USING POSTPONEMENT STRATEGIES TO REDUCE PLANNING UNCERTAINTY IN MEAT SUPPLY CHAINS

Willem A. Rijpkema, Jack G.A.J. van der Vorst, Roberto Rossi
Wageningen University, Logistics, Decisions and Information Sciences Group,
The Netherlands, Tel. 31 (317) 485644; Fax +31 (317) 485646
Wageningen University, Hollandseweg 1, 6706 KN Wageningen, The Netherlands,
E-mail: Willem.rijpkema@wur.nl

Abstract

This article discusses an application of postponement in the pork processing chain. This chain faces uncertainty in both supplied and demanded quality features. Based on a chain analysis, we propose a supply chain redesign in which carcasses are classified *after* they have been cooled, rather than *before* cooling as is done in the current setup. This postponed differentiation allows logistics planners to reduce demand uncertainty and to minimize deviations from customer specifications.

This case study addresses one of the gaps in postponement literature indicated in the literature review by Boone (2007); a lack of research on postponement as a reaction to uncertainty in efficient supply chains with functional products.

An illustrative example was simulated for both scenarios, and revealed that claim costs following from products delivered out of customer specifications could be minimized by 90 % by postponed differentiation. These results indicate that postponement of carcass differentiation is an effective mechanism to react to demand uncertainty pork processing. This contrasts to findings by van Hoek (1999), who stated that postponement in food supply chains is largely limited to postponed packaging and distribution, rather then to processing.

Further research is suggested both to further enhance the body of knowledge on postponement in other efficient Food Supply Chain Networks that face high uncertainty, and thus further address the gap of literature indicated by Boone (2007). Furthermore, it is suggested to do further research on other interesting logistics implications of the proposed alternative cooling setup, such as its effect on throughput-time and the ratio of orders that can be made to order rather then to stock.

Introduction

The world of meat is becoming more and more complex. In these chains, consumers demand a large variety of high quality, safe and animal friendly meat products, while retailers prefer products packed in specific materials with their own logo an specifications. Globalization lead meat processing companies to serve an increasing number of customer markets (Grunert,2006). These markets differ in demand for specific quality features, meat cuts, logistics services, and demand volatility. Due to this growing demand complexity food companies must acquire new competences in order to effectively satisfy consumers demands (Grunert,2006).

Many developments are taking place on the demand side as well, in which a variety of production systems is present that differ in breeding, feeding, production methods and animal handling (Perez et al.,2009). These factors affect the quality of final products, and result in quality heterogeneity of finished pigs (Perez et al.,2009). This heterogeneity affects multiple quality features, like animal weight, lean meat ratio, fat layer thickness, etc (Rosenvold et al.,2003), and exists both between pig batches from different farmers (pig batches differ in average quality features) and within pig batches itself (pigs within a batch differ in quality features).

Slaughterhouses and meat processing companies are in the middle, trying to match uncertain demand with variability in supply. The key question here is how to do this as efficiently as possible, while maintaining responsive to supply and demand changes. Planning flexibility is a key factor to deal with uncertainty. Postponement is mentioned in literature as a possible way to increase planning flexibility and deal with uncertainty. Postponement refers to a concept in which activities in the supply chain are delayed until a demand is realized (Boone et al.,2007). Boone et al. indicated that there are still several research challenges related to postponement. One of these challenges is the further development of postponement as a response to uncertainty in efficient chains with functional products. We will address this gap in literature by providing a case study example of how postponement in the pork chain can reduce uncertainty and improve planning flexibility.

The remainder of this paper is organized as follows: First, we present an overview of the literature on postponement and on pork chain specific characteristics. Second, we provide a problem description, followed by a description of the research work. The research work section is followed by a section describing the results. The final two sections will give a discussion of the research results and conclusions.

Literature review

Postponement is an important organizational concept that can be used to improve a firm's performance. The essence of this concept is not to perform certain activities until final customer orders are received (van Hoek,2001). By delaying these activities planning uncertainty and risks are reduced. The two most common types of postponement are form and logistics postponement. In *form postponement* the product configuration is not finalized until exact customer requirements are known. With *place postponement* the number of inventory points is limited, and shipment to local sales points is postponed until customer orders are received (van Hoek,2001).

Postponement has drawbacks as well. Implementation can reduce economies of scale and result in longer lead times. Furthermore, implementation of postponement requires a redesign of the supply chain, which involves high costs as well (Cheng et al.,2010).

Postponement is tightly related to two other concepts: *product differentiation point* (PDP) and *customer order decoupling point* (CODP). A product differentiation point is a point after which a product is transformed from a generic form into a less generic form (van der Vorst et al.,2001). In the fashion industry for example, products are weaved, dyed and packaged: after each of these production steps (i.e. PDPs) the products become less generic and more market specific. Several specific PDPs can be distinguished in literature. One of them is the *material decoupling point* (MDP). This is the point where strategic inventory is held in a generic form. Positioning the MDP further downstream in the supply chain, closer to the final market place makes a production chain more flexible and makes it possible to reduce required inventory (Christopher et al.,2000). Another important PDP is the CODP, which is defined as the point in the manufacturing value chain in which a product is linked to a specific customer order (Olhager,2003). This point separates forecast-driven activities upstream of the CODP from the order driven ones after the CODP.

Olhager (2003) identified five manufacturing strategies that differ with respect to the position of their CODP. These strategies range from working completely order driven (design to order) up to completely forecast driven (make to stock). Shifting the CODP upstream allows the manufacturer to cope with high demand uncertainty, whereas shifting it downstream makes it possible to focus more on production efficiency. A more elaborate discussion on CODP and manufacturing strategies can be found in (van Donk,2001) and (Olhager,2003).

Postponement is well-studied in literature, as can be concluded from the literature reviews of Boone (2007), and van Hoek (2001). These authors, however, both indicate that there are still several research challenges. Boone formulated 5 challenges for future research, being: (i) assessing application of postponement relative to performance; (ii) selecting appropriate postponement points; (iii) developing postponement concepts for the service industry; (iv) further development of postponement as a response to uncertainty; and (v) investigating implementation of postponement.
In research challenge (iv) the author states that only little research has specifically linked postponement strategies with a response to uncertainty. One of the open research questions in this field is to investigate what postponement strategies might be applicable for supply chains involving functional products that face uncertainty. Van der Vorst (2001) discussed such a case on postponement in the poultry chain to counter demand uncertainty by postponing actions like packaging and labelling. We will focus on meat processing itself, in which use of meat quality information plays an important role. We will focus on countering uncertainty in supply and demand within production planning by means of postponement. The case presented in this study has specific characteristics, however, similar characteristics can be found in multiple food supply chain networks as well.

A food supply chain network (FSCN) comprises organisations responsible for production and distribution of vegetable or animal-based products (van der Vorst et al.,2009) and it often has a set of specific characteristics. Van Donk (2001) grouped these characteristics into product characteristics (e.g. perishable nature, heterogeneous quality), process characteristics (e.g. variable yield), and market characteristics (e.g. large number of producers). These characteristics affect logistics planning and the use of differentiation points (van der Vorst et al.,2001). More details on specific FSCN characteristics can be found in Van Donk (2001), van der Vorst (2005) and Akkerman (2010).

Characteristics that are relevant to pork chains are, among others, a variety of farmer production systems and processing systems. Furthermore, market segments have their own specific demand for product specifications and logistics services. Factors like changing quality features over time, a variety of relevant product quality features (e.g. weight, lean meat ratio), and a “divergent” production process (one pig ends up in a multitude of end products) increase logistic complexity in this sector and contribute to planning uncertainty. In this particular type of supply chain, both demand and supply uncertainty are present. Demand uncertainty is linked to the degree of predictability of customer demand, whereas supply uncertainty relates to uncertainty in quantity or quality of raw materials that is supplied by the producer (Lee,2002). These special characteristics make this chain interesting for research on postponement strategies.

In the following sections we will focus on a specific problem that we observed within a medium/large company in the meat sector. We will first discuss the current production system and then we will propose and assess an alternative production setup in which postponement is used to reduce demand uncertainty. Our discussion aims to demonstrate the fact that postponement is a viable concept in this particular sector.

<u>Description of the problem / challenge</u>
Pork processors face both supply and demand uncertainty. This makes effective logistics planning in this industry challenging. By means of a process analysis of the pork supply chain, expert interviews, and a literature review, insight in logistics planning and decision points in the pork chain was gained. Matching of carcasses with production orders was identified as one of the key PDPs in pork chains to create a match between supply and demand. Mismatches at this place, due to uncertainty in either supply or demand, will result in poor compliance with customer specification, low raw material yield and inefficient processing. We will investigate whether planning performance at this PDP can be improved by use of postponement strategies. We will therefore analyze whether a postponed setup improves flexibility to uncertain demand if compared to a traditional, non-postponed pork processing setup.

<u>Case description</u>
This section gives a description of two scenarios. The first scenario represents the logistics setup that is currently being used, whereas the second scenario describes an alternative setup in which postponement is applied.

After animals arrive at the slaughterhouse they are transferred to the slaughtering line. In this slaughtering line they are stunned and subsequently slaughtered. Dead animals are cleaned, intestines and organs are removed, they are cut in halves (carcasses), and quality information is gathered (e.g. weight, lean meat percentage, fat layer thickness). After these steps, carcasses are chilled prior to carcass processing to ensure food safety, maximize shelf life and reduce weight losses (Savell et al.,2005).

After chilling, carcasses are matched with production orders, which, due to uncertainty in both supply and demand is a critical point in this processing chain. For a more elaborate review on pork supply chains see Perez (2009). We will now provide a description of two logistics scenarios for differentiating and cooling of carcasses.

Scenario 1. Current cooling setup
In the current cooling setup, carcasses are sorted directly after slaughtering into approximately 24 to 48 different classes (Figure 1, product differentiation point 1). This sorting is based on fixed quality specifications with respect to weight, lean meat ratio, muscular quality, fat layer thickness, gender, and organic/non-organic. These carcass classes are used after cooling to match carcasses with production orders. Their quality specifications are chosen as to provide the best average match between supplied and demanded characteristics. This point is identified as the MDP, since before this point carcasses are in their most generic form, whereas they are grouped into different classes afterwards. The classified carcasses are then transferred to a cooling room, where classes are chilled in separate,

parallel tracks for a minimum period of 16 to 24 hours (Savell et al.,2005). After the carcasses are chilled, they can be transferred to the processing room or buffered temporarily in the cooling room.
After carcasses have been transferred to the processing room, carcass classes are matched with production orders. (Figure 1, product differentiation point 2). This point is identified as the main CODP in this chain (although, in some cases and for some end products the CODP is further downstream). Planners try to create an optimum match between supplied and demanded characteristics at this point by maximizing raw material yield while fulfilling customer demand.

A schematic overview of this processing setup and the differentiation points in it can be found in Figure 1.

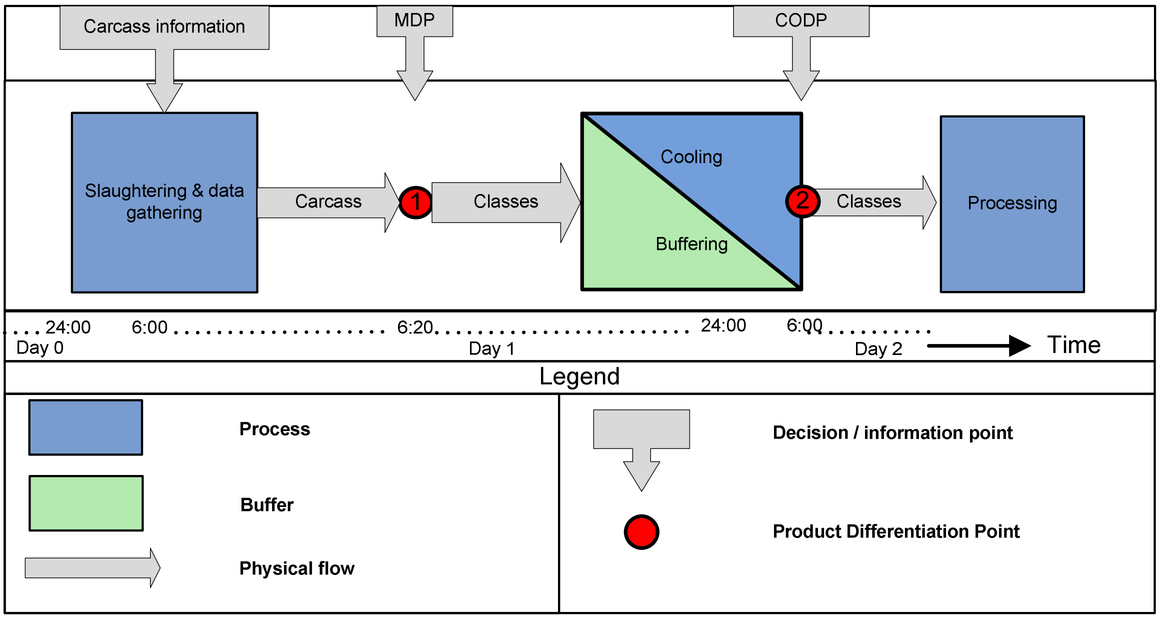

Figure 1 Schematic overview scenario 1: current cooling setup

Scenario 2. Alternative cooling setup
In this setup, carcasses are not sorted *before* but *after* the cooling. Carcass information is still gathered before the cooling, and carcasses are transferred in serial order to the cooling room after slaughtering. This serial order, in which carcasses are constantly moving through different zones, allows for so-called ‘rapid chilling’ (Jones et al.,1993). This is realized by using variable temperature zones in the cooling tracks, and reduces required chilling time while enhancing meat quality. After chilling, carcasses can be transferred directly to the cutting room or temporarily stored (Figure 2, product differentiation point 1). At this differentiation point, information on both individual carcass characteristics and customer orders is available, which can be combined to maximize raw material yield while fulfilling customer demand. In this processing setup, the product differentiation can be regarded as both the MDP and the CODP. A schematic overview of this processing setup and the differentiation points in it can be found in Figure 2.

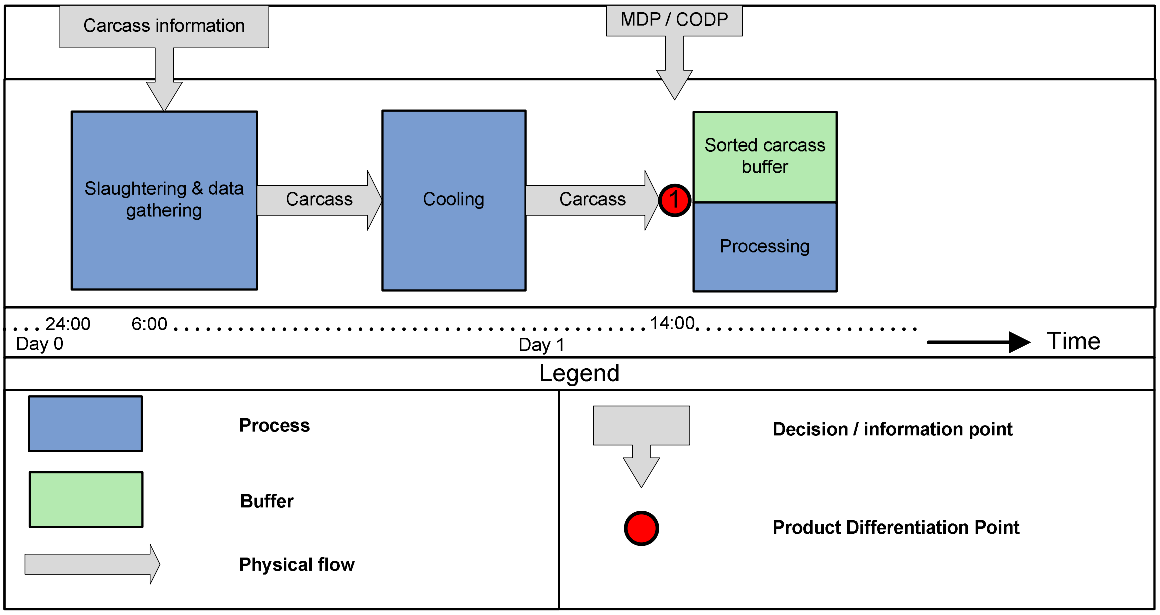

Figure 2 Schematic overview scenario 2: Alternative cooling setup

The proposed alternative setup has several implications. Rapid chilling reduces the required chilling time to 8 hours, and significantly reduces evaporative weight losses (Tomovic et al.,2008). This short carcass chilling period allows for direct processing after the right temperature is reached, which makes it possible to slaughter and process on the same day (see time bar in Figure 2). In the current setup, in which carcasses slaughtered throughout the day are clustered in different classes and chilling tracks, this is not possible (see time bar in Figure 1).

Another advantage of this changed setup is that, by differentiating at a later stage, carcasses are still in their most generic form during chilling, since decisions can still be made on individual carcasses, rather than on class level. This allows the planner to sort carcasses after cooling specifically to fit customer demand. Use of fixed quality classifications like in scenario 1 is no longer required. This later differentiation links up to the postponement concept described earlier, and gives planner more flexibility to respond to uncertain customer demand. The next section will illustrate how postponement can improve chain performance.

Illustrative example

We will now provide an example that illustrates how postponed carcass differentiation can improve product homogeneity and compliance with customer specifications, and how it can lower customers claim costs. We will present a simplified example in which classes are based on only one of the quality features: carcass weight. The company uses three weight ranges: (i) ‘light’ carcasses (0 to 86 kg); (ii) ‘medium’ carcasses (86 – 91 kg); (iii) ‘heavy’ carcasses (91 kg and more). In the real life situation, these weight ranges are subdivided further based on other quality features. This is simplified in this example.

Daily demand for medium weight products is uniformly distributed between 1050 and 2450. In case insufficient carcasses of this weight range are available, carcasses with a higher weight will be delivered instead. This will, however, result in poor compliance with demanded specifications and claim costs. Based upon insight in current practice, we assume these claim costs to be € 0.50 per kg out of the specified weight range. Delivering a carcass of 95 kg will therefore result in (95 – 91) * 0.50 = € 2 claim costs.

In the current setup carcasses are differentiated before final product demand is known. In most cases, the availability of carcasses from the medium range is sufficient to fulfil demand. In other cases, carcasses from the ‘heavy’ weight range are used to fulfil demand. The carcasses selected from this range form a random sample from the complete weight range within this class, since this setup doesn’t allow to differentiate carcasses based on previously gathered information.

In the alternative setup, differentiation of carcasses is postponed until final customer demand is known. This allows for sorting specifically to fulfil demand; if the number of available carcasses within the specified 86 to 91 kg range is insufficient, the deviation from this maximum weight in delivered carcasses is minimized by selecting carcasses as close to 91 kg as possible.

We assessed the setup of a slaughterhouse that processes 7000 animals each day with a normally distributed weight around 90.9 kg and a standard deviation of 7 kg, which represents the current average weight distribution.

An example of the sorting performance of both scenarios in case of shortages can be observed in Figure 3. In the current cooling setup, all carcasses within the 86 to 91 kg range are selected, and for the remaining demand, carcasses from the heavy weight range are selected (see upper histogram, Figure 3). In the alternative cooling setup carcasses can be assigned to orders on the basis of the final demand information. Therefore, deviation from the demanded quality specifications is minimized (see lowest histogram, Figure 3) by selecting carcasses close to 91 kg.

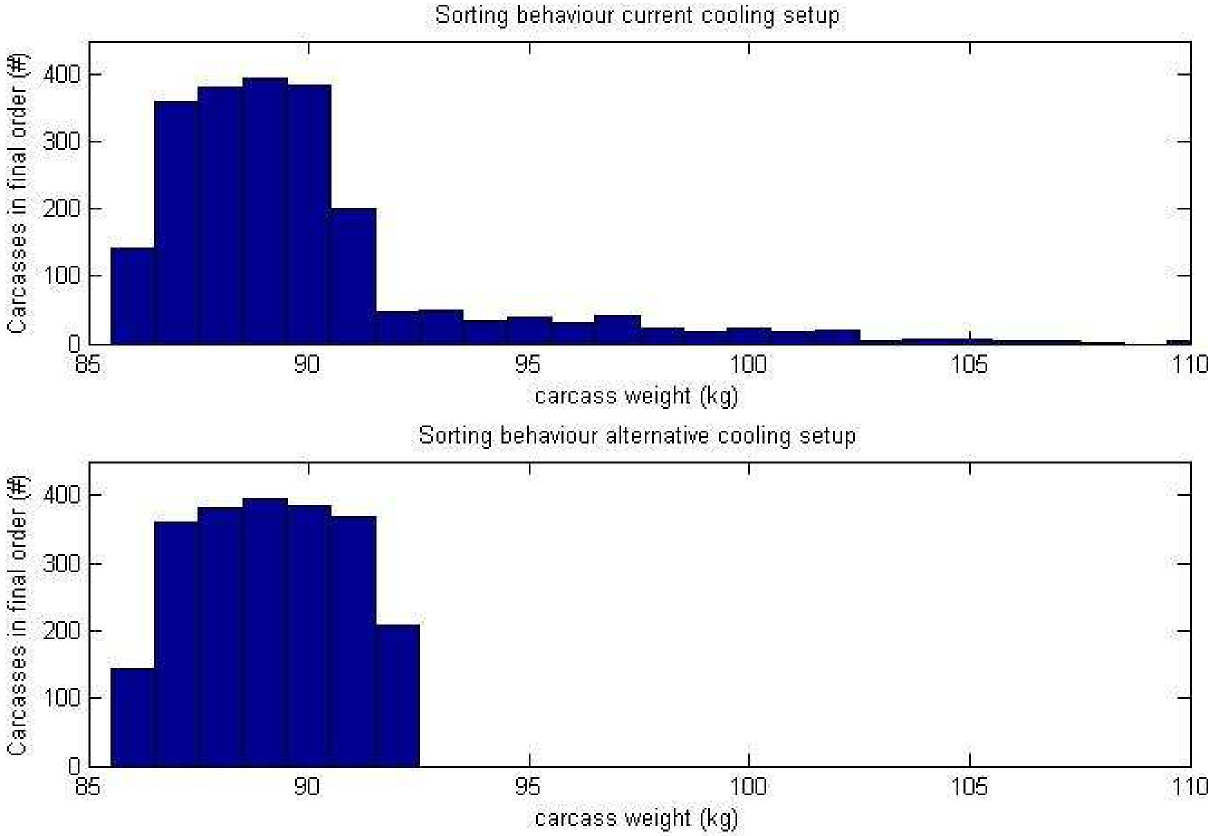

Figure 3 Example histograms current and alternative cooling setup

In order to compare the performance of both sorting scenarios, both scenarios were simulated under the before-mentioned weight characteristics, daily capacity, preferred weight ranges, uncertainty in demand, and claim costs. Both scenarios were simulated 1500 times. The results showed average daily claim costs of € 394 for the current setup, whereas average claim costs in the alternative cooling setup would be only € 37 (reduction of 90 %).

Discussion

The results of the illustrative example indicate that postponement may reduce planning uncertainty in meat chains, improve compliance with customer specifications, and reduce claim costs.

Our example provides insight on a viable strategy for implementing postponement for reduction of uncertainty in meat chains with functional products. One of the research challenges posed by Boone (2007) is addressed: the lack of studies on uncertainty in supply chains with functional products. Furthermore, our findings contrast to the findings of van Hoek (1999), who found that application of postponement in food supply chains focuses mainly on packaging and distribution, rather than on product customization. A possible explanation is that the large heterogeneity in demanded and supplied pork quality features. This heterogeneity, in combination with uncertain demand, might be favourable for application of postponement. Future research on comparable chains would be required to test this hypothesis.

In this study, an illustrating example was used to show the principles behind this postponement case, revealing a reduction of claim costs by 90 %. In real life, the number of different carcass classifications is, however, much larger (24 – 48 instead of 3), and there is a large variety of different end-products, each with their own product specifications and demand uncertainty. Performing an analysis of effects of postponement on such a real-size instance is indeed interesting, but would require more real world data, as well as a suitable combinatorial optimization model.

This study focused on operational application of postponement, in which supply uncertainty was not taken into account, since after slaughtering quality information is measured directly. On a tactical decision level (day to day) supply uncertainty will, however play a role, since day-to-day variation in supplied quality features is present.

We expect that implementation of the proposed alternative cooling setup will have multiple effects on pork processing, of which the postponement effect is only one. Another one is the reduction of meat drip losses and a shorter cooling time (Tomovic et al.,2008). This reduced cooling period might allow for same day processing of meat, which makes it possible to work late in the evening and improve supply chain responsiveness while reducing throughput-time. The proposed supply chain redesign would, however, also require substantial investments. Future research could be aimed at analysing and quantifying these advantages and disadvantages, and could yield a broader view on this supply chain redesign.

Conclusions

In this case study we proposed postponement as a means to reduce planning uncertainty and inefficiencies in matching carcasses with demanded product orders. We showed how postponement of carcass differentiation can give planners more flexibility to react to uncertain customer demand, and how it can improve compliance with customer specifications and reduce claim costs. To do this, we described both the current carcass planning setup and an alternative logistics scenario using postponement. Performance of both scenarios with regard to customer claim costs for out of specification deliveries was compared for a simplified example. Our preliminary results indicate that postponement of carcass classification may reduce claim costs and improve compliance with customer specifications. Further analysis on a more realistic case is however required to quantify savings in a realistic context. Our study provides an example of postponement as a means to reduce uncertainty in a chain with functional products, thus it links and tries to provide an answer to the research challenge formulated by Boone (2007). Furthermore, our results show that the application of postponement in food supply chains may also apply to product customization, an area that, according to (van Hoek,1999), has received little attention both in research and in practice.

References

- Akkerman, R., van der Meer, D. & van Donk, D. P. (2010), 'Make to stock and mix to order: choosing intermediate products in the food-processing industry.' *International Journal of Production Research,* Vol. 48, (12), pp. 3475 - 3492.
- Boone, C. A., Craighead, C. W. & Hanna, J. B. (2007), 'Postponement: an evolving supply chain concept.' *International Journal of Physical Distribution & Logistics Management,* Vol. 37, (8), pp. 594-611.
- Cheng, T. C. E., Li, J. & Wan, C. L. J. (2010), 'Application of Postponement: Examples from Industry.' *Postponement strategies in supply chain management*. New York, Springer science**:** 125-132.
- Christopher, M. & Towill, D. R. (2000), 'Supply chain migration from lean and functional to agile and customised.' *Supply Chain Management,* Vol. 5, (4), pp. 206-213.
- Grunert, K. G. (2006), 'How changes in consumer behaviour and retailing affect competence requirements for food producers and processors.' *Economia Agraria y Recursos Naturales,* Vol. 6, (11), pp. 3-22.
- Jones, S. D. M., Jeremiah, L. E. & Robertson, W. M. (1993), 'The effects of spray and blast-chilling on carcass shrinkage and pork muscle quality.' *Meat Science,* Vol. 34, (3), pp. 351-362.

- Lee, H. L. (2002), 'Aligning supply chain strategies with product uncertainties.' *California Management Review,* Vol. 44, (3), pp. 105-119.
- Olhager, J. (2003), 'Strategic positioning of the order penetration point.' *International Journal of Production Economics,* Vol. 85, (3), pp. 319-329.
- Perez, C., de Castro, R. & Font i Furnols, M. (2009), 'The pork industry: a supply chain perspective.' *British Food Journal,* Vol. 111, (3), pp. 257-274.
- Rosenvold, K. & Andersen, H. J. (2003), 'Factors of significance for pork quality--a review.' *Meat Science,* Vol. 64, (3), pp. 219-237.
- Savell, J. W., Mueller, S. L. & Baird, B. E. (2005), 'The chilling of carcasses.' *Meat Science,* Vol. 70, (3), pp. 449-459.
- Tomovic, V. M., Petrovic, L. S. & Dzinic, N. R. (2008), 'Effects of rapid chilling of carcasses and time of deboning on weight loss and technological quality of pork semimembranosus muscle.' *Meat Science,* Vol. 80, (4), pp. 1188-1193.
- van der Vorst, J. G. A. J., Beulens, A. J. M. & Beek, P. (2005), 'Innovations in logistics and ICT in food supply chain networks.' *Innovation in Agri-Food Systems*. W. M. F. Jongen and M. T. G. Meulenberg. Wageningen, Wageningen Academic Publishers**:** 245-292.
- van der Vorst, J. G. A. J., Dijk, S. J. v. & Beulens, A. J. M. (2001), 'Leagile supply chain design in the food industry - using decoupling points in an inflexible poultry supply chain with high demand uncertainty -.' *The International Journal on Logistics Management,* Vol. 12, (2), pp. 73-86.
- van der Vorst, J. G. A. J., Tromp, S. O. & Zee, D. J. v. d. (2009), 'Simulation modelling for food supply chain redesign: integrated decision making on product quality, sustainability and logistics.' *International Journal of Production Research,* Vol. 47, (23), pp. 6611-6631.
- van Donk, D. P. (2001), 'Make to stock or make to order: The decoupling point in the food processing industries.' *International Journal of Production Economics,* Vol. 69, (3), pp. 297-306.
- van Hoek, R. I. (1999), 'Postponement and the reconfiguration challenge for food supply chains.' *Supply Chain Management,* Vol. 4, pp. 18-34.
- van Hoek, R. I. (2001), 'The rediscovery of postponement a literature review and directions for research.' *Journal of Operations Management,* Vol. 19, (2), pp. 161-184.