliable and delivery times are short for most products, which has a downstream effect on the DP. The predictability of demand is not experienced as very high, which leads to a more upstream location of the DP. The variety in finished products is quite large. However, the commonality in recipes is quite large as well, as five recipes are responsible for 70% of the total amount produced. On the other hand, there are also a number of recipes used for only one product/customer.

With respect to the process characteristics we notice that the throughput times are not very large, but that set-up times are relevant. The process is reliable and the storage costs are not very large in either of the possible locations. However, the risk of obsolescence is not negligible, due to the variety in packaging forms and the shelf-life guaranteed.

The starting point in deciding how each product will be stored (in the sense of determining the Decoupling Point for each product) is the observation that the storage space in the silos is limited. A natural point to start is there.

Firstly, if a product is produced from a unique, product-specific recipe, it will not be stored in the silos. The idea is that such a product is client-specific from the first step in processing; intermediate storage is not useful then. The decision to produce either to order or to (end) stock depends on the amount and lead time of these products. One third of the products is thus excluded from storage in the silos.

A second observation is that the processing stage has less capacity than the subsequent stage. Capacity can be used most efficiently if the number of set-ups and the amount of cleaning time is limited. Producing in large runs is advantageous, but only necessary for products with a large aggregate demand (across all different granules). These products (recipes) are stored in the silos to enable a fast reaction to market demand without carrying excess inventory and running the risk of obsolete products or having the right product in the wrong packaging. By applying this rule to the products, a number of products could be selected that can be stored in the silos.

A last rule that was applied dealt with a number of products with irregular demand and small quantities requested. Normally, one produces such products to order (and the Decoupling Point is the stock of raw materials). However, because demand for these products is smaller than minimum batch sizes, some stock of these (finished) products will remain. This inventory has a relatively high risk of becoming obsolete. It could be that reconsidering the market strategy and eliminating such products yields better profits in some cases.

RESULTS AND DISCUSSION

In applying the above rules, it was possible to change the Decoupling Point for about 75% of the number of finished products, from production to end-stock to either the production from raw materials or production from intermediate products. The main reason for having end products on stock is the very short time asked for delivery, usually in combination with the wish of customers to maintain an amount of dedicated inventory. Other products are kept in this stock, as well, because demand is very stable so no risk of obsolescence is present.

Changing the Decoupling Point in this way affected customer service only in a positive sense: the number of end-items in stock is drastically reduced and inventory control is made easier. Obsolescence and inventory costs are reduced. The efficiency of the production process is not actually reduced, because aggregate demand is stable and the run-length (minimal batch size) in the first stage is reasonably long. Moreover, there are some products that have a longer lead-time or are made to stock, to fill possible gaps in capacity usage.

A last result stems from the fact that in deciding the location of the Decoupling Point, all factors related to market and process were analysed. This yields a fresh look upon the position of the company in the market and discussions on the product portfolio, market strategy, and the lack of commonality in recipes of products. Discussion and interaction between sales and production departments are stimulated.

There are a number of general conclusions to be drawn as well. The frame developed for the location of the Decoupling Point in food processing industry is a valuable tool for finding the important factors in market and process, and deciding the actual location of the Decoupling Point. Moreover, in developing this frame we added to the knowledge of both the characteristics of the food processing industry and the Decoupling Point theory. The case study showed the theory's usefulness, but further validation across the range of food processing industry is needed.

Some issues need to be addressed. The theory of the Decoupling Point focuses on describing the relevant factors for the location of the Decoupling Point, without paying attention to the way these factors should be (or could be) balanced, in a qualitative or quantitative sense. Further development of the frame as presented in this paper could be helpful in developing such decision rules. Current developments in the food processing industry make this industry an attractive area for further study.

This paper did not address the actual planning and organisational consequences in the new situation. In general, combining make-to-order and make-to-stock on one machine or process is a difficult planning task, which needs further research. Organisational consequences apply to re-arranging tasks and responsibilities between departments (production and sales), redesigning the process of order-acceptance and more co-ordination around the flow of goods and information. The above themes are also of interest in inter-organisational issues. In this case also, the effect on transaction costs and supply chain development are relevant. More insight into these issues is needed as well.

REFERENCES

Bolander, S.F. (1980), “Materials Management in the Process Industries”, in: American Production and Inventory Control Society 1980 Conference Proceedings, pp. 273-275.

Cachon, G.P. & Fisher, M.L. (1997), "Campbell Soup's Continuous Replenishment Program: evaluation and enhanced inventory decision rules", Vol. 6, pp. 266-276.

Coopers & Lybrand (1996), Efficient Consumer Response Europe, Value Chain Analysis project overview.

Fransoo, J.C. & Rutten, W.G.M.M. (1994) “A Typology of Production Control Situations in Process Industries”, International Journal of Operations & Production Management, Vol. 14, No.12, pp. 57-72.

Hoekstra, S. & Romme, J.(Eds.) (1992), Integral Logistic Structures: Developing Customer-oriented Goods Flow, McGraw-Hill, London.

Hutchins, R.(1997), “Category Management in the food industry; a research agenda”, British Food Journal, Vol. 99, No. 5, pp. 177-180.

Kurt Salmon Associates (1993), Efficient Consumer Response: Enhancing Consumer Value in the Grocery Chain, Food Marketing Institute, Washingston DC.

Meulenberg, M.T.G. & Viaene, J. (1998), “Changing food marketing systems in western countries”, in: Jongen, W.M.F. & Meulenberg, M.T.G. (Eds.), Innovation of Food Production Systems: Product Quality and Consumer Acceptance, Wageningen Press, Wageningen (The Netherlands), pp. 8-36.

Taylor, S.G. Seward, S.M., Bolander, S.F. (1981), “Why the Process Industries Are Different”, Production and Inventory Management Journal, Vol. 22, No. 4, pp. 9-24.

Van Dam, J.P., Gaalman G.J.C. & Sierksma, G. (1993), “Scheduling of packaging lines in the process industry: An empirical investigation”, International Journal of Production Economics, Vol. 30-31, pp. 579-589.

Van Donk, D.P. (2000) “Make to stock or make to order: the decoupling point in the food processing industries”, International Journal of Production Economics, (to appear).

Van Donk, D.P. & Van Dam, J.P. (1998) “Structuring complexity in scheduling: a study in a food processing industry”, British Food Journal, Vol. 100, No. 1, pp. 18-24.

Van Wezel, W. &Van Donk, D.P. (1996), “Scheduling in Food Processing Industries: Preliminary Findings of a Task Oriented Approach”, in: Fransoo, J.C. & Rutten, W.G.M.M. (Eds.), Second Int. Conference on Comp. Integrated Manufacturing in the Process Industries - Proceedings, BETA, Eindhoven (The Netherlands), pp. 545-557.

Wortmann, J.C., Muntslag, D.R. & Timmermans, P.J.M. (1997), Customer Driven Manufacturing, Chapman & Hall, London.