SUPPLY CHAIN STRATEGY:

INFLUENCING FACTORS CONJOINTLY DETERMINING THE LOCATION OF THE DECOUPLING POINT IN A SUPPLY CHAIN IN THE FOOD INDUSTRY

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Abstract

The decoupling point is the point in the supply chain to which the customer's order penetrates and where real-time data and forecast-driven activities meet. Locating the decoupling point is part of developing the supply chain strategy, and the concept of the decoupling point is related to several other strategic concepts. The aim of this research is to discover how the influencing factors conjointly determine the location of the decoupling point in the supply chain in the food industry. Characteristics of the food industry and factors that influence the decoupling point are explained. A categorization of the factors is made based on the type of influence they have on the decoupling point: constant influencing factors, variable influencing factors, opening and restricting factors and factors with an unclear influence. Two strategic concepts, market winners and market qualifiers, are explained in the theoretical framework as an instrument to weigh the influence of factors. From the theoretical framework can be derived that the influence of many factors is dependent on the situation.

A model is developed and explained on how factors conjointly determine the decoupling point. This model consists of several steps: determining the influence of all the factors, considering the interrelations, attaching weights to the factors and locating the decoupling point. This model is applied in two different market scenarios, a mass market and a niche market. These analyses are performed to display the difference that a market type makes in a clear and tangible way. The main difference is that the decoupling point is located downstream for the mass market, while it is located upstream for the niche market.

Lastly, a case where the location of the decoupling point is set, is critically analysed from the perspective of the model proposed in this thesis. A lot of information on factors is missing and many factors and some interrelations are not considered. Also, the weights attached to the factors are not stated and argued in the case. In conclusion, with the model proposed in this thesis, balancing the influencing factors, attaching weights to factors with argumentation, and setting the location of the decoupling point in the food industry becomes a clear process.

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1. Introduction

The tendency in today's business is that supply chains compete with each other, instead of companies (Towill & Christopher, 2002). To establish a competitive supply chain, a supply chain must be designed very carefully. Supply Chain Design is a complex process and a relatively new concept, but it is crucial for success nowadays. A well-designed supply chain supports the goals of the organisation and can create important competitive advantage (Fawcett, Ellram & Ogden, 2014). This competitive advantage originates from getting the right product, at the right time to the consumer, and is the key to survival for supply chains (Towill & Christopher, 2002).

Especially in the food industry, designing a supply chain and supply chain strategy is complex and must be considered very carefully. In this industry, the supply chain must also be concerned with the deterioration of food products (Kaipia, Dukovska-Popovska & Loikkanen, 2013) when getting the products to the right place, at the right time, in the right way. The supply chain design process generally consists of three phases, according to Nel & Badenhorst-Weiss (2010): first, the nature of the needs of the end customer must be understood. Second, a supply chain strategy must be selected, and third, the supply chain structure must be configured. Part of developing the supply chain strategy, is locating the decoupling point. The customer order decoupling point, decoupling point for short, is the point in the product flow stream to which the customer's order penetrates and where real-time data and forecast-driven activities meet (Nel & Badenhorst-Weiss, 2010). The choice of where to locate the decoupling point must be considered and made very carefully (Yang & Wang, 2014), since this component of the supply chain strategy is related to several strategic concepts, such as supply chain strategy, manufacturing strategy and push or pull strategy (Olhager, 2003; Fawcett et al. 2014; Towill & Christopher, 2002).

The location of the decoupling point depends on many different factors (Van Donk, 2001; Olhager, 2003), originating from the environment, the product and the production of the supply chain (Van Donk, 2001; Olhager, 2003). To give an example of a product factor, deterioration of food products is a factor that must be considered when locating the decoupling point. These different factors can be seen as forces on the decoupling point that work in one of the two possible directions. When having only separate factors that influence the decoupling point as handles, setting the decoupling point is a complex and difficult decision to be made (Nel & Badenhorst-Weiss, 2010). So, factors force the decoupling point in different directions in different situations (Olhager, 2003), but some factors of influence are interrelated and some work in opposite and some work in parallel directions. This causes theoretical ambiguity concerning setting the location of the decoupling point when confronted with a set of factors at the same time. A synthesis of all the factors that influence the location of the decoupling point has not been performed yet. All the influencing factors combined will illustrate more clearly how the location of the decoupling point is set. Considering that influencing components work in a specific direction dependent on the situation (Olhager, 2003), it could be that syntheses of the components are supply chain specific. This means that setting the decoupling point will be affected by different factors of different strength per situation, e.g. in different industries.

Since locating the decoupling point is argued to be a complex and strategic decision (Nel & Badenhorst-Weiss, 2010), more knowledge on where and how to locate the decoupling point could be very valuable. The aim of this research is to discover how the influencing factors conjointly determine the location of the decoupling point in the supply chain in the food industry. This research will provide supply chain decision makers with more handles to set the location of the decoupling point in the supply chain. This paper focusses on the food industry, because of the relevance of this industry in everyday life, and the interesting industry-specific characteristics that influence the location of the decoupling point.

This research consists of four steps, leading towards the aim of this research. In the first step, the factors that are described that influence the location of the decoupling point in the supply chain are identified from the literature and their forces are explained. Thus, this step is concerned with finding out whether these forces work upstream or downstream in the supply chain, and which situation corresponds with which direction in the supply chain. For overview, a categorization of the individual influencing factors is performed based on type of influence. Also, characteristics of the food industry and tools for attaching weights to the factors are discussed in this step.

The second step in this research will be developing a model for the analysis of the conjointly influencing factors on the decoupling point in the food industry. This model is based on the theoretical framework explained in the first step. As far as my knowledge on the literature reaches at this moment, I observe that the case studies concerning locating the decoupling point are generally performed unstructured. This model will provide a structured method to locate the decoupling point systematically in a situation in the food industry.

The following steps aim to show the applicability of this model. In the third step, the model is applied in two different created market scenarios; a mass market and a niche market. The location of the decoupling point is set by applying the model in two different scenarios that differ in market type. This analysis is performed to display two different processes of locating the decoupling point in a clear way. Because niche market and mass market are such common concepts, these applications are imaginable and tangible.

In the fourth step, a case study from the literature where the decoupling point is located in the food industry will be critically analysed with use of the model. This is done to see if this case is understandable from the perspective of the model developed in this thesis. The case is evaluated critically from the perspective of the model proposed in this thesis. This analysis is performed to show the information requirements to apply the model.

2. Theoretical framework

This section provides a theoretical framework of the elements that play a role in locating the decoupling point in the food industry. First, the concept of the decoupling point is defined and put in a strategic context. Second, characteristics of the food industry are discussed to describe the link between the food industry and the decoupling point. Next, the influencing factors on the decoupling point that are identified in the literature are explained. These factors are categorized and interrelations between these factors are described. Finally, the process of weighing influencing factors is discussed.

2.1 Concept of decoupling point within the supply chain strategy

Locating the decoupling point is part of the second phase of the supply chain design (Nel & Badenhorst-Weiss, 2010) and argued to be an important decision within designing the supply chain. This illustrates the strategic character of this concept, also because the decoupling point is related to several important strategic concepts within the supply chain strategy explained below.

The decoupling point is defined as the point in the product flow stream to which the customer's order penetrates and where real-time data and forecast-driven activities meet (Nel & Badenhorst-Weiss, 2010). The decoupling point is in the literature also referred to as the customer order decoupling point or the order penetration point (Olhager, 2010; Olhager, 2003). A supply chain has two distinguishable sides relative to the decoupling point. Upstream of the decoupling point is the supplier side, downstream is the customer side.

The decoupling point is described as a boundary between several concepts of strategic character. As the definition already states, it separates the forecast-driven activities, thus, the activities upstream of the decoupling point, and the order-driven activities, thus, the activities downstream of the decoupling point (Van Donk, 2001). Aligned with this, the decoupling point is related to pursuing a push or pull strategy in the supply chain. The push strategy will be pursued upstream of the decoupling point and the pull strategy will be pursued downstream (Nel & Badenhorst-Weiss, 2010).

Also, the decoupling point is argued to be the boundary between a lean and agile strategy within the supply chain. The lean strategy is concerned with cost reduction by operating the basic processes with a minimum of waste (Ambe, 2012). An agile strategy is concerned with responsiveness and flexibility and is used in rapidly changing markets and can deal with volatile demand (Nel & Badenhorst-Weiss, 2010; Ambe, 2012). The decoupling point being a boundary between these strategies is the case when a leagile strategy is pursued by the supply chain. With respect to the leagile strategy, the companies upstream of the decoupling point pursue lean strategy, and an agile strategy is pursued downstream of the decoupling point. In this situation, the advantages of both the lean strategy and the agile strategy are combined to a certain extent (Ambe, 2012; Towill & Christopher, 2002).

Another aspect that the decoupling point is related to is the manufacturing situation. Different manufacturing situations, such as Make-To-Stock (MTS), Make-To-Order (MTO), Assemble-To-Order (ATO) and Engineer-To-Order (ETO) all correspond to different positions of the decoupling point (Olhager, 2003), as illustrated in figure 1.

The relations between these strategies can be described best with an example. Consider a hybrid supply chain, this is a supply chain with the lean strategy pursued upstream of the decoupling point, and the agile strategy pursued downstream of the decoupling point. Aligned with this, the push strategy and the forecast-driven activities are pursued and performed upstream of the decoupling point, and the pull strategy and the customer order-driven activities are pursued and performed downstream of the decoupling point. The manufacturing strategy is dependent of the location of the decoupling point. When the decoupling point is located more upstream, MTO or ETO are pursued, and in these cases, the downstream part of the supply chain is long. This means, the largest part of the supply chain pursues an agile and pull strategy and works with customer order-driven activities. When the manufacturing strategy is MTS, the upstream part of the supply chain is long and will pursue a lean and push strategy and will work with forecast-driven activities.

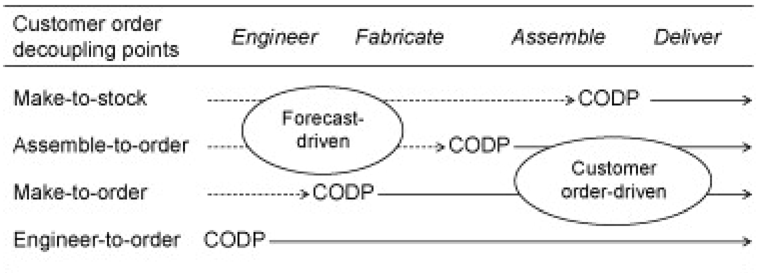

Figure 1: Different positions of the decoupling point, related to the manufacturing strategy and illustrating the boundary of forecast-driven and customer order-driven activities (Olhager, 2010).

A major aspect of food products is the perishability of the products, i.e. the limited shelf life (Kaipia et al., 2013). Van Donk (2001) states that the decoupling point is the most downstream location in the supply chain where stock is held. So, an MTS strategy in the food industry is not possible by default, concerning the perishability. To locate the decoupling point optimally, characteristics of industries must be considered.

2.2 Characteristics food industry

Characteristics of a certain industry can be important determinants of strategic decisions within the supply chain. The choice of supply chain strategy depends on the supply chain design, marketing-, production-, and organization specific activities (Towill & Christopher, 2002). With this given, the industry-specific characteristics of the food industry are important to consider while making supply chain decisions.

Within the food processing industry, two types of companies can be distinguished according to Van Donk (2001): companies that process raw materials and produce intermediate products, and companies that process intermediate products into consumer products. This is a rough distinction; some organizations process consumer products directly from raw materials. Since the food industry is a broader term then the food processing industry, it is argued here that another type of company can be included, namely, producers of the raw materials, e.g. the farmers. The decoupling point can be located at the stock of one of these types of companies.

According to Van Donk (2001), characteristics of this industry can be divided into plant characteristics, product characteristics and production characteristics. Note that only a limited number of these characteristics will be relevant in most cases in the food processing industry (Van Donk, 2001).

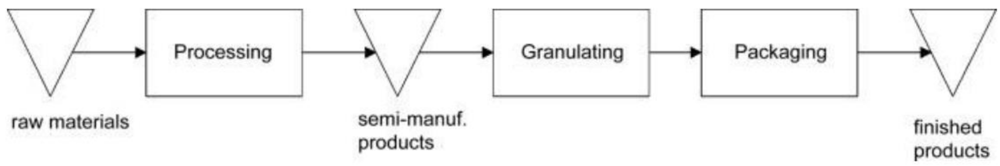

Figure 2: an example of a production process in the food industry. The triangles represent possible locations of the decoupling point. Source: Van Donk (2000)

With respect to plant characteristics, it is argued that the food industry has long set-up times between producing different product types, and that the capacity is single-purpose and expensive. This is coupled with a small product variety and high volumes in the industry (Van Donk, 2001). To illustrate this, with respect to the set-up times, it will take a long time for a producer of carrots to switch to producing milk from cows. The machines used to sow, and harvest carrots can only be used for growing carrots and are capital intensive. Additional to this, producing the raw materials generally takes a long time, i.e. the supply lag is long in agricultural production (Drabik & Peerlings, 2016).

Concerning the product characteristics, the quality, supply and price of the raw material varies in the processing industry due to unstable yield of farmers. This effect can result in price and volume differences further in the supply chain at the customers. Another aspect of the food industry is the perishability of the raw material, the semi-manufactured products and the end products (Van Donk, 2001). This aspect is of great impact on the supply chain strategy, since food products cannot be kept in stock for a long time (Kaipia et al., 2013).

About the production process of the raw materials, the processes have a variable yield and production and processing time (Van Donk, 2001). This variability needs to be taken into account while developing a strategy in the food industry. Also, the process of packaging consumer goods can be labour-intensive and different recipes for a product are available due to the uncertainty in price, quality and supply of the raw materials.

So, the perishability of products, long set-up times, variability in yield, supply, quality and price are important aspect in the food industry.

2.3 Identifying influencing factors

From the literature, several categories of factors that influence the location of the decoupling point can be derived. The categories that are mentioned multiple times in the literature are market-related factors (Olhager, 2003; Van Donk, 2001). Other types of characteristics mentioned are product-related (Olhager, 2003; Yang & Wang, 2014), process-related (Van Donk, 2001) and production-related (Olhager, 2003). This categorization shows the strategic character of the decoupling point, since the supply chain strategy is integrated with the marketing strategy, customers' needs and the product strategy (Ambe, 2012). Nevertheless, the factors influencing the decoupling point are here summarized and explained by a categorization based on the type of influence, since this paper aims to perform an analysis of the conjointly influencing factors.

Constant influencing factors

This category of factors has a constant influence on the location of the decoupling point, because organizations generally prefer a certain outcome of the factor. To illustrate its definition, delivery time is used as an example. Every organization wants their delivery time to be short. It is not logical to argue that, looking exclusively at the delivery time, the time it takes to get the product to the consumer should be longer. So, a short delivery time is a generally accepted preference of organizations. This creates a constant influence of this factor on the decoupling point in a downstream direction. This category consists of only two factors; delivery time and delivery reliability.

Delivery reliability is a feature that describes how certain the customers are of product delivery. If the market dictates that the delivery reliability needs to increase, it has a downstream effect on the decoupling point (Van Donk, 2001). With a decoupling point located downstream in the supply chain, the supply chain will be forced towards an MTS strategy (Olhager, 2010). To illustrate more clearly, a company will be more reliable to deliver products if the products are already made and in stock, then when the company still have to make the products with an MTO strategy. Because no organization will deliberately lower their delivery reliability, the influence of this factor will always be downstream. In the food industry, the delivery reliability is required to be high (Van Donk, 2001).

Delivery time indicates how long it takes for the delivery to arrive at the customer. If this time is short, it forces the decoupling point downstream (Van Donk, 2001), since a short delivery time cannot be possible with a large part of the supply chain operating on customer order-driven activities. Short delivery times are only possible if a large segment of the supply chain works with forecast-driven activities i.e. a downstream located decoupling point. Looking exclusively at the factor delivery time, this factor will always force the decoupling point downstream, since it is assumed that companies will never deliberately lengthen the delivery time.

Variable influencing factors

This category consists of factors of which the direction of their force on the decoupling point is situation specific. To illustrate this clearly, demand volatility is used as an example. Demand volatility of a product is assumed not to be an aspect of the market that can be influenced by a single organization and there is no generally preferred demand volatility by organizations. So, the influence on the decoupling point by this element is situation specific, since a high or low demand volatility is a given and thus influences the decoupling point upstream or downstream respectively.

Product demand volatility is the degree of how changeable the demand for a product is in the market (Olhager, 2003). It indicates to what extent it is possible or reasonable to make products to order or to stock. Low volatility means that the supply chain can suffice easily with forecast-driven activities, because the demand is close to constant, and constant demand is easily to forecast. A high demand volatility can best be handled with order-driven activities. So, a low volatility has a downstream effect on the decoupling point, and a high volatility in the market forces the decoupling point upstream. In the food industry, the demand is described as unpredictable (Kaipia et al., 2013; Van Donk, 2001). Van Donk (2001) describes how the relation between the unpredictability of demand and the short delivery time requirements could be handled. He states that retailers could require extremely short delivery times from their suppliers, such that the retailers shift the uncertainty in demand to their suppliers.

Product range and customization requirements is an aspect of the market that indicates what size of the product range or how many customization opportunities the market prefers. A wide set of customized products is impossible to produce to stock, since the amount of inventory would be enormous. Thus, when more customization or a broader product range is needed in a market, the decoupling point is pushed upstream. (Olhager, 2003)

Customer order frequency indicates how often customers place an order. A high customer order frequency leads to repetitive demand, which makes accurate forecasting of demand possible. So, if the customers in the market tend to demand products with a high frequency, the decoupling point is forced downstream. If the frequency is low, forecasting is difficult, and the decoupling point is forced upstream.

Seasonal demand can be seen as an extreme example of demand volatility, but with relatively predictable periods of high demand and low demand. This characteristic can cause switches in manufacturing strategy. Seasonality indicates that there is a peak demand in a certain period of the year. To produce with an MTO strategy during the entire year can be uneconomical, since it can be difficult to satisfy the entire peak demand. So, production needs to be levelled slightly by producing products to stock in anticipation of the peak demand. Thus, during the year, a shift in the location of the decoupling point takes place. During the season, the decoupling point will shift upstream in such a way that an MTO or an ATO strategy can be pursued, but some products are still in stock to satisfy the peak demand (Olhager, 2003). The choice between MTO and ATO depends on the product and the situation. Within the food industry, some products have seasonal demand because the raw materials are only harvested during a particular season.

A ***product life cycle*** is the time between the moment that the product is introduced on the market and the moment that the product is not sold anymore on the market. This product life cycle has four stages: introduction, growth, maturity and decline (Fawcett et al., 2014, p. 226). The total length of this cycle affects the decoupling point. A short product life cycle is a market characteristic that has a downstream influence on the decoupling point (Yang & Wang, 2014). The consumer's ever-changing wishes concerning food products (Van Donk, 2001) causes the product life cycle to also be applicable in the food industry. Nevertheless, the product life cycle of food products is in the literature not described as far as my knowledge reaches, so, this factor is assumed not to have influence on the decoupling point in the food industry.

When a producer manufactures products with a ***modular product design***, the decoupling point is forced towards the point in the supply chain where an ATO strategy fits (Olhager, 2003). A modular product design is a design in which replaceable parts can be assembled together with the possibility to create customized products. Upstream operations are made to stock and downstream operations create customer-specific products. A relatively short delivery lead time is possible with this design. In a food chain, this design is assumed to be possible, e.g. providing customized mixes of ingredients of specific quantities. If this product design is not used in a supply chain, this factor is not considered, since it will not have any impact in that case.

The ***customization opportunities*** and ***product range offered*** by the producer, indicates how many products or varieties are offered. A higher degree of customization, or a larger product range, has an upstream effect on the decoupling point in the supply chain (Yang & Wang, 2014). With a large amount of customization and product opportunities, an MTO strategy must be followed, with which an upstream location of the decoupling point coheres, i.e. an upstream located decoupling point is a requirement to offer many customization opportunities (Olhager, 2003). This factor is strategically relevant, since it determines how many segments are served and is thus part of the marketing strategy (Ambe, 2012; Kotler & Keller, p. 231).

The ***deterioration rate*** of products can be an important factor when locating the decoupling point in industries where this element plays a role, especially in the food industry. Kaipia et al. (2013) state that the perishability of food products limits the opportunity of using stock as a buffer in the supply chain. In line with this, Yang and Wang (2014) found that the position of the decoupling point shifts upstream when the deterioration rate increases, i.e. when products deteriorate in a very short time, the decoupling point is forced upstream in the supply chain. With fast deteriorating products, holding stock for a small period is already challenging, so an upstream located decoupling point is required for fast deteriorating products. Van Donk (2001) described the degree of deterioration as the risk of obsolescence, which has a similar effect; the risk increases when the decoupling point shifts downstream. The terms deterioration, perishability and risk of obsolescence are used interchangeably in this thesis.

With respect to ***controllability***, some industries use processes where the outcome of the process cannot be controlled. This can be the case when an industry uses raw, natural materials. The variability in quality of the natural materials can have variability in quality of the end product consequently. When the controllability is low, this factor has a downstream influence on the decoupling point, since storing a product after the uncontrolled process safeguards undisturbed delivery (Van Donk, 2001). In other words, after the uncontrolled process, the quality is set and can be controlled, and the delivery of the quality can be guaranteed (Van Donk, 2001). In the food industry, the controllability is low at the production of raw materials, since agricultural production is dependent on many uncontrollable factors such as the weather (Drabik & Peerlings, 2017). Since this is in general the uncontrollable process in the food industry, as described in section 2.2, and this process is located at the first supplier in the food chain, this process does not influence the decoupling point in the food industry.

Factors that restrict or open possibilities for locations of the decoupling point

The third category consists of factors that restrict or open possible locations for the decoupling point. These factors do not force the location of the decoupling point in a direction, they set or lift restrictions on possible locations of the decoupling point.

The ***delivery lead time requirements*** indicate a benchmark set by the market of how long it can take for a product to get to the customer. If this requirement is not strict i.e. the delivery lead time can be long, it opens possibilities for the supply chain to shift the decoupling point upstream (Olhager, 2003). In the food industry, the delivery lead time requirements are very strict, i.e. short delivery times (Van Donk, 2001). This is due to the high rate of perishability, as illustrated by Kaipia et al. (2013).

A planning point is a manufacturing resource, such as a work centre, that can be viewed as a production entity. The ***number of planning points*** within an organization or supply chain restricts the amount of possibilities of where to locate the decoupling point. When an organization or supply chain has relatively more planning points, there is a large variety in possibilities for the location of the decoupling point. So, this factor opens possibilities both upstream and downstream (Olhager, 2003).

Production lead time is the time it takes to produce the product. This factor can be split into two elements; the production time of a product (Olhager, 2003), and the cleaning and set-up times in the production process (Van Donk, 2001). When the production lead time is long, the literature argues that it would have a downstream effect on the decoupling point (Van Donk, 2001), since a supply chain with long production lead time is required to work with forecast-driven activities. Olhager (2003) argues that the production lead time restricts the possibilities for locations of the decoupling point, since the production lead time is a major element of the delivery time. So, one could argue that when the production lead times are reduced, more locations upstream are opened for the decoupling point. Within the food industry, the set-up and cleaning times of processing steps are generally short (Van Donk, 2001).

Some resources within a production process have ***set-up times*** that are ***sequence dependent***. These set-up times are determined by both the job that the machine is set up for and the previous job the machine is currently set up for. These resources are best positioned upstream of the decoupling point, because they can easily turn into bottlenecks without proper sequencing (Olhager, 2003). The process of proper sequencing is very difficult for resources in downstream operations, which is why these particular resources are best positioned upstream of the decoupling point (Olhager, 2003). Summarizing, when many resources that require sequence dependent set-up times are present in the supply chain, this forces the decoupling point downstream. If little resources require these set-up times, it opens possibilities upstream in the supply chain. In the literature, as far as my knowledge reaches, nothing can be found about the presence of sequence dependent set-up times specifically in the food industry. Therefore, this factor is assumed not to be of influence in general in the food industry.

Flexibility of the production process represents how flexible the organization is considering creating more volume of products or more variety of products. This factor is indicated by the set-up times of the production process (Olhager, 2003). Thus, short set-up times of the production process create more flexibility, and short set-up times are argued to be a prerequisite for an MTO strategy. A flexible production process opens the possibility to locate the decoupling point more upstream (Olhager, 2003). This factor is interrelated to customization opportunities and product range offered, since a flexible production process is required when a producer offers a wide range of customized products.

Factors with an unclear influence

Factors in the last category have an unclear influence on the location of the decoupling point. These factors are mentioned in the literature, but a clear effect has not been established. The effect of the elements bottlenecks, value-added, product structure, customer order size, and company's core competencies are ambiguous in such a way that effects on the decoupling point cannot be distinguished in this paper.

A clear effect of the position of a ***bottleneck*** in a production process is not distinguishable. Olhager (2003) argues that the bottleneck would best be located upstream from the decoupling point from a resource-optimization perspective. On the contrary, he mentions that it would be best having the bottleneck positioned downstream of the decoupling point considering the just-in-time principle. The latter means that the bottleneck would only have to work on products for which the firm has customer orders. The decoupling point can also be located at the bottleneck in the supply chain, which can be advantageous when the resource involved in the bottleneck is expensive and performs significant activities in the production process of the product (Olhager, 2003). The theoretical effect on the decoupling point of bottlenecks is hard to determine and extremely situation specific, and is therefore unclear.

A high ***value added*** in the production process can have an upstream effect on the decoupling point, as Van Donk (2001) argues, since it can be financially beneficial to store low-value products instead of higher valued end products. But, this is only the case in very specific situations. Van Donk (2001) also states that the effect of value-added on the decoupling point is generally unclear.

Product structure indicates the complexity of the product. A deep structure relates to long cumulative production lead times. A clear effect on the location of the decoupling point is difficult to state, since a producer of a product with a complex product structure must deal with several supply chains. All the possible elements of the product structure and paths of these different elements must be analysed in terms of lead times to determine where inventories of the elements of the products need to be kept. Given these points, the effect of the product structure on the decoupling point is unclear. (Olhager, 2003)

Customer order size is an indication of the volume of the customer orders. This factor is described in the literature, but its effect is unclear. This factor is related to customer order frequency, described below.

Ambe (2012) argues that when determining a supply chain strategy, the element ***core competencies*** of the organization and of supply chain members should be considered. Since locating the decoupling point is a vital aspect of determining the supply chain strategy (Nel & Badenhorst-Weiss, 2010), it can be argued to include the core competencies of the organization should also be considered when locating the decoupling point. The effect of this factor is in its nature company- and supply chain specific, which causes the result of this aspect on the decoupling point to be unclear in general.

The above presentation of the categories, the individual factors, and their effects is summarized in table 1 for overview purposes. Consider that these are potentially influencing factors, in other words, these factors do not necessarily influence the location of the decoupling point (Olhager, 2003). The factors that are not in bold are argued not to be of significance in the food industry.

Factor	**Category**	**Located upstream when**	**Located downstream when**
Delivery reliability	Constant influencing factors		High
Delivery time	Constant influencing factors		Short
Product demand volatility	Variable influencing factors	High	Low
Product range & customization requirements	Variable influencing factors	Large number of products/high requirements	Small number of product/low requirements
Customer order frequency	Variable influencing factors	Low	High
Seasonal demand	Variable influencing factors	During the season	Before the season
Product life cycle	Variable influencing factors	Long	Short
Modular product design	Variable influencing factors	Towards an ATO strategy	Towards an ATO strategy
Product range & customization opportunities offered	Variable influencing factors	Large number	Small number
Deterioration	Variable influencing factors	Fast	Slow

Controllability	Variable influencing factors	High	Low
Delivery lead time requirements	Factors that restrict or open possibilities for locations of the decoupling point	When flexible, opens possibilities upstream	When strict, restricts possible locations to downstream locations
Number of planning points	Factors that restrict or open possibilities for locations of the decoupling point	When number increases, it opens more possibilities	When number increases, it opens more possibilities
Production lead time	Factors that restrict or open possibilities for locations of the decoupling point	Opens possibilities upstream when reduced	
Flexibility production process	Factors that restrict or open possibilities for locations of the decoupling point	High opens possible locations upstream	Low
Sequence dependent set-up times	Factors that restrict or open possibilities for locations of the decoupling point	Opens new possibilities for upstream locations when number of resources that need sequence dependent set-up times decrease.	A lot of resources that require sequence dependent set-up times are present.
Value Added	Factors with an unclear influence	Unclear	Unclear
Order size	Factors with an unclear influence	Unclear	Unclear
Product structure	Factors with an unclear influence	Unclear	Unclear
Bottlenecks	Factors with an unclear influence	Unclear	Unclear
Company's core competencies	Factors with an unclear influence	Unclear	Unclear

Table 1: Summation of factors and effects with respect to the decoupling point. The factors that are not in bold are argued not to be of significance in the food industry.

2.4 Interrelations individual factors

Above, many different factors are described that potentially influence the location of the decoupling point. Some of these factors are interrelated to some extent. Below, some of the relevant interrelations are explained. Figure 3 illustrates how factors, according to the categorization of Olhager (2003), can be interrelated.

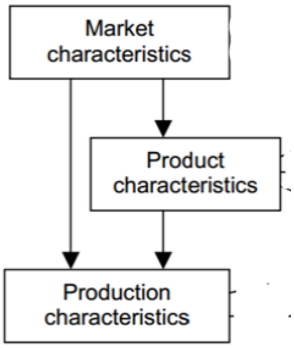

Figure 3: interrelations of categories of characteristics. Source: adjusted from Olhager (2003)

Product range & customization requirements is a market characteristic that is related to the product characteristic ***product range & customization opportunities offered*** by a producer. Fabricators of food products respond to the market requirements for number of different products, i.e. in terms of how many different segments the market should be and served (Kotler & Keller, p. 231), by making the strategic decision to offer those opportunities. Here, the interrelation between to characteristic categories illustrated in figure 3 is represented clearly; a market characteristic influences a product characteristic.

Customer order size and customer order frequency are related in the way that when the order sizes are large, customers make a long-term delivery contract with a large order size, and let it be delivered in smaller batches with a high frequency (Olhager, 2003). Due to the deterioration rate of food products, this delivery construction is very suitable for food products. So, a link can be made with this delivery construction and ***deterioration rate*** of products. If products are characterized by a high rate of deterioration, e.g. fresh vegetables, a large order cannot be delivered all at once, since a part of the products will be deteriorated by the time they are sold. So, if the order size is large, the customer order frequency must be high with fast deteriorating products.

The next relation discussed is between ***product range & customization opportunities offered by the producer,*** a product characteristic, ***and flexibility of the production process,*** a production characteristic. Flexibility of the production process is measured in terms of set-up times, which can be long or short. Short set-up times are indicating a flexible production process. To be able to offer a wide range of customized products, a flexible production process is required (Olhager, 2003). So, the force corresponding with these factors work upstream, since a flexible production process opens locations for the decoupling point upstream and a high number of products or customization opportunities offered forces the decoupling point upstream. This interrelation is illustrated in figure 3; the product characteristic requires a certain outcome of a production characteristic.

Production lead time is a major element in the ***delivery time*** (Olhager, 2003). This relationship can be described most clearly in a situation where a supply chain pursues an MTO strategy. With this strategy, a customer order arrives, and the producer starts making the product. When the production lead time is long, the delivery time will also be long. When the production time is reduced, the delivery time is also reduced with an MTO strategy. This means, that an MTO strategy is not possible when the delivery time requirements are very strict, and the production lead time is very long.

2.5 Weighing the factors

Many factors can potentially influence the location of the decoupling point, but not every factor will influence the location of the decoupling point in every situation (Olhager, 2003). Some factors are most likely more important than others, because of their strategic value in a specific situation. To illustrate this, in the food industry is deterioration of food products an important factor to consider, but this factor does hardly have any influence in the electronics industry.

A tool to identify importance of factors, are market qualifiers and market winners. Market qualifiers are the basic criteria that permit a firm's product to be considered as a candidate for purchase by customers, while market winners are the criteria that win an order (Towill & Christopher, 2002). So, when a factor that influences the decoupling point is a market winner or influences a market winner, it is important to attach a high weight to this factor, since a market winner should be enhanced. The same reasoning can be applied on market qualifiers.

These concepts relate to different supply chains strategy, as the article illustrates in table 2. Additional to the information given in table 2, the market winner for a leagile supply chain is generally the factor lead time (Reiner & Trcka, 2004). Since the decoupling point is a vital element of the supply chain strategy, these concepts also relate to the location of the decoupling point.

	Market Qualifiers	**Market Winners**
Agile strategy	Quality Costs Lead time	Service Level
Lean strategy	Quality Lead time Service level	Costs

Table 2: Market qualifiers and winners in agile supply chains and lean supply chains. Source: Towill & Christopher, (2002)

Reiner and Trcka described performance measures that are possible market qualifiers or market winners, such as quality, flexibility, costs and supply chain indicators. The latter can be divided into direct and indirect indicators. Direct indicators can be seen by supply chain partners, such as lead time and service level. Indirect supply chain indicators are not visible for outsiders, but are relevant for supply chain partners, such as work in process, cycle time variability, safety capacity or inventory. Another aspect that can be a market winner is product variety offered, i.e. product range (Bommer, O'Neil & Treat, 2001).

To summarize, in this section, the strategic concepts market winners and market qualifiers are described as a tool for attaching weights to factors that influence the location of the decoupling point, and possible aspects that can be market winners or market qualifiers are presented.

3. The Model

The following section describes and explains a model that illustrates how factors conjointly influence the location of the decoupling point in a food chain. This model is based on the theoretical framework.

3.1 Model description

In the above framework, it is argued that most factors have a variable force on the decoupling point. These variable factors can also be described as factors that have a situation dependent influence on the location of the decoupling point. Besides the variable factors, it is argued above that the two factors identified as constant influencing factors, both influence the decoupling point downstream. The effect of the category of factors that opens and restricts possibilities for locations of the decoupling point is also dependent on the situation. Factors with an unclear influence on the decoupling point are impossible to include in an analysis, so the factors customer order size, value-added, bottlenecks, product structure and company's core competencies are left out of the model. Also, as mentioned in 2.3, the factors product life cycle and sequence dependent set-up times are left out of further analyses due to the argued insignificance in the food industry. In short, the majority of the influences on the decoupling point differ per situation, thus, the effects of these factors are situation specific. So, to do an analysis of the conjointly influencing factors, specific situations, i.e. cases are required. Moreover, Reiner & Trcka (2004) argued that a supply chain must be analysed very product- and company specific, which is also an argument to analyse situations when locating the decoupling point.

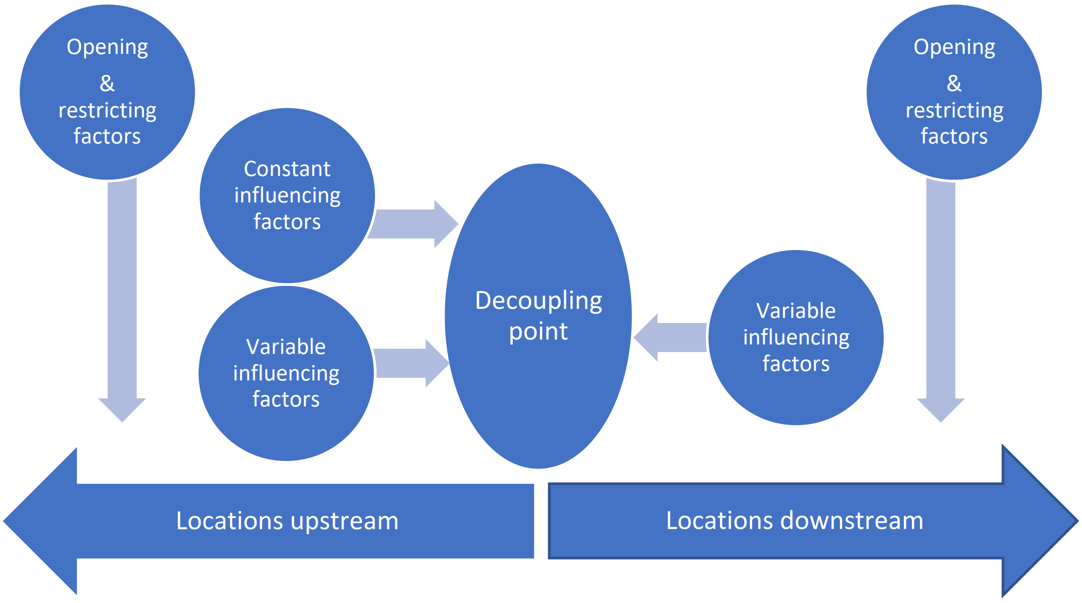

Figure 4: graphical illustration of the model. The length of the arrows does not imply strength of the forces.

The basic idea of this model, is that factors influence the location of the decoupling point. In this model, the decoupling point can slide upstream or downstream, dependent on the direction of the force and how strong the forces of the factors are. As described, the direction of the force of the variable influencing factors is situation specific, so this category works both upstream and downstream in the model. The opening and restricting factors work situation specific on the possible locations of the decoupling point, not on the decoupling point itself. So, the arrows from the opening & restricting factors point towards the locations upstream and locations downstream. Finally, the constant influencing factors force the decoupling point downstream. The model is illustrated graphically in figure 4.

3.2 Application of the model

To apply this model, information about the situation of the supply chain must be gathered. More specifically, information about the categories of factors mentioned in the model is required. Note that not every factor mentioned in the framework will influence the decoupling point in a situation (Olhager, 2003). When the variable influencing factors are identified, the direction of their force needs to be established. Concerning the category of opening and restricting factors, these need to be analysed in terms of which locations are available for the decoupling point. The constant influencing factors will be considered last, since these factors will always influence the decoupling point downstream.

Next, the interrelations discussed above must be considered to see if the factors involved in these interrelations are aligned with each other. This prevents clashes between factors, e.g. production lead time and delivery time. An example of a clash would be the following; when short delivery lead times are required by the market, and the production lead time is very long, the decoupling point should not be set at a location with which an MTO strategy is corresponding, since the delivery lead time cannot be short in this situation.

Some of the factors are more relevant than others, i.e. the strength of the influence on the decoupling point will differ. To identify this difference in strength, weights must be attached to the influencing factors with help of identifying market winners and market qualifiers. Finally, the location of the decoupling point needs to be set.

Since this model is applied in the food industry in this thesis, the model can be specified to the food industry. The factor deterioration rate of food products is of great relevance in the food industry and must be considered carefully when locating the decoupling point, since deteriorated products cannot be sold to customers. Also, the factor controllability is in the food industry low, but the uncontrollable process generally takes place at the very beginning of the supply chain. Therefore, this factor only restricts location of the decoupling point before growing the raw material, i.e. the stock of seeds, bulbs etc. Other uncontrollable processes may be used in some situations in the food industry, which must be recognized in that case, but the uncontrollable process of growing the raw materials is always present in a food chain.

Summarizing, setting the location of the decoupling point must be done situation specific. To do that, information needs to be gathered concerning the factors, interrelations must be considered and lastly, weights must be attached to relevant factors.

4. Analysis mass market & niche market

Different market types are suitable to illustrate the difference in locating the decoupling point, since market characteristics influence the product and production characteristics. So, because of the different market type, some product factors and production factors will also be different, as illustrated in figure 3. This causes a large difference in factors that influence the location of the decoupling point, thus, these scenarios illustrate a clear difference in the process and result when locating the decoupling point. Also, the market types used are common concepts and therefore, these concepts are imaginable and tangible instruments to illustrate applications of the model clearly.

For this analysis, a distinction between two types of markets is made. Here, a producer that serves a mass market in the food industry, and a producer that serves multiple niche markets in the food industry will be considered. The characteristics of these two markets and characteristics of the food industry are described and matched with the analysis of the influencing factors and analysed, which will result in setting the location of the decoupling point.

4.1 Market description

A mass market is a large group of customers where different segments are not distinguished. The entire market is targeted with one offer (Kotler & Keller, 2012, p. 233), which is also the case in this scenario. Customers in mass markets have roughly the same preferences (Kotler & Keller, 2012, p. 233). In the food industry, a supply chain that serves a mass market could be a product that is generic in its nature and is hard to customize, e.g. broccoli. Broccoli is not used as an ingredient in many different products.

A niche is a smaller, more narrowly defined customer group seeking a distinctive mix of benefits within a segment (Kotler & Keller, 2012, p. 234). According to Kotler & Keller (2012), a niche market has the following characteristics:

- Customers have a distinct set of needs
- They will pay a premium price to the firm that best satisfies them
- The niche is small but has size, profit and growth potential

- It is unlikely for the niche to attract competitors
- The niche gains certain economies through specialization

So, niche markets in the food industry would appear within product categories where many different variations can be produced, e.g. desserts.

In this scenario, multiple niches are served by a producer, all within the same product category. To display the distinction most clearly, the number of niches served by the producer needs to be high and is quantified to fifty niches in this scenario. Each niche is served by one product. The niches are not all the same size, this would be unrealistic because of the size and growth potential of niche markets. The producer that serves the mass market will be referred to as producer M, and the niches serving producer will be referred to as producer N from now on.

4.2 Chain description

In this scenario, we consider the following, simple supply chain. In this chain, three production or processing steps take place and stock is held at four locations.

Stock of seeds/bulbs of raw material → producing raw materials → **stock of raw materials** → processing → **Stock of semi-manufactured products** → processing → **Stock of finished products**

In this chain, the first processing step takes more time than the second processing step. The second processing step is assumed to be short and packaging is included in this step. Concerning producer N, the location of the decoupling point can be set on different locations per product. The details of the chain are further elaborated in section 4.3.

4.3 Analysis of factors

In this section, the influencing factors are identified, and the direction of their forces are explained in both market scenarios. The forces of some factors will be similar for both producer M and N, and some factors will be influence the decoupling point differently in both scenarios. This is done per category for overview, starting with the variable influencing factors, then the factors that open and restrict possible locations, and ending with the constant influencing factors.

Variable influencing factors

The demand volatility of the total market is assumed to be the same for the total demand in both markets. However, the total demand for producer N consists of demand of fifty products. It is unlikely to assume that fifty products all have the same volatility, so, here it is assumed that the demand volatility per product for N differs strongly. Demand is in general in the food industry unpredictable, which causes an upstream effect (Van Donk, 2001) in both markets in this scenario.

As Yang & Wang (2014) state, deterioration of products is a relevant factor in controlling the decoupling point, and the deterioration rate is high when it comes to the food industry (Kaipia et al., 2013). But, the deterioration rate of food products can differ significantly, e.g. when a product is dried and packed, e.g. crackers, it can be kept in stock longer than for instance fresh fruits and vegetables. This can affect the location of the decoupling point. In this situation, the deterioration rates are high and equal for M and N. To make the deterioration rate tangible, the shelf life of finished products is determined to be 7 to 14 days. So, both products can be kept for the same, short amount of time in stock, before the products will become deteriorated.

The product range offered by producer N are logically much higher than of M, since N serves fifty niches and M serves one mass market. This is due to the higher product range requirements of the niche markets that N serves. So, the decoupling point of N is forced upstream and the decoupling point of M is forced downstream due to this factor.

The controllability of processes is generally low in the food industry and, as described in 3.2, this is due to the production of raw materials. This factor forces the decoupling point away from the location of the stock of bulbs or seeds etc., since the uncontrollable process is preferred to be upstream of the decoupling point. It is assumed that in both production processes, no other uncontrollable processes exist. So, the controllability for both producer M and N is equal and has a downstream force.

The customer order frequency will also not be influenced by the type of market. Here, it is assumed that the frequency of delivering products is equally high in both market types, due to the equal deterioration rate. So, the decoupling point is forced downstream, since the high frequency makes forecasting easier.

The products that M and N produce do not have a seasonal demand, they are consumed constantly throughout the year. Neither products have a modular product design in this scenario. Thus, these factors do not influence the decoupling point.

Opening and restricting factors

The number of planning points is the number of production entities where the supply chain plans its production. These planning points are possible locations for the decoupling point. From the chain description can be derived that there are four planning points, and thus four possible locations for the decoupling point. Note that for every product, four different locations of the decoupling point exist, i.e. the decoupling point can be set on a different location per product. For N, this means that for all fifty products, the location of the decoupling point must be set, and for M for only one product.

The factor production lead time must be split into two elements here: the lead time of the production processes, and the set-up and cleaning times. Considering the production processes, the production of raw materials will take a long time, as mentioned in 2.2, e.g. production of chickens takes six to nine weeks (Drabik & Peerlings, 2016), some crops or animals take even longer. Processing the raw materials into semi-manufactured products is assumed to take three days. Processing the semi-manufactured products into finished products takes two hours in this food chain. These lead times are the same for producer M and N. This factor restricts the stock of seeds/bulbs of the raw material from being a possible location for the decoupling point, since producing the raw materials simply takes too long. The number of set-ups will be higher for N, since N must switch between the processing of ingredients due to the high number of products produced. For simplicity, it is argued that the set-up and cleaning times for are short and equal for both producer M and producer N. This element of the production lead time does not restrict any possible location for the decoupling point.

In mass markets, the delivery lead time requirements are very strict. When a customer arrives, and M does not have the product in stock and the customer must wait, the customer will go to competitors who have the product in stock. This restricts the three upstream locations for the decoupling point for M, the stock of seeds/bulbs of raw materials, the stock of raw materials and the stock of finished products, because when located at either one of these points, the delivery simply takes too long. Customers in a niche market have a distinct set of needs and they are prepared to pay a high price for the niche product that satisfies their needs best. It can be argued that, with this information given, customers in niche markets have other delivery lead time requirements than customers in a mass market. Customers in niche markets are prepared to sacrifice product's aspects such as a low price and a short delivery time to get their niche product. So, based on this reasoning, the delivery lead time requirements are more flexible for producer N, but, as Van Donk (2001) argues, these requirements are generally strict in the food industry. Thus, this factor restricts the following locations for N: the stock of seeds/bulbs of raw materials and the stock of raw materials.

The flexibility of production processes is a requirement for producers that offer a large product range, i.e. for producer N. The flexibility of the production process is indicated by set-up times of the processes. The set-up times of growing the raw materials is very long (Van Donk, 2001), and for the process steps, the set-up times are considered short. So, this factor only restricts the stock of seeds/bulbs of the raw materials, and the flexibility is sufficient for the product range offered by N. For M, the flexibility is not relevant, since M only produces one product.

Constant influencing factors

As mentioned, delivery time and delivery reliability always force the decoupling point downstream. Thus, this will also be the case in this scenario.

In table 3, the effects of the factors on M and N are summarized for overview.

Factor	Effect M	Effect N
Demand volatility	Upstream	Generally upstream and differs per product
Deterioration rate	Upstream	Upstream
Product range/customization opportunities offered	Downstream	Upstream
Product range/customization requirements	Downstream	Upstream
Controllability	Downstream	Downstream
Customer order frequency	Downstream	Downstream
Seasonal demand	Does not apply	Does not apply
Modular product design	Does not apply	Does not apply
Number of planning points	Four possible locations	Four possible locations per product
Production lead time	Restricts the location 'stock of seeds/bulbs of raw materials'	Restricts the location 'stock of seeds/bulbs of raw materials'
Delivery lead time requirements	Restricts the locations 'stock of seeds/bulbs of raw materials' and 'stock of raw materials' and 'stock of finished products	Restricts the locations 'stock of seeds/bulbs of raw materials' and 'stock of raw materials'
Flexibility of the production process	Restricts the location 'stock of seeds/bulbs of raw materials'	Restricts the location 'stock of seeds/bulbs of raw materials'
Delivery reliability	Downstream	Downstream
Delivery time	Downstream	Downstream

Table 3: overview of the effects of factors on M and N

4.4 Interrelations

The product range/customization requirements and the product range/customization opportunities offered must be aligned for both producers. In this case, M serves market type that does not require a product range larger than one product, and N serves a market type that requires fifty products, i.e. these factors are aligned for producer M and N.

As described above, the flexibility of the production process is sufficient for the product range offered by producer N, so these factors are aligned. This interrelation is not of relevance for producer M.

Production lead time is also here a major element of the delivery time. The production lead times of the production processes is limited to several hours, and this time must be considered when analysing the delivery time and the delivery lead time requirements.

The customer order frequency and deterioration rate are also not causing problems in this case. The deterioration rate is high, and the customer order frequency is also high.

4.5 Weighing the factors

Different weights must be attached to the factors in these different market types, because of the different strategies required to be competitive on these different types of markets. In other words, niche markets and mass markets have different market qualifiers and market winners.

It can be derived from the niche market characteristics that meeting the specific needs of the customers is one of the important aspects in a niche market. This is the reason why meeting the needs of the customers through delivering superior quality is a market winner for N. Quality would be a market qualifier for M. The quality of the product of M must be similar to or better than the quality that competitors offer, for consumers to consider M's product a candidate for purchasing. The aspect of quality includes that the food products must not be deteriorated.

A market winner in a mass market would be costs, since producer M does have competitors that will try to conquer the market with a similar offer. When the offer of M is more expensive than the offer of competitors, customers will buy a similar product from the competitor. Costs are less important for producer N, since niche customers are willing to pay a premium price. Nevertheless, the costs should not be excessively high.

A short delivery lead time would be a market qualifier for M. Since the competitors offer roughly the same product, the customers are not willing to wait for a long time. When producer M's product is not available, the customer will choose for another offer of a competitor, and the offer of producer M is not even considered an option. For N, the delivery lead time requirements are argued to be more flexible then the deliver lead time requirements for M.

Since quality is a market winner in a niche market, the product range offered is an important factor that can be assigned a high weight. The element that products should not be deteriorated, is also included in the aspect quality and thus, deterioration rate of the food products should be assigned a high weight. The focus on costs in the mass market indicates a lean supply chain strategy (Towill & Christopher, 2002), which indicates a downstream located decoupling point. Also, the delivery time requirements are quite short for producer M, since a short delivery time is a market qualifier. An overview of the market winners and market qualifiers for M and N and the cohering factors is given in table 4.

	Winners/Qualifiers	Factors
Market Winners M	Low costs	Indicates a lean supply chain strategy, which coheres with a downstream located decoupling point
Market Qualifiers M	Quality, short delivery time	Deterioration rate
Market Winners N	High quality	Product range offered, deterioration rate
Market Qualifiers N	Not excessively high costs, reasonable delivery time	Delivery time

Table 4: overview of market winners and market qualifiers for producer M and producer N

An aspect that can also be considered relevant in this situation is the demand volatility, but, this factor cannot be given a high weight based on the concepts market winners and market qualifiers. So, demand volatility is assigned a high weight in setting the decoupling point.

4.6 Setting the decoupling point

This section analyses the factors conjointly and locates the decoupling point per producer. First, we consider producer M. Looking at the summation of the factors in table 3, we notice that only two factors influence the decoupling point upstream in this situation. These two factors, deterioration rate and demand volatility are assigned a high weight. All the other variable influencing factors and constant influencing factors force the decoupling point downstream. Also, the opening and restricting factors restrict every location for the decoupling point, except the stock of finished products. The restricting factor with the most influence is the strict delivery time requirement in the market where M operates, since this factor is argued to be a market qualifier. Also, the argumentation that costs is a market winner for M, indicates that the supply chain of M must pursue lean strategy for the largest part of the chain. So, analysing the factors conjointly, the decoupling point in the supply chain of producer M must be located at the stock of finished products. This location coheres with a make-to-stock manufacturing strategy.

Considering producer N, we can see that more factors influence the decoupling point upstream. The most important difference compared with M, are the factors product range offered and product range requirements. These are argued to be factors that enhance market winners, so, these factors are assigned a high weight. Looking at the opening and restricting factors, we see that the locations 'stock of semi-manufactured products' and 'stock of finished products' are not restricted. So, the choice must be made for fifty products if the decoupling point must be located at the stock of finished products or at the stock of semi-manufactured products.

Since the effects upstream and downstream are balanced, a decision can be reached when considering the factor demand volatility. Demand volatility is a factor that is assumed to differ per product, but this factor is in general high in the food industry. So, within the fifty niches served by N, a few niches are assumed to be characterized by a low demand volatility, and can be produced made-to-stock, since forecasting is easier with a low demand volatility. Niches where the demand volatility is high, must be produced made-to-order, i.e. the decoupling point should be located at the stock of semi-manufactured products, since forecasting is difficult. Food waste would occur through deterioration if these products would be produced with a made-to-stock strategy. So, most products are produced according to an MTO strategy, and the decoupling point is located at the stock of semi-manufactured products.

To conclude, in niche markets in the food industry, more factors influence the location of the decoupling point upstream than in mass markets in the food industry. Since delivery lead time requirements are generally short in the food industry (Van Donk, 2001), and short delivery time is a market qualifier, these factors have great influence on the location of the decoupling point. The key difference between these markets are the product range differences, which lead to the variation in the location of the decoupling point.

5. Case study analysis

Here, the case that Van Donk (2001) analysed in his paper is critically investigated once more. This analysis shows the requirements for the application of the model in a practical situation. In this case, the location of the decoupling point is set with influencing factors as argumentation. A critical analysis is done by investigating what information, factors and interrelations are missing, how the factors are weighed, and if the decoupling points are set at the right location. Before the critical analysis, a short description of the case is given. A summary with background information of the case is given in the appendix.

5.1 Case description

The location of the decoupling point differs per group of products. For products that are ordered irregularly, but in larger amounts than the minimum batch size, the decoupling point is set at the stock of raw materials. For products with irregular demand and an order size smaller than the minimum batch size, the decoupling point is located at the stock of finished products. The semi-manufactured products with sufficiently large demands, are stored in silos. As a result, 75% of the finished products are produced to order. The reason to produce to stock for 25% of the products, is the very short delivery lead time required. Because of this manufacturing situation, these products have a high risk of becoming deteriorated.

Several factors are of influence in this case. The demand volatility is given much attention. Due to the irregular and aggregate demand, an upstream effect on the decoupling point is established. Also, the delivery time requirements are included in the case. For some products, these requirements are very strict, which restricts upstream located locations. For other products, the requirements are more flexible. The factor deterioration rate of the products is of relevance too. The limited shelf life of the products causes an upstream effect in this situation.

The number of products produced is 200. This is a large product range, which causes an upstream effect on the location of the decoupling point. Considering the interrelations, the production lead time is treated as a major element of the delivery lead time. The factor controllability is mentioned briefly in terms of the production process being reliable concerning quality and amounts of output. This factor does not have any influence in this case. Other factors are not mentioned to have an influence on the decoupling point.

5.2 Critical analysis

In this case, the factors customer order frequency, seasonal demand, and modular product design are not mentioned in the case. For simplicity, it is assumed that these factors do are not relevant. The factor flexibility of the production process is also not mentioned, but this can be a crucial factor because of the interrelation with product range and customization opportunities offered. A flexible production process is required for the large product range, especially if a large share of the product range is produced according a MTO strategy, but information about the flexibility is missing.

Delivery lead time requirements should also be investigated more thoroughly. It is mentioned in the case that these requirements differ between customers, e.g. some customers require less than the standard five days lead time, some require delivery within two weeks. This factor must be researched more to identify a potential pattern in the requirements, e.g. certain lead time requirements per product, or according to customer size. When a pattern exists and is identified, the restrictions by this factor can be determined per product, and the location of the decoupling point could be located more optimally.

The last factors that are not mentioned in the case, are the delivery reliability and the delivery time, which always influence the decoupling point downstream.

Considering interrelations, the link between product range opportunities offered and the flexibility of the production process is not described. Also, the connection between the factors product range offered and product range requirements is not made. This producer produces 200 products, of which five products cover 70% of the total demand. The producer should analyse thoroughly if producing all the other 195 different products is economically feasible for the company, i.e. if the product range offered matches with the product range requirements. Producing fewer products, will make problems concerning planning and stock simpler. The last interrelation that is not considered in this case, is the relation between customer order frequency and the deterioration rate.

Another missing aspect of the case study, is that weights attached to the factors are not clearly stated. Weights of some factors can be derived from the extent to which a factor is discussed the relevance of the argumentation in setting the decoupling point, but the weights are not argued and stated. This causes ambiguity in this situation. The concepts market winners and market qualifiers should be determined in the market where the company operates, and in the consumer market. Then, the company can decide what aspects are important for direct and indirect customers, and locate the decoupling point accordingly.

Given these points, categories of factors can be distinguished, based on the extent to which they are explained. Some factors are missing completely and are not even mentioned. It could be that some of these factors are not mentioned because it is not relevant in this situation, e.g. seasonal demand and modular product design. One factor is mentioned but not explained sufficiently, i.e. the importance is addressed, but not completely explained, which causes ambiguity concerning this factor. Finally, some factors are sufficiently explained, which means the situation in the case and the effect on the decoupling point of these factors is described clearly. This is summarized in table 5.

Missing	**Not sufficiently explained, i.e. information is missing**	**Sufficiently explained**
Customer order frequency	Delivery lead time requirements	Demand volatility
Seasonal demand		Product range & customization opportunities offered
Modular product design		Controllability
Flexibility production process		Deterioration rate
Product range requirements		Number of planning points (described in other terms)
Delivery reliability		Production lead time
Delivery time		

Table 5: Summary of the missing factors, the factors that are not sufficiently explained and the factors that are sufficiently explained in the case of Van Donk (2001)

Besides the factors, several interrelations are not investigated, and weights attached to factors are not stated or argued well. Since so much information is missing in this case, the locations of the decoupling point set by Van Donk (2001) cannot be criticized properly. With more information, the decoupling points would most likely not be located the same as described in the case. Thus, setting the decoupling point can most likely be done more optimally when obtaining more information.

6. Conclusion

The aim of this thesis is to discover how influencing factors conjointly determine the location of the decoupling point in the supply chain in the food industry. To achieve this, a model is developed (section 3.1, p. 15) where different categories of factors influence the location of the decoupling point and open or restrict locations of the decoupling point. The last steps in the model are considering the interrelations and attaching weights to the factors. With this information, the opposite and parallel forces are balanced, and the decoupling point is set. So, this model shows a method to analyse the influencing factors conjointly, and how this results in a location of the decoupling point.

The market analyses and the critical case study show the applicability of the model. Concerning the market analyses, these show that differences in factors result in different locations of the decoupling points. The critical case analysis shows that much information is required on the factors to analyse a situation with the model proposed. Information that is missing can result in a different location of the decoupling point.

The applications of this model also show that locating the decoupling point can be done systematically and structurally. Because of this clear structure, this method can be adopted by managers and applied in practice. So, this thesis provides more handles to supply chain decision makers to locate the decoupling point in the food industry.

Further research in this area should be aimed at applying the decoupling point theory with more case studies from the food industry, using the model proposed in this thesis. If more cases are researched and analysed, more situations are addressed and more insight in the strategic process of locating the decoupling point is created. As a follow-up on the market analyses, existing similar companies within the food industry serving different market types would be interesting to analyse and to compare with the scenarios analysed here. Because deterioration rates are argued to be an important factor specific for the food industry, investigating cases concerning products with different deterioration rates would be useful. Also, in further research the effect of the factors with an unclear influence could be clarified and additional influencing factors can be discovered, so more knowledge can be provided to supply chain decision makers.

7. Discussion

Several remarks can be made with the conclusions in the section above. First, a few remarks are made concerning the model. It is uncertain if the overview of the factors influencing the decoupling point is complete. These factors are described in several literature studies, and as far as my knowledge reaches at this moment, the list of factors described in this thesis is complete. Nevertheless, there is a possibility that the literature has not been investigated thoroughly enough and that not all factors influencing the decoupling point are described in this report. Also, the factors product life cycle and sequence dependent set-up times are argued to be irrelevant in the food industry, but this argumentation is not supported by literature. Descriptions of these factors in the food industry were not found in the literature, but there is a possibility that these factors exist and are relevant in the food industry.

Another remark about the model relates to attaching weights to factors. The instruments used to attach weights are market winners and market qualifiers. These instruments do not attach weights in the most accurate way possible, since market winners and market qualifiers do not cover all the factors. This is illustrated in section 4.5 (pp. 20-21), where demand volatility is argued to be of great relevance, but a high weight was not attached to this factor. Demand volatility could not be linked to a market winner or market qualifier in the scenarios, which illustrates that the process of attaching weights is incomplete.

The next remark concerning the model is about the aim of the model to create structure in the process of locating the decoupling point. It is mentioned in this report that case studies do not seem to have much structure when analysing cases. The model developed in this thesis aims to provide that structure. Clear descriptions of the steps of the model and the applications of the model (pp. 16 - 24) show that this model provides a structured method. So, the process of locating the decoupling point can be done systematically and structured with this model.

The last remark concerning the model is about the industries in which the model is applicable. This thesis solely focussed on the food industry. It is argued that characteristics of the food industry influence which factors play a role in a situation and how relevant some factors are, e.g. deterioration in the food industry. However, industry characteristics do not influence the model itself, i.e. the model is applicable in other industries as well. But, the factors that are argued to be irrelevant in the food industry must be reconsidered when this model is applied in other industries.

Second, a remark can be made concerning the market analyses. These scenarios used for the market analyses are created and non-existing, i.e. these scenarios largely based on assumptions. This affects the credibility of these scenarios in a negative way, since the outcomes can be manipulated easily by changing certain factors or leaving out certain factors that do not support the aim of these analyses.

Third, a remark can be made concerning the critical case analysis. Information is lacking in the case to apply the model in this situation. This makes criticizing the results of the case of Van Donk (2001) difficult. Concerning these results, the following question must be asked: if the missing factors, missing information, missing interrelations and missing weights would be included, would that alter the location of the decoupling point? It is mentioned in this report that not every factor is relevant in every situation (p. 14). On the other hand, many factors, interrelations and attaching weights to factors are not considered, i.e. much is missing to apply the model. So, the location of the decoupling point would likely be different for some products in the case if the missing factors, missing information, missing interrelations and the missing weights would be included.

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8. Appendix

8.1 Summary and background of the case

In the case of Van Donk (2001), a company produces 200 different products, which are different due to the recipe and the type of granulation and packaging. This company is opening a new production facility where decoupling points for these products must be located. Demand is not easy to forecast, since it is stable in an aggregate way but very irregular. Five recipes cover 70% of the entire demand and the number of customers is high. The delivery lead time is 5 days standardly, but some customers do ask for a shorter delivery lead time.

This case considers a production process that consists of three steps: processing, granulation and packaging. The processing step consists of mixing and several other uninterrupted steps without intermediate storage. Three possible locations for the decoupling point are possible: stock of raw materials, stock of semi-manufactured products and stock of finished products. The semi-manufactured product can be stored in silos or granulated and packaged directly. When packaged, the product is put in bags of different sizes. The finished product can either be stored or directly delivered to the customer. The product is not extremely perishable, since it can be kept in stock for almost six months. However, the producer must guarantee a shelf life of at least four months, which means the products can be kept in stock at this company for two months maximum. Lastly, there are restrictions on minimal batch sizes due to technical limitations and room for stock of semi-finished products is limited to about the average sales of a week.

The case states that semi-finished products that are customer specific can be excluded from storage, i.e. the decoupling point is located at the stock of raw materials. A third of the semi-manufactured products can be excluded. Secondly, the products with large aggregate demand are produced in large batches and stored in silos to reduce the number of set-ups and still be able to deliver fast. Granulation and packaging can be performed in response to the market.

Source: Van Donk (2001)