BUYER FOCUS, SHARED RESOURCES AND UNCERTAINTY IN A FOOD PROCESSING SUPPLY CHAIN

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ABSTRACT
It is often suggested that food supply chains are typical for what can be achieved in supply chain management. This paper challenges this believe by investigating the possibilities and limitations for supply chain integration for food processing companies. We argue that a combination of typical food characteristics and the use of shared resources limit the possibility for integration, while uncertainties and complex business conditions increase the need for integration. The paper explores to what extend integration is possible and how the food processing companies can integrate their activities with their buyers. The theoretical considerations are explored in a case study involving a large complex food processing plant. A number of suggestions are made to improve supply chain integration with the main buyers of the food processing plant.

Keywords: supply chain management, buyer focus, shared resources, food processing

INTRODUCTION
Supply chains in the food processing industries seem to be in the front-line with respect to the supply chain practices, coordination of the chain and advanced concepts like EDI, VMI, QR and CPFR (e.g. Hill and Scudder, 2002). Almost everyone is aware of real-life applications in a number of cases such as Wall-Mart and Kmart (Schwartz, 2004). Initiatives in the food processing chain originate mostly from these large retail chains and the aim is to reduce inventories in their distribution centres while maintaining the same level of customer service. Exchange of information, use of category management and cross-docking operations are among the most applied practices (Van der Vorst and Beulens, 2001). Thus one might consider the food supply chain as a true example of an integrated, truly collaborative supply chain. However, it is unclear how the above initiatives of large retail-chains, influence the operations of the food manufacturers. For some initiatives, it seems that uncertainty is just passed on to the manufacturer.

In general, we submit that the position of food processing industries (or food manufacturers) has been relatively ignored. Specifically, a number of the specific characteristics of food processing industries have been ignored in exploring the possibilities and limitations or special problems for introducing supply chain management and integration for and in these industries. Specific characteristics of food processing industry apply to the capacity-orientation in at least one stage, the relatively high utilisation, high set-up and cleaning times, limited shelf-life for (intermediate) products, large variety of recipes and packaging sizes (e.g. Van Donk, 2001). In many cases the main operation in a plant is a single-capacity batch processor like an oven or kettle that limits the total output of the plant. Limited capacity that is used for all products also pose limitations on what can be achieved in close coordination within the supply chain (Van der Vaart and Van Donk, 2004). Moreover, in some food processing industries it is common to have one-off large export orders.

Recently, a number of papers (Van der Vaart & Van Donk, 2003, 2004; Van Donk & Van der Vaart, 2004, 2005) shed a new light on the complex relationship between capacity and supply chain integration. They show that in general shared resources (defined as capacity used to serve different customers) limit the
possibilities for supply chain integration. On the other hand, more integration is required if uncertainty with respect to timing, volume and mix of orders is higher. The combination of both uncertainty and shared resources can be seen as one of the most difficult ones and therefore the position of food processing industries is interesting for supply chain research.

The paper will explore how food processing industries can operate their process, given the opposing requirements and their specific characteristics. We distinguish four basic SC strategies that can be used as stating point for developing a supply chain strategy aimed at coping with demands and uncertainties from the supply chain: (1) singling out part of the resources (buyer-focused resources), (2) virtually singling out resources, (3) integration at an aggregate level, (4) operational integration at the level of scheduling.

The theoretical part is illustrated in a recently conducted case study in a factory producing different types of food products based on one main raw material for both domestic and export markets. The main problems are analysed and the above alternatives are explored and we suggest a number of approaches to redesign supply chain practices for this plant.

The paper is organized as follows. The next section will develop the theoretical background of the paper by linking previous work on supply chain context to the specific characteristics of food processing industry. The third section of the paper will elaborate upon the supply chain strategies as mentioned above. Then, we will introduce the case and subsequently, analyse demand, production and planning aspects of this case. The fifth section will pay attention to (re-)design alternatives. In the last section we formulate our conclusions.

UNCERTAINTY AND SUPPLY CHAIN CONTEXT IN FOOD PROCESSING

Supply chain management research seems to be dominated by a focus on the instruments needed to apply and implement supply chain management. Research has been conducted to find the influence of information systems on supply chain performance (Vickery et al., 2003), the influence of the arc of integration on various performance measures (Frohlich and Westbrook, 2000) or the effect of simplifying the materials flow (Childerhouse and Towill, 2002). Others stress the development and implementation of specific tools, such VMI, CPFR, radio frequency or bar-coding in a supply chain context. The above and similar studies add to our knowledge and understanding of what can be achieved and how performance can be improved. Most of the published studies fail to address the business conditions or context of a supply chain (Ho et al., 2002). Ramdas and Spekman (2000) are among the few that investigated the influence of business conditions as availability of substitutes, changes in market conditions, changes in technology, market maturity and product life cycle in order to distinguish between functional and innovative products. As such they add to the work of Fisher (1997) who argues that innovative products can be associated with high levels of uncertainty and need responsive supply chains, while functional products need efficient supply chains.

Only one business condition and its influence on supply chain management and integration has been explored in more depth: uncertainty. To Lee (2002) uncertainty is one of the drivers for supply chain integration. Empirical evidence also indicates that the level of uncertainty influences the level of integration (Davis, 1993; Childerhouse and Towill, 2002). Recently Van Donk and Van der Vaart (2004) add a number of other business conditions: the decoupling point (MTO/MTS), time window for delivery, volume-variety characteristics, process type (batch size, set-ups and routings) and order-winners. In line with Davis (1993), these factors are important indicators for the amount of uncertainty suppliers are facing in their production planning and delivery schedules. Propositions are derived that state that higher levels of integration can be expected in supply links if suppliers’ business conditions are characterised by low volume, high product variety, small batches, make-to-order, a long time window for delivery and flexibility among the main order-winners. These conditions correspond with a high level of uncertainty within the supply link. If business conditions are to a larger degree characterised by high volume, low product variety, large batches, make-to-stock, a short time window for delivery and costs as a major order-winner, lower levels of integration are expected.

As stated in the introduction, shared resources limit the possibilities to perform integration while buyer focus is an enable for supply chain management practices. In a multiple case-study, these two basic propositions (see Figure 1) are confirmed (Van Donk & Van der Vaart, 2004).
**Figure 1- Propositions about the impact of context on supply chain integration**

**FOOD PROCESSING INDUSTRY**

The food processing industry is generally considered as a part of the (semi-) process industry. Process industries in general and food processing industries in particular have been considered as being large-scale, capital-intensive, mass producers of bulk products in large batches for low costs. This uniform picture of process industries has been challenged by empirical work by Dennis and Meredith (2000), who clearly showed the diversity in production systems in process industries. For many food processing companies the scenery has changed due to trends in markets and changes in consumer’s preferences. As a result food processing industries and specifically those that manufacture consumer products have adapted their product portfolio and production strategy in order to survive. The market for food products can be characterised by an increase in packaging sizes, products, recipes and product introductions (Meulenberg et al., 1998); higher logistical performance due to restructuring in the supply chain of retailers (e.g. Wall-Mart); and low margins in retailing and thus downwards pressure on prices for the producers. As a result, food processing companies face a dilemma, as on the one hand they have to produce in response to the market, but, on the other hand, they have to produce at the lowest cost. In other words, flexibility and dependability are needed and on the other hand high utilisation. To complicate supply chain management initiatives further, we need to incorporate a number of food specific production characteristics. From previous studies (Van Donk, 2001; Van Wezel and Van Donk, 1996) we compile the following enumeration: (1) **Plant characteristics** (expensive capacity, flow shop oriented design, long (sequence dependent) set-ups); (2) **Product characteristics** (variable supply, quality and price of raw material due to unstable yield; raw material, semi-manufactured products and end products are perishable); (3) **Production process characteristics** (variable yield and processing time; homogeneous products; not labour intensive except for the packaging phase; production rate determined by capacity; divergent product structure especially in the packaging stage.

In many food processing companies the above characteristics are not all present and not all characteristics present will be evenly important for managing the process. Moreover, only a few of them will be really influential in implementing supply chain management initiatives.

Supply chain management and food processing industry

If we combine the two above subsections some interesting first observations can be made. With regard to the type of resources, we can conclude that both types co-exist in many food processing companies. Shared resource can be recognised in the expensive capacity and high set-ups, but the packaging lines are often more dedicated to a limited number of products and buyers. Total output is usually determined by the (limited) capacity of the processing stage. Decoupling of the two stages is normal, but rather limited due to limited storage space and limited shelf-live of unpacked products. The flexibility of the packaging stage is normally larger: fluctuations in mix (different packages) can easily be dealt with and fluctuations in volume can be achieved by adapting the amount of labour.
With respect to the business conditions one might be inclined to see food processing as a typical case of functional products and simple business conditions as high volume, low variety, make-to-stock, short time for delivery and costs as a major order-winner. However, the market requirements ask for smaller batches, more product differentiation and product innovations. The make-to-stock policy is not viable in a number of situations as retailers demand products with the most recent best-before date. Due to the nature of raw materials processing times and yields in a stage of processing can be unpredictable. Also the attuning of the two main stages (processing and packaging only separated by a limited storage capacity) results in delays and waiting times. This last type of uncertainty is, together with the earlier mentioned business conditions typical for the type of uncertainty that has to be dealt with in production planning and control (Davis, 1993).

What are the consequences for supply chain management in food processing given these observations. First, as can be noticed in Figure 1 many initiatives have been taken in lower-left corner. The simple business conditions and shared resources result in efficient information and material flows. Secondly, the combination of increased performance requirements, the resulting higher variety and the specific characteristics of food processing all press the industry into more complex business conditions. The overall conclusion is that supply chain management practices and integration are needed, but hard to reach because of the shared resources.

DESIGNING SUPPLY CHAIN MANAGEMENT STRATEGIES IN FOOD PROCESSING

The above section made clear that two types of uncertainty are important for managing the supply chain in food processing industry: uncertainty in demand and uncertainty in manufacturing due to typical food characteristics. Moreover, the tuning of the processing stage and the packaging stage adds to the complexity of supply chain management in food processing companies. Each of the two stages has different characteristics. The processing stage is often flexible in the type of product to be produced but inflexible with respect to volume as capacity is limited. The packaging stage often is inflexible with respect to type of product as lines are dedicated for one (or a few) type(s) of packaging, but volume flexibility is often considerable because labour is relatively flexible (e.g. adding an extra shift). In summary, the challenge for many food processing companies is to deal with the external and internal uncertainty while attuning the two stages in their process.

In these complex business conditions, the preferred strategy in line with the propositions presented in Figure 1 would be to single out resources for one single buyer (buyer-focused operations). If such an approach is not possible, an appropriate strategy might be to divide the available capacity between the different buyers and allow these buyers to fill “their capacity” according to their requirements. This could be labelled as a virtual buyer focus. A next option is to define aggregate measures and constraints that enable to make decisions at an aggregate level that form constraints for lower level scheduling decisions. A last option to deal with the complexity and uncertainty might be to make integrated planning and scheduling decisions. We will elaborate each option.

The first approach is to single out part of the (shared) resources for one single buyer. In a number of situations the packaging stage might be buyer-focused already if either the volume of one buyer is large enough to justify such or if the type of packaging is buyer specific. However, as indicated previously, the main problem might be the processing stage and the intermediate storage. Singling out part of the capacity can only be achieved in case of different lines or capacities. In some cases the processing stage is one source of capacity e.g. a kettle or integrated process. Then, of course capacity can not singled out for one buyer. In other cases, we might have a number of interchangeable kettles. In such cases we can single out one kettle to serve the needs of one single buyer. The advantage will be that flexibility in mix and delivery can be totally attuned with the buyer to achieve a high level of supply chain integration.

The second approach is to single out part of the capacity for specific buyers virtually. Here, it is assumed that physically singling out resources is not possible either because of technological or financial reasons. Depending on the situation, capacity is allocated to a certain buyer for a fixed number of days each week or a number of hours each day. A real-life example might be the way in which hospitals allocate capacity of an operating theatre. Within the allocated capacity considerable freedom is present to produce the different products of the buyer. On the one hand, SC integration will be limited, but the flexibility to change priorities and react to uncertainties will be larger within a more or less fixed volume. It seems that one of the prerequisites is that volume uncertainty is not too large and that the packaging stage has little or no shared resources.
The third way to manage this type of situation is to organise the planning decisions in a hierarchy. The background of such an approach goes back to among others Hax and Meal (1984) and the basic idea is to attune decisions at an aggregate level. Within the boundaries of the aggregate plan decisions at lower levels of aggregation can be decoupled, including processing and packaging stage. Van Dam et al. (1998) design such an approach in a case study of a tobacco company. Basically, the demand of each group of product or customers is balanced against the available capacity over a longer period of time e.g. a week or month. Within the planning horizon each group receives a part of the available capacity that can be filled without any further attuning with other decisions. Here, the division of capacity at an aggregate level is crucial for the success of the approach. Stability of aggregate demand is a necessary prerequisite. This approach is not suitable if different groups of products not only use the same capacity in the first stage of the process, but also compete for capacity a certain packaging lines. If the main source for uncertainty is within certain product families this might be the ideal way of dealing with uncertainty.

The last possibility stems from the more classical production and operations management approach. The basic idea is that by using all available information regarding orders to be produced, processing times and sophisticated algorithms and software, the problem of attuning the two stages can be reduced to a scheduling problem of finding the optimal order of producing the required product quantities in time. It might be clear that considerable effort is needed to implement this option, as all basic data with regard to processing need to be known. Another prerequisite is that within the scheduling/planning horizon, the number of changes should be minimal. Rescheduling an integrated schedule/plan will cause a lot of organisational disturbance and confusion (e.g. Van Wezel et al., 2005). Rescheduling might also take too much time. It seems therefore that this option is specifically relevant for situations with relatively low levels of uncertainty within the planning horizon, little production disturbances and relatively low complexity of the process.

We realize that each of the above strategies might be appropriate under the circumstances sketched, but each strategy is probably only applicable if the business context (or both types of uncertainty) is more or less homogeneous for all main buyers. It is not directly clear if and how different strategies can be mixed or applied next to each other for different buyers.

INTRODUCTION TO THE CASE STUDY
The food processing company under study is part of a multinational company that operates a large number of plants across the world and serves a number of consumer and industrial markets in different countries. The plant under study is large in this type of industry and mainly produces consumer products for both export and domestic markets. The majority of products is produced as own brand, some of these brand are A-brands, but the plant also produces private label products for large retail chains, as well as a limited number of brand-products for other food suppliers. The variety in products is large: both in recipe and in packaging size and labelling. All production is make-to-order and is destined for three buyers that are the commercial business units of the parent multinational. The business units stock and distribute the products to a large number of customers around the world. End products have a shelf-life between nine months up to two years. Still, products cannot be stored that long as buyers will not accept relatively short remaining shelf lives.

Data gathering
The approach taken to collect the data uses a variety of data-gathering techniques: mapping of the processes, interviews with employees, reading reports and manuals (for knowing formal procedures) and analysing data with respect to production and demand from the plant’s ERP-system. A substantial part of the material was collected by a master student as part of his final project, complemented with plant visits by the authors. The main focus of the project was to investigate the operation of the plant, but we also took interviews with representatives of the business units. While the use of different methods and sources of data already guarantees the quality and reliability of the findings, we also presented the main results and findings at several occasions to the management of the plant to further triangulate the findings. As a last step a final report was written, that is the basis for this paper.

Production and process characteristics
The production process is typical for food processing companies. There are two main stages: the processing stage and the packaging stage. The operations in the processing stage can be subdivided into three main categories. The first stage involves preparation activities like, the receiving of raw (natural) materials and the pre-processing of raw material to achieve homogeneous materials. The second stage is blending batches of different types of raw materials in tanks and adding additives to have the basic recipes. In the third processing stage products follow different routings: evaporation for normal products, evaporation for sweet products, or the products are processed in the special products lines. After processing the products are temporarily stored in a large number of large storage tanks.

The packaging stage consists of three departments that package a specific range of packaging sizes and types (carton, glass bottles, metal). The operations performed consist mostly of sterilizing, packaging (sometimes in reversed order), labelling, case-packaging and palletising. The flow of products is summarised in Figure 2.

As indicated above, the plant has three buyers: the commercial business units of the parent company that are responsible for the contacts with the customers and for inventory control. Each of the business units has distinct characteristics and different type of customers in diverse markets. Business Unit Export delivers products to a number of European, Asian and African Markets. Here a number of well-established brands are delivered to partly independently operating foreign buyers, which distribute and sell the products in their countries. In general, demand is unpredictable. The timing of the deliveries is partly dependent on shipping dates. The Business Unit Home Market sells and distributes both the own well-established brand to all retail chains and some other distributors as some retail brands for large retailers. Achieving an almost 100% customer service is one of the main objectives, as well as good cooperation with major buyers to support promotional activities. In general the demand of the consumers is relatively predictable and stable. The third Business Unit Supply maintains and supports buyers that outsource their production to the focal plant. Supply started to sell excess capacity and now is a significant part of the total business. Here, less influence and insight exists with respect to demand and demand patterns, but fluctuations in capacity usage are more or less restricted by agreements with respect to total capacity and number of batches. The forecast accuracy differs between the buyers.

As with more food processing companies, this plant has experienced a steady increase in the number of SKUs over the years. The number of recipes is increased due to the increased pressure for healthy and low-fat food and variety in taste and ingredients, while also the number of packaging sizes and types is increased due to demographic reasons (e.g. on average smaller sizes of households), increase in brands and demand for easy-to-use products. The increase in both recipes and packaging types, while total demand is staying the same, naturally reduces batch sizes in both stages of production. Batches sizes are further decreased as a result stock reductions in the supply chain. To some extend, this is problematic, as the plant was originally developed (as many food processing plants) to produce large batches.

Due to the important role of meeting due dates and the make-to-order policy as described above, planning starts with demand planning, due date setting and planning of the packaging lines. Given the packaging planning an overall plan for the processing is developed, including planning of the required raw material. More and more it is felt that whereas packaging can cope with fluctuations and due dates, the processing departments have problem in producing the required amounts. In fact, it seems that processing has become the main bottleneck of the whole process. The increase in recipes and the reduction in batch size cause more set-ups and cleaning time than before.

![Figure 2 - Flow of goods](image-url)
The above short description makes clear that the plant under consideration is finding itself precisely in the situation sketched above. Each of the various factors from the theoretical introduction will be further analysed in the next section.

ANALYSIS OF THE CASE STUDY

As indicated in the previous sections, uncertainty is one of the main drivers for improved supply chain management. We start our analysis with a more detailed examination of demand uncertainty and production disturbances. Furthermore, we analyse the production process and also investigate the influence of specific food processing characteristics and the way planning handles uncertainty in demand.

Demand

The packaging departments produce about 590 different SKUs each month. Over the last year there was a slow increase in SKUs of 3%. In general, this number is higher than expected in the operational yearly plan: for one packaging department it was estimated that 154 SKUs would be produced each month, while 174 are actually produced on average. This strongly indicates that the batch sizes ordered are smaller than expected. With respect to the recipes, the same pattern can be noticed. Here, the number of recipes produced each month is increased with 10%, partly due to the introduction of new recipes.

The demand pattern and uncertainty in demand are rather different between the three Business Units (BU’s). BU Export keeps a close contact with their customers and forecasts monthly demand over a horizon of three months, based on forecasts of the customers and a number of important factors. However, the average forecasts suffer from a very low accuracy (about 44% lies outside the preset accuracies). For some products the actual demand differs 100% from the forecasts. The knowledge of upstream inventories is weak and delivery lead times of these export products are equal to one month. BU Supply receives estimated demand for a year of most customers. At the operational level a two-month rolling forecast is provided. The reliability of the rolling forecast differs among customers: some provide more or less lumpy, hardly forecasted demand, while others have the ability to make reliable forecasts. In general minimum batch sizes are agreed. BU Home Market operates in a rather stable market and sells a large variety of different packaging sizes and types. The BU keeps stocks of all products both own brand and retail brands. Demand is forecasted on a weekly base and production orders are based upon demand and stock positions. Orders for different SKUs can be combined into one processing order if it involves the same recipe. The main deviations here are caused by promotional activities, which are generally known beforehand.

Production

Production is in fact relatively simple as it concerns basically mixing, processing, packaging and preservation. The amount of lines and products adds to complexity. The large number of routings possible and the connections and relations between lines and stages further increases the complexity. Packaging lines within one department use some common equipment; lines in different departments package the same recipe and might get the intermediate product from the same storage tank. In production, we also see a number of typical food processing characteristics. Limited shelf-life of some (and certainly the main) raw material induces the need for cleaning after a certain time period but also between different recipes. Contamination of different products is usually seen as a large problem both from a quality and hygienic perspective. As production speeds differ and because the processing is batch oriented, the processing and packaging stage are separated by a number of tanks. The three processes in the processing stage and the tanks are all more or less general purpose: serving a broad range of products/recipes. The packaging departments have lines that are more labour intensive and dedicated to one type of packaging (e.g. glass bottle of ½ litre). Some packaging lines are even producing for just one end user or one BU. Here cleaning is also an issue. Most packaging lines operate at high speed, but seem to be vulnerable for breakdowns. The due date performance is, as a result, rather fluctuating and on average 70% (range 20%-95%) on a weekly base. The result is that the intermediate storage is longer occupied and the processing stage and specifically the special products lines that have limited capacity cannot produce at full speed.
Planning
Planning needs to balance demand and capacity at various levels over time and at the same time to assure supply of raw material. Specifically with respect to the main raw material coordination takes place at various levels and plans are adapted at various moments in time to assure optimal supply. Due to the possibility to balance the supply of this factory with others, supply is generally not a problem. As the company as a whole has a policy of being market oriented and market driven, the starting point for planning are the packaging departments. In general, their plans form the basis for the plans of pre-processing. Here, a capacity check is made at various levels (month, weekly and daily plan). In general, inventories of finished products are hardly considered in the planning process. Stocks are kept by the customers (for BU Export and Supply) or by the buyers (in case of BU Home Market). In general, it is felt that coordination at a monthly level is insufficient and that too many adaptations have to be made to the more detailed plans.

All in all, the conclusion is that the business conditions are complex due to the unpredictability of demand, the relationships between departments and the uncertainty in production. In complex business conditions, one would like to have a high level of integration in the chain, but due to the shared resources and some of the specific food characteristics, this seems hard to achieve. It is also clear that there is hardly any difference between the different buyers with respect to integration. The next section explores to what extend the three basic strategies are applicable.

REDESIGNING THE CASE
It might be obvious that choosing among the suggested strategies would be the preferred course of action, if we want to change the current situation. Before investigating that choice, it should be stressed that from a SCM point of view, it is not that bad to start planning with actual demand and due date setting and with the planning of the packaging departments. Due to the flow of goods between the three main processing and packaging departments complex interrelationships come into being. The shared resources in the processing stage limit total output both in the long and short run, but output is also determined partly by the type and size of packaging orders and the disturbances in packaging. It seems logical to pay attention to the operational constraints (Bertrand et al., 1990) on the orders accepted and planned for packaging. Bertrand et al. mention batching constraints (e.g. to avoid set-ups), sequence constraints (e.g. to combine work orders), workload constraints (to realize a certain level of utilisation) and capacity constraints (possible adjustments in the short and long run). A second concern is that the three BU’s and their customers differ in type and the ability to forecast demand and thus pose different requirements on the production system.

If we consider the analysis of the case and the above conclusions, it seems that the proposed alternative strategies are hard to implement as overall solutions. The integrated planning and control option is hard to implement as an overall strategy due to the uncertainties in the market and the process inducing frequent rescheduling. The complexity of the plant also limits applicability of this option. A hierarchical approach of planning seems to be an option but processing and packaging are not fully decoupled and another problem are the different demand characteristics of the three buyers. The third option is to single out part of the shared resources for one buyer, either as buyer focus or as virtual buyer focus. This is also limited at first sight by the use of capacity for different buyers. Each of the alternatives can, however, be used at a lower level of analysis. Our concern is thus to split the overall complexity into relatively manageable parts. For that purpose a number of observations can be made: the BU’s differ in level of uncertainty, packaging lines are almost dedicated (or buyer-focused) and some volumes are large and stable.

The relationship with BU Home Market has relatively little uncertainty, a number of specific recipes and packaging types and there is a low level of integration with the buyer. In principle according to Figure 1, this might be fine. Part of the buyer-focused strategy can be used here. The exchange of more information, better and joint decision making e.g. with regard to inventory and batch sizes could yield some extra flexibility to cope with the uncertainty of the other business units. For a number of products it is beneficial to increase batch sizes if all costs are considered (batching constraint). Currently, such trade-offs along the supply chain are hardly made. For some of the high volume recipes it could be beneficial to single out part of the capacity in the processing stage to integrate it with the packaging lines that are already buyer-focused. This separation of capacity can be achieved virtually by reserving capacity each week or at certain days. Actual producing and packaging might be postponed until relatively late in the planning process to produce those packaging
sizes that are most needed for replenishing (change of capacity constraint). The positive effect can be increased delivery performance if for these products a limited number of fixed tanks is used such that disturbance here do not influence other parts of the process. An integrated scheduling and planning approach could manage this part of the supply chain (last strategy).

The workload and capacity constraint need to be changed as well in order to maintain supply chain control. As a result of the market-orientation, batches tend to become smaller. Given the considerable amount of cleaning time, the influence of batch sizes on capacity utilisation is rather large. So far, too much emphasize has been put on overall volume of products, while from a capacity point of view, the number of cleaning and set-up times can be directly incorporated. Specifically for BU Supply this will result in proper agreements with customers to really sell capacity. That implies that within a given volume the number of different recipes (and thus the amount of cleaning time) will be restricted. Here in fact the operational constraints in processing and packaging can result in adoption of the third strategy of aggregate hierarchical planning at a high level that is detailed in a later stage within the agreed constraints.

For the BU Export it seems that the current efforts paid to forecast demand is a waste of time. The uncertainty in demand is not really a problem as the lead-time is about one month. The preferred course of action is to invest in developing the tools to schedule the orders that come in. Good planning and scheduling to be able to process the orders, fast delivery of supplies and coordination with transport are the main instruments to increase performance.

For the longer run it seems that constantly monitoring the product portfolio both in terms of SKUs and recipes and their profitability is needed. A second point related to that is the possibility to change the point at which products become specific. Most products consist basically and for the larger part of the same raw materials and only their relative percentages and some ingredients differ, the specific recipes are mixed before the processing stage. Considerable amounts of cleaning time could be saved if mixing could be postponed until just before packaging. It seem that technological progress will allow for that soon. It should be noticed, however, that while such solutions are promising, they do not solve the fundamental problem of shared resources.

CONCLUSIONS
This paper aims at developing a better understanding of the specific problems in food processing companies that aim at supply chain integration. While it seems that integration is specifically high in food supply chains, we show that the specific nature of food processing companies and specifically the shared resources that are operated in such companies can be barriers for integration. Specific factors are the increase in product variety, smaller batch sizes and uncertainties in demand, combined with limited shelf life of products and processing uncertainties. We develop four basic strategies to deal with these circumstances: singling out buyer-focused resources, virtual buyer focus, hierarchical planning and, integrated planning and scheduling.

A case study is used to illustrate the concepts and relationships developed. The case clearly shows the problems that have to be dealt with in food processing companies. The four strategies developed are applicable to improve supply integration and performance, if different types of demand are dealt with separately, linked to specific characteristics and structure of the process. Dealing with the shared resources is possible, but they will be a major factor in supply chain improvements.

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