

## **Exploring demand and production planning challenges in the food processing industry: A case study**

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## **Abstract**

This paper explores demand and production management challenges in the food processing industry. The goal is to identify the main production planning constraints and secondly to explore how each of these constraints affects company's performance in terms of costs and customer service level. A single case study methodology was preferred since it enabled the collection of in-depth data. Findings suggest that product shelf life, carcass utilization and production lead time are the main constraints affecting supply chain efficiency and hence, a single planning approach is not appropriate when different products have different technological and processing characteristics.

**Keywords:** Demand management, production planning, food processing industry, case study.

## **1. Introduction**

Demand planning and management has been recognized as the most important challenge among supply chain professionals (Wagner et al, 2009). Many authors have advised that an organization has to develop an effective demand planning practice in order to be competitive in the market (Gallucci, 2008; Chen et al, 2007; Lapide, 2006; Ross, 2004). The role of demand planning is to enable sales to achieve their goals by using optimal resources and working capital (Gallucci, 2008). This is mainly related to determining safety stock levels which further affect projection of manufacturing capacity and inventory levels (Chen et al, 2007).

Bower (2007) suggested that managing forecast accuracy is a prerequisite for successful supply chain operations. He advised that improving accuracy is attainable if forecast errors are timely identified and analyzed, and all events disturbing forecast baseline are properly processed. Communication and teamwork are also considered as important factors in reducing forecast errors. Although demand planning is considered to be a planning operation in which customers are responsible for creating their own plans, Rojas and Frein (2008) and Dudek and Stadler (2007) found that centralized planning is a much better solution for improving planning effectiveness as it tackles the problem of managing information sharing across supply chain members much more efficiently. They argue that planning coordination from a single point provides a much better visibility of demand. This is particularly important in chains where a company has multiple distribution channels because total product availability can be more effectively managed.

The perishable nature of products in the fresh food industry poses significant constraints on planning processes. This is particularly the case in meat processing which is one of the most challenging fresh food subsectors. In addition to a short product shelf life, there are constraints with regards to the very long lead times (due to the technological processes) and raw material utilization. Integrated supply chain practices are thought to deal with the aforementioned issues, but implementing the same concepts in all industries neglecting the type of product is often not an optimal solution. Some industries, such as meat processing, are dealing with different types of products which have to be treated differently in the planning process. In these cases, a cross-product comparison is needed with regards to supply chain planning.

The overall aim of the paper is to contribute to the supply chain planning body of literature by analyzing one of the most complex and challenging industries, meat processing. In contrast to other surveys (e.g. Taylor, 2006; Entrup, 2005; Fearné, 2000;

Stokes *et al.*, 1998), a cross-product analysis is adopted in this research, with three main product categories (fermented sausages, cooked sausages and canned products) been investigated and compared. The paper is organized as follows: the literature review on supply chain planning processes with specific reference to the meat processing industry is initially presented, followed by the research design, the empirical findings, while discussion and concluding remarks are presented in the final section.

## **2. Demand and production planning in the food industry**

### *2.1 Challenges and constraints*

Product shelf life is one of the greatest challenges and constraints in fresh food industries. Due to the perishable nature of these products, inventory levels across fresh food supply chains have to be very low in order to avoid waste due to product expiration and spoilage (Soman et al, 2004b). Liu et al. (2007) analyzed lot sizing and its effect on inventory levels and lost sales. They found that holding inventory in order to satisfy most of the demand is not the optimal solution. This is particularly critical in perishable industries where shelf-life constrains the storage time. Many authors have elaborated on this issue suggesting optimal solution for managing perishable products' supply chain. Jiang and Chen (2007) developed a collaborative manufacturing, planning and scheduling system with integration of lean and agile production. This system is capable of adapting production schedules based on real-time information and also to consider available resources and capacities of entire supply chain. Soman et al. (2004a) also investigated the production planning and scheduling process in perishable manufacturing industries. They suggested that food producers should strive to deliver fresher products to their customers but also to reduce inventory time and avoid subsequent deliveries of products with the same expiry date. This goal may lead to more frequent manufacturing which in turn increases machine setup costs, and may affect product quality issues (Soman et al, 2004b).

Goyal and Vishwanathan (2002) and Chowdhury and Sarker (2001) suggested that production scheduling optimization could be achieved through adjusting either cycle time or production rate, or both simultaneously. Decreasing batch size or more frequent production of a product may result in decreasing production lead time, thus making a manufacturer more responsive. Due to improved responsiveness, inventory levels could be kept lower which in turn provides fresher products and less waste costs. Silver (1989) also outlined that reducing production rate could be an effective solution for dealing with shelf life constraint. Vishwanathan (1995) and Goyal (1994) agreed that a reduction of production rate could be economical but they also questioned the feasibility of such production scheduling. If a product is about to be produced in smaller batches, it would increase complexity of production scheduling and more frequent machine set-ups which could further cause respective costs. In order to avoid additional setup and potential product quality costs, Rajaram and Karmarkar (2004) and Rajaram and Karmakar (2002) suggested "campaigning" product manufacturing in finite cycles. On the other side, Soman et al. (2004a) suggested that a production rate decrease could lead to product

quality issues. They argue that in such situations, more frequent quality control is necessary because each batch must be examined, which also creates additional cost.

Houghton and Portougal (2001) found that optimal production planning does not necessarily mean that the just-in-time concept should be strictly followed to reduce operating costs. They were analyzing the case of a food manufacturer who kept overproducing even out of season and was building inventory in order to avoid production shortages in the season. The result was a 50% cost decrease of overtime work with the increase of inventory for only 10%. Adenbanjo (2009) investigated independent demand planning challenges, particularly trade promotions, in a food trading organization and its effect on supply chain flexibility. His findings suggest that there is a gap between a food trade organization's operational flexibility and manufacturers' (suppliers) flexibility in meeting demand for promotional activities. Manufacturers and suppliers cannot react as flexible as trading organizations when for example, promotions are planned. Following an analysis of the UK fresh food sector, Taylor and Fearn (2009) outlined that a raw material producer such as a farm must have much longer planning horizon than a trader of fresh meat, which also conforms to Adenbanjo's findings on supply chain relationship flexibility.

## *2.2. Production Planning in the Meat Processing Industry*

The supply chain of meat processing is very challenging due to the perishable nature of the product, and the processing complexity. Despite the above, this supply chain has not been widely analyzed in the literature and very few authors have investigated its relevant challenges. Stokes *et al.* (1998) applied mixed integer linear programming in meat packing production planning. Based on input data, such as live pigs supply, plant capacity, inventories and demand plans, their system determines optimal production plan. The plan incorporates information on quantity of meat products needed to be produced, additional carcasses required to purchase, allocation of processed and fresh meat, and processes sequences from pig slaughter and deboning to finished products processing. This system is created in a way that inventory levels are optimized in order to both reduce waste costs due to higher inventory causing expired products, and reducing the lost sales costs due to insufficient products in storage.

Entrup (2005) has investigated the integration of shelf life into production planning. His research also examined the requirements which advanced planning systems have to meet in order to effectively and efficiently support production planning for yoghurt, scalded sausages and poultry products. Many authors (Palmer, 1996; Fearn, 1998 and 2000; Katz and Boland, 2000; Francis *et al.* 2008), analyzed the importance of alliances and partnerships in beef processing industries. They found that greater coordination, often in the form of cross-functional team working, in the chain is a prerequisite for reducing risks and uncertainties and eliminating waste. Uncertainties are an important issue in meat supply chains both in terms of anticipation of future demand and cattle carcass composition. Unfortunately, carcass imbalance as a constraint of effective planning has not been widely considered in the supply chain literature. Taylor (2006) has pointed that finding the optimal (which satisfies different customer demand for primal cuts) live animal (that will enter the production process) is a great opportunity area to reduce waste and associated costs in the supply chain.

### 3. Research Design

Case study research was the method chosen for this study. Despite the concerns that have been expressed by several researchers (Smith, 1990; Verschuren, 2003), case study research has been recognized as an increasingly important type of research in the context of agri-business sector (Sterns *et al.* 1998), but also in supply chain and logistics research (Mangan *et al.* 2004; Frankel *et al.* 2005). Given the aim of the research and the need for an in-depth data collection, the case study methodology was preferred. Secondary data were also extracted from the company's local Enterprise Resource Planning (ERP) system. A description of the company and the research process of the study follow.

#### 3.1 Study context

The case study organization is a South East European based meat processor with annual revenues of over 30 million euros. The company (from now on called Meat Co.) is vertically integrated owning pig farms, meat processing operations, and partially distributing final products to its own retail stores - butcheries. The distribution network of the company spans to three neighboring countries. Sales to these countries reach twenty percent of total annual sales.

The company product portfolio includes fermented sausages, cooked sausages and canned products, such as ready meals and pates. Cooked and fermented sausages have a shelf life of two and three months, respectively, while pates and ready meals are less perishable given that their shelf life is three years. In Table 1, an overall presentation of the characteristics of the three product group categories is provided.

Table 1 – Shelf life, sales volume and profit of company's products

| Product group      | Shelf Life | % of sales volume | % of profit |
|--------------------|------------|-------------------|-------------|
| Fermented Sausages | 90 days    | 12%               | 19%         |
| Cooked Sausages    | 60 days    | 75%               | 58%         |
| Canned Products    | 3 years    | 13%               | 23%         |

#### 3.2 Data collection

Primary data were collected through in-depth interviews with company's managers. Key issues in the interview process were the selection of the interviewees, the selection of the interview type as well as the questions and the topics (Seale *et al.* 2004; Robson, 2002; Chisnal, 2001; Taylor and Bogdan, 1998). Selecting the interviewees was a critical step in this research process because their knowledge, experience, skills and willingness to cooperate could constrain the data availability. With reference to the interview type the unstructured interview was selected. This way, the interviewees were answering to open-ended questions and were allowed to discuss particular topics providing more information for the qualitative research objectives. Considering the nature of the research objectives, the interviewees were selected in a way that each of them had sufficient practical skills and knowledge so as to provide quality information. These interviews

provided closer insights into the role of each function in the planning processes, and the use of the supply chain planning input and output information. The interviews were held in a one month period, with approximate duration of an hour per interview. All interviews were transcribed, while the most important information was extracted for further data analysis. Details about interviewees, key topics and questions are presented in Table 2.

Table 2 – The list of selected interviewees and key topics

| <b>Interviewee</b>                                  | <b>Topics</b>   |
|---|---|
| IT Manager  | Describe the information flow between the Production, Sales and Logistics departments in the company      |
| Human Resource Assistant                            | Present the organizational chart of the company   |
| Sales manager                                       | Explain the process of sales planning   |
|   | What is the connection between sales and demand and production planning function?                         |
|   | Which are the key performance indicators for customer service?  |
| Demand and Production Planner                       | Describe the process of demand and production planning  |
|   | Which are the inputs and outputs of each of the planning processes?                                       |
|   | Who uses the output information and how?  |
| Distributors Demand Planner                         | Describe the process of demand planning at distributors   |
|   | Which are the inputs and outputs of the distributors demand planning process?                             |
| Purchasing Manager                                  | Explain the process of material requirements planning   |
|   | Which are the inputs and outputs of the material requirements planning?                                   |
|   | How do the material requirements planning affect suppliers' performance?                                  |
|   | Which are the main product groups in the company depending of processing technology applied?              |
| Chief Technologist for Primary Processing           | Present the organizational chart of the Primary Processing department                                     |
|   | How is the Primary Processing organized and which activities does it perform?                             |
|   | Which are the inputs and outputs of the Primary Processing (both the products and information)?           |
| Chief Technologist for Finished Products Processing | Present the organizational chart of the Final Products Processing department                              |
|   | How is the Finished Products Processing organized and which activities does it perform?                   |
|   | Which are the main product groups in the company depending of processing technology applied?              |
|   | Which are the inputs and outputs of the Finished Products Processing (both the products and information)? |

Secondary data collected for the company included data from historical reports and statistical data about supply chain effectiveness and efficiency. Based on the primary data collection, a list of required documentation and statistical and financial data were created. Preliminary list of needed data included:

- Historical sales information
- Indicators of the planning processes performance (demand planning accuracy, production plans fulfillment)
- Reports on material movements through the supply chain of the company (live cattle input, basic meat cuts output, ingredients and materials inputs, finished product expedition)
- Meat, ingredients and packaging materials utilization
- Direct material costs of the finished products
- Inventory information (raw materials, work-in-progress, finished products)
- Reports on customer service performance (product availability, case fill rates, product returns from customers)

## 4. Empirical research

### 4.1 Findings

Production planning is the most complex part of the supply chain planning process in Meat Co. involving two major phases and five tasks. In Figure 1, the major phases and tasks of the production process are presented.

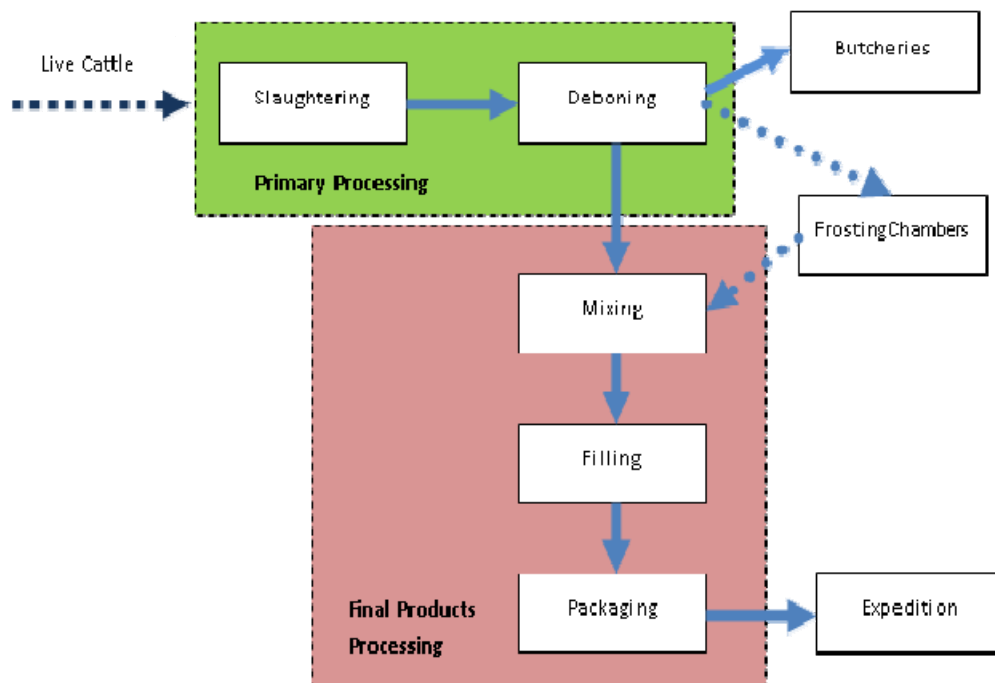


Figure 1 – Product Flows within the Production Process

Responsibility for planning is shared between Meat Co. and distributors' planning teams, but there is a clear distinction of scopes for each of the sides. The planning process is initiated by an overall sales plan created by Meat Co. sales force on the basis of the company's annual budget. The Sales Manager of Meat Co. suggested that although his role was to push for the distributors' demand and their sales plans, *“the final sales plans per distribution channel have to be aligned and agreed with distributors”*. Without definite commitment of each distributor to the agreed sales plan, the sales planning is not completed. Thus, the overall Meat Co. sales plan is further divided into countries' distributors' sales plans, and own retail chain's sales plan. Processing the final product requires different production lead times for different product groups. Total production lead time per product group is given in Table 2.

Table 2 – Production lead time per product group

| Product Group                       | Mixing   | Filling  | Packaging     | Production Lead Time |
|-------------------------------------|----------|----------|---------------|----------------------|
| Fermented Sausages (diameter 37 mm) | same day | same day | after 28 days | 29 days              |
| Fermented Sausages (diameter 55 mm) | same day | same day | after 49 days | 50 days              |
| Cooked Sausages                     | same day | same day | next day      | 2 days               |
| Canned Products                     | same day | same day | after 14 days | 15 days              |

As shown in Table 2, the production lead time varies from 1 day to 50 days for the product groups involved. This is the time the final products processing department could react to demand for products. The Demand and Production Planner emphasized that: *“this characteristic of fermented sausages and canned products strongly affects the production planning in a way that planning horizon for these product groups have to be longer. If this planning constraint is not properly reflected on production plans it could cause issue with product availability and a failure to meet market demand”*

With regards to the impact of specific production processes (e.g. the fermentation process) on cost, the Chief Technologist for Final Processing added that: *“the fermentation process alters the products in terms of their weight”*. The percentage of lost weight due to maturing for fermented sausages is shown in Table 3. Thus, fermented sausages with a 37 mm diameter lose an additional 3.8% if sold to the market a week after it had been initially scheduled.

Table 3 – Lost weight of fermented sausages depending on over-maturing time

| Product Group                | Maturing Scenario | Maturing Days | Lost Weight % |
|------------------------------|-------------------|---------------|---------------|
| Fermented 1 (diameter 37 mm) | normal            | 28            | 38.0%         |
|                              | + 3 days          | 31            | 40.1%         |
|                              | + 7 days          | 35            | 41.8%         |
|                              | + 14 days         | 42            | 43.0%         |



|                                 |           |    |       |
|---------------------------------|-----------|----|-------|
| Fermented 2<br>(diameter 55 mm) | normal    | 49 | 39.0% |
|                                 | + 3 days  | 52 | 40.1% |
|                                 | + 7 days  | 56 | 41.1% |
|                                 | + 14 days | 63 | 41.8% |
|                                 | + 21 days | 70 | 42.3% |

Also, the technologists suggested that the maturing process for fermented products could also affect product quality. As a product continues losing humidity, it becomes stiffer, while fat portion in the product increases. This means that different maturing time for the same product could consequently result in non-standardized fermented sausages. Canned products (pates and ready meals) also have longer production lead time, but it is not linked to the technology applied.

Production lead time in the case of fermented sausages and canned products constraint production planning in a way that not all plans for particular processing stage can be conducted at the same. From one side, if produced quantities are lower than actual demand, it could affect product availability with lower inventory. And vice versa, if producing quantities are bigger than demand in particular week, products on stock would rise above optimal. The second case is more critical for the fermented sausages group. Given that these products are losing weight over time it could affect increased waste and quality issues (stiffness).

With regards to purchasing, a Purchasing Manager commented that: *“purchasing different meat categories on the market is not easy especially because required categories are in deficit at all slaughterers”*. Additionally, the market price of any particular meat category is higher when bought in the external market instead of sourced and primary processed pig within Meat Co. The comparison between market and Meat Co planned prices for an eight month period is shown in Table 4.

Table 4– Value difference between market and planned prices of pork meat for processing

| Meat Category        | Market Price per 1kg of Meat (in €) | Meat Co. planned Price per 1kg of Meat (in €) | Material Requirements for Processing in kg | Market Price Value (in €) | Meat Co. planned Price Value (in €) |
|----------------------|-------------------------------------|---|--|---------------------------|-------------------------------------|
| Ham, boneless        | 4.00                                | 3.43  | 251,599                                    | 1,006,396                 | 862,985                             |
| Shoulder, boneless   | 3.47                                | 2.98  | 376,546                                    | 1,306,615                 | 1,122,107                           |
| Loin, boneless       | 5.79                                | 4.96  | 41,090                                     | 237,911                   | 203,806                             |
| Neck, boneless       | 4.42                                | 3.79  | 98,971                                     | 437,452                   | 375,100                             |
| Meat Trimmings 80/20 | 2.53                                | 2.16  | 235,426                                    | 595,628                   | 508,520                             |
| Head Trimmings 70/30 | 1.58                                | 1.35  | 143,134                                    | 226,152                   | 193,231                             |

|                       |      |      |                  |                  |                  |
|-----------------------|------|------|------------------|------------------|------------------|
| Bloody Meat Trimmings | 1.47 | 1.26 | 12,804           | 18,822           | 16,133           |
| Back Fat              | 1.26 | 1.08 | 434,777          | 547,819          | 469,559          |
| Fat                   | 1.05 | 0.90 | 409,134          | 429,591          | 368,221          |
| Lean Bacon (Belly)    | 2.84 | 2.44 | 336,118          | 954,575          | 820,128          |
| Jowls                 | 1.63 | 1.40 | 51,218           | 83,485           | 71,705           |
| Skin                  | 0.74 | 0.63 | 176,062          | 130,286          | 110,919          |
| Total                 |      |      | <b>2,566,879</b> | <b>5,974,731</b> | <b>5,122,414</b> |

The data (taken from company's ERP) presented in Table 4, indicate that the same raw material quantities when purchased externally from the market result in an additional cost of approximately 0.85 million €. Obviously, this potential cost benefit is subject to the possibility of actually selling the different parts of the pig as fresh meat.

The effect of neglecting these constraints in demand-production planning could be realized either through poor customer service, or increased costs. Particularly for fermented sausages, ineffective planning may result in product quality and availability issues, as well as extra waste costs derived from over-maturing and product expiry. The extent of the utilization of pig carcasses is the common constraint for all product groups which may strongly affect raw material cost. In the following table (Table 5), an overall summary of these issues is provided.

Table 5 – The impact of planning constraints

|                             | <b>Cooked Sausages</b> | <b>Fermented Sausages</b>                 | <b>Canned Products</b> |
|-----------------------------|------------------------|---|------------------------|
| <b>Product Shelf Life</b>   | waste cost             | waste cost                                |                        |
| <b>Production Lead Time</b> |                        | waste cost, availability, product quality | availability           |
| <b>Carcass Utilization</b>  | raw materials cost     | raw materials cost                        | raw materials cost     |

#### 4.2. Discussion

The reduction of inventories is of particular importance to the meat processing industry given that these products have perishable nature where product freshness may be a competitive advantage for a company (Gallucci, 2008; Chen et al, 2007; Leung and Ng, 2007; Lapide, 2006; Soman et al, 2004b). In the case of Meat Co., a reduction of finished product inventory of fermented sausages was found to bring additional value with decreasing over-maturing waste costs and prevention of product quality issues, such as product stiffness and the fat portion increase. This should put extra pressure on meat processing companies to further integrate their demand and production planning processes.

Previous research and literature exploring constraints in supply chain planning in meat processing industry is scarce. Only several authors have elaborated on this subject finding product shelf life (Entrup, 2005) and carcass imbalance (Taylor, 2006; Stokes et al, 1998) as the main constraints in the planning processes. Product shelf life was also considered in other relevant industries (Darlington and Rahimifard, 2007; Leung and Ng, 2007; Soman et al, 2004a; Soman et al, 2004b), so its general effect on planning process in food processing industries is well stated. This cross-product research confirmed that product shelf life and carcass utilization are important constraints in meat processing industry supply chain planning, but also suggest that production lead time of certain product categories should not be neglected in creating effective and efficient planning system.

Same as in other food industries, the meat processors also have to strive to deliver fresher product to the market in order to maintain a competitive advantage (Leung and Ng, 2007; Entrup, 2005; Soman et al, 2004b). Product shelf life as a constraint is found to be important for cooked and fermented sausages which represent 87% of total sales volume at Meat Co. while canned products with three years shelf life are not affected. The research at Meat Co. revealed that delivering relatively older products to customers results in additional cost of 0.3% of total sales revenues as compensation for delivering products with less than 75% shelf life remaining. The issue with critical product shelf life is initiated by poor and overestimated market demand planning, while production plan and materials requirement plan, as derived and dependent plans, should not be directly affected by this constraint. In order to minimize the effect of waste due to product expiry, the emphasis should be put on improving independent market demand planning and forecasting as it had already been outlined by many authors (e.g. Wagner et al, 2009; Gallucci, 2008; Chen et al, 2007; Mentzer, 2006).

Production lead time in Meat Co. was recognized as a constraint in weekly production planning for fermented sausages and canned products due to technological processing requirements and product characteristics. Given that the lead time for cooked sausage processing is only two days, this product group is not affected by this constraint at weekly level. Scheduling mixing and filling, and packaging of cooked sausages for a day ahead of the final product demand makes them timely available for delivery to customers. On the other side, production lead time for the other two product groups is longer and it is measured in weeks.

Carcass imbalance and optimal utilization was recognized as an important planning constraint in the meat processing industry (Taylor, 2006; Stokes et al, 1998) which our study has confirmed. Finding an optimal live animal (as an input in the production process) is extremely difficult, if not impossible, for a processing company. Nevertheless, there are still opportunities for cost improvements when comparing the costs of slaughtering livestock to the costs of purchasing meat parts externally from the market.

## **5. Conclusions**

This research contributes to the supply chain management literature by providing more information about meat processing supply chain planning and constraints affecting the planning effectiveness and efficiency. Product shelf life, carcass utilization and production lead time were identified as main constraints affecting supply chain

efficiency. Our cross-product approach highlighted that the single planning approach for an industry is not appropriate when different products have different technological and processing characteristics. The significance of integration and centralization of planning functions was noted in our research confirming further previous research.

In terms of the practical implications of this work, we have provided many suggestions for the design of the supply chain planning process within a meat processing industry. This research has showed that the decision to slaughter live pigs yield an advantage in raw materials cost of 14% against the option to purchase pig parts separately. Thus, the meat processing industry should strive to achieve as much possible utilization of pig carcasses while only remaining parts of pig, which could not be utilized by slaughtering, should be bought on the market. The analysis of constraints in planning should raise awareness of supply chain professionals about potential obstacles in developing planning process at their organizations.

Lastly, the main concern of this research is that the findings on a single case may not be applicable in general (Verschuren, 2003; Yin, 2003) and our results are limited to a single company and its operations, products and applied processing technology. Thus, subsequent attempts to quantify the supply chain planning efficiency (e.g. the percentage of waste due to fermentation, product expiry costs, or the raw material cost saving potential), could not be applied to every meat processing industry. Nevertheless, we believe that there are some important lessons to be learned from this research. The supply chain planning processes under investigation were limited to one company and our research did not consider possible constraints affected by relationships with the company's suppliers, own farm of pigs, or final consumers.

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