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UNIVERSITY & RESEARCH

## **BSc Thesis Supply Chain Management**

‘The Bullwhip effect under the presence of competitive markets’

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## **Abstract**

This literature study contributes to the creation of applicable and useful literature for supply chain members, active in competitive markets, and their supply chains to give more insight in the phenomenon bullwhip effect. Beside the well-known traditional causes of the bullwhip effect, market competition is recently found to be a factor leading to the bullwhip effect. In almost every market there is a certain degree of competition. However, the bullwhip effect is not present in all markets. Therefore, this study investigates what underlying factors in the competitive market lead to the bullwhip effect. When these factors are determined, the consequences of each underlying factor are explained. In the managerial implication part possible ways to reduce the bullwhip effect under the presence of competitive markets will be determined. To conclude, potential further research directions will be presented and limitations will be discussed.

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# Chapter 1 - Introduction

## 1.1 Problem Statement

The identification of the bullwhip effect is a significant advancement in our understanding of supply chain management (Duan et al, 2016). The bullwhip effect within the supply chain is already extensively researched. Observations in industry operations, simulated experiments and macroeconomic data reveal huge extra supply chain costs due to this problem (Quyang & Li, 2010). The bullwhip effect describes the effect by which moving consumer demand creates large swings in production for the suppliers at the other end of the supply chain (Wang & Disney, 2016). It refers to the shift in consumer demand that causes increasingly swings in inventory levels as one moves further up the supply chain. An industry exhibits the bullwhip effect if the variance of the inflow of material to the industry is greater than the variance of the industries sales (Wang & Disney, 2016). Consumer demand is rarely stable, therefore firms must forecast demand to deliberately determine inventory levels and other resources. These statistically based forecasts contain errors. Because of these errors firms often carry an inventory buffer called safety stock. Moving up the supply chain the error and thereby the need for safety stock becomes bigger (Wang & Disney, 2016). Supply chain managers experience this variance amplification in both inventory levels and orders. Research has shown that the bullwhip effect leads to several supply chain inefficiencies: poor customer service, excessive inventory investment, lost sales revenues, ineffective transportation, misguided capacity plans and missed production schedules (Lee et al, 1997).

While researchers paid a lot of attention to the bullwhip effect, companies are still failing to successfully manage the supply chain and overcoming the inefficiencies of the bullwhip effect (Chen et al, 2000). This is because there is not one simple factor leading to the bullwhip effect, that can be tackled easily. There are several complex causes leading to the bullwhip effect. Hassanzadeh, Jafarian and Amiri (2014) identified five major causes of the bullwhip effect i.e. demand signal processing, lead time, price fluctuations, order batching, and supply shortage (in this study referred as traditional causes). A recent study of Ma and Ma (2017) showed a new insight into the phenomenon bullwhip effect, namely that market competition is an important factor leading to the bullwhip effect. This is a remarkable new insight, because almost all markets are competitive, or at least to a certain degree (Gu, 2016). In the supply chain model constructed by Ma & Ma (2017), two retailers are included which are competing in the same market. The stronger the competition in the market, the greater the absolute value of the bullwhip effect is (Ma & Ma, 2017). However, the study of Ma & Ma (2017) does not go into detail why the bullwhip effect becomes stronger when market competition increases. It only states that market competition is a factor leading to the bullwhip effect, but not why.

In the current society companies are facing a rising pace of competition in increasingly global markets, with an intensifying demand to improve products and services (Joshi et al, 2015). Due to this rising competition we face today, investigating the bullwhip effect under the presence of competitive markets responds perfectly to the current state of affairs.

According to Jaipuria & Mahapatra (2014) the most challenging and important issues that need to be addressed, in the supply chain management field, is finding the underlying factors that lead to the bullwhip effect, and ways to reduce the bullwhip effect. As mentioned earlier market competition is a factor that leads to the bullwhip effect. However, in the study of Ma & Ma (2017) the underlying reasons why competitive markets lead to the bullwhip effect are not addressed, neither ways to reduce it. According to Ma & Ma (2017) market competition is hard to be adjusted to reduce the bullwhip effect. For managerial implications this study looks at the underlying factors in the competitive market (that lead to the bullwhip effect) to see whether these can be reduced more easily.

According to Ma & Ma (2017) both the traditional causes and market competition are factors leading directly to the bullwhip effect. However, the study of Lee et al. (1997) and the study of Geary et al. (2006) imply that the five traditional causes may result from optimizing behaviour by members in the supply chain. Members within the supply chain try to maximize their own profits by for example planning shipments in their own interest, order in batches, and by constantly adopting their price in order to be competitive. This optimizing behaviour described by Lee et al. (1997) and Geary et al. (2006) can be interpreted as market competition. So, a competitive market can make it possible that the traditional causes can pop up and give rise to the bullwhip effect. Therefore, this study has questions concerning the findings of Ma & Ma (2017). According to Gu (2016) in almost every market there is a certain degree of competition. If market competition truly leads directly to the bullwhip, then the bullwhip effect should be present in almost every market according to Gu (2016). However, this is not the case (Wang & Disney, 2016). Therefore, this study will investigate whether underlying factors in the competitive market are more determinative for causing the bullwhip effect, instead of the competitive market as a whole.

Currently there is no research that identifies which underlying factors in the competitive market lead to the bullwhip effect (Ma & Ma, 2017). This literature review will focus on finding these factors, by extensively researching existing literature and by combining these findings to come to new insights. When the underlying factors are defined, this study will investigate whether the findings of Ma & Ma (2017) or the findings of Lee et al. (1997) and Geary et al. (2006) are more applicable to reality. This will be done by investigating whether or not the factors in the competitive market can lead directly to the bullwhip effect (Ma & Ma, 2017) and/or whether they have an indirect impact (Lee et al. 1997; Geary et al. 2006) on the bullwhip effect.

Thereby this study will contribute to the supply chain management research by giving a clear understanding of the bullwhip effect under the presence of competitive markets. In more detail, this study will contribute to research by filling the gap concerning the underlying factors in the competitive market (leading to the bullwhip effect) and by assessing how these specific factors influence the bullwhip.

The purpose of this literature study is to contribute to the creation of applicable and useful literature for supply chain members, active in competitive markets, and their supply chains to give more insight in the phenomenon bullwhip effect. Therefore, for managerial implications possible ways to reduce the bullwhip effect under the presence of competitive

markets, will be determined. In the end potential further research directions will be presented and limitations will be discussed.

## **1.2 Research Questions**

The central research question in this literature review is

‘How can specific factors in competitive markets lead to the bullwhip effect in the supply chain?’

The following research questions are derived in order to answer to the problem statement and the central question. After answering the research questions, an answer to the problem statement can be given.

1. What is the bullwhip effect and what are the major causes?
2. How does the bullwhip effect manifest itself under the presence of competitive markets according to literature?
3. Which underlying factors in the competitive market have an influence on the bullwhip effect in the supply chain?
4. What is the impact of each underlying factor of the competitive market on the bullwhip effect?
5. What are possible managerial implications to reduce the bullwhip effect, under the presence of competitive markets, in the supply chain?

### 1.3 Structure of the Research

The structure of this thesis relies on giving an answer to the problem statement. The first chapter introduces the topic and the problem statement.

Chapter 2 will give a clear definition of the bullwhip effect and explains the causes leading to it. This chapter will serve as a clear fundament for the rest of the study, so later on in the study it can be investigated if and in what way market competition influences the traditional causes and the bullwhip effect.

In chapter 3 the bullwhip effect, under the presence of competitive markets, according to existing literature will be discussed. First the study of Ma & Ma (2017) will be discussed in this chapter. Subsequently the studies by Lee et al. (1997) and Geary et al. (2006) will be discussed.

Currently there is no research that identifies which underlying factors in the competitive market lead to the bullwhip effect. In chapter 4 the study will focus on finding these factors by extensively researching existing literature.

When the specific factors in the market are determined, chapter 5 will discuss the impact of each factor on the bullwhip effect. In the study of Ma & Ma (2017) the five traditional causes of the bullwhip effect and the recently found cause market competition are presented as shown in figure 1. This means that both the traditional causes and market competition are factors leading directly to the bullwhip effect.

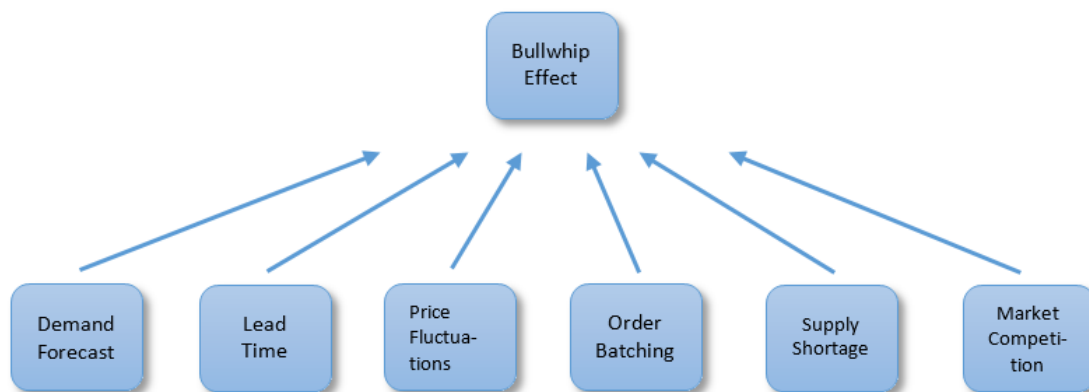


Figure 1: Causes of the bullwhip effect

However, the study of Lee et al. (1997) and the study of Geary et al. (2006) imply that the five traditional causes may result from market competition. This means that market competition has an indirect impact on the bullwhip effect, which is shown by figure 2. Therefore, this study will investigate whether underlying factors in the competitive market are more determinative for causing the bullwhip effect, instead of the competitive market as a whole. This means that it will be assessed whether figure 1 or figure 2 is more applicable to reality.

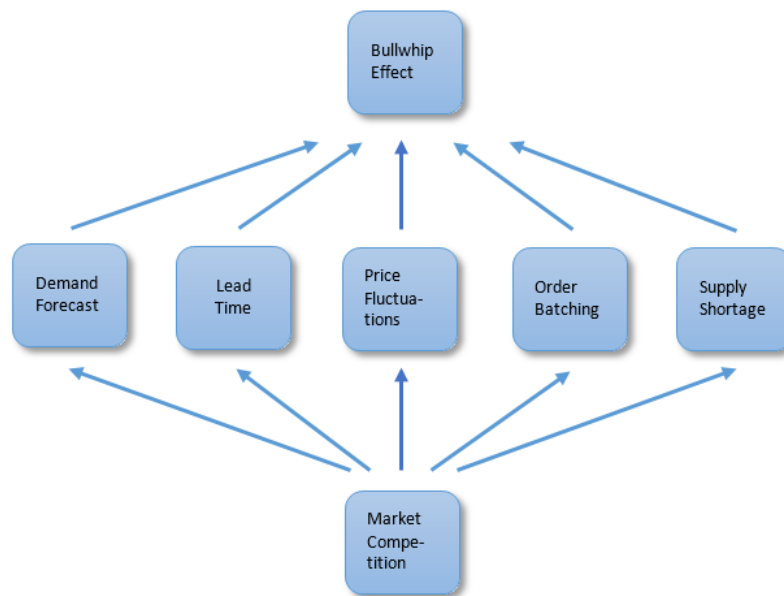


Figure 2: Market competition leading to the causes of the bullwhip effect

In the managerial implication part, chapter 6, possible countermeasures to reduce the bullwhip effect under the presence of competitive markets will be explained. First some general reduction strategies will be discussed, afterwards these will be applied to each specific underlying factor in the market.

Finally the study will determine how specific factors in the competitive market can lead to the bullwhip effect in the supply chain, and thereby answer the central question. At the end limitations, recommendations, and possible topics for further research for the literature study will be provided.

So, chapter two, three, four, five and six will discuss and answer the five research questions. Based upon the information gathered by the research questions, all the needed information will be there to give a well-founded and structured answer to the problem statement, which then will be concluded and discussed in the last chapter.

#### 1.4 Method: Literature Search

This bachelor thesis is an integrative literature review, which is *'a form of research that reviews, critiques and synthesizes representative literature on a topic in an integrated way'* (Choi, 2011). The integrative literature review is a distinctive form of research in that it generates new knowledge about a topic based on literature search, which is exactly what this bachelor thesis aims to do. The review of the existing literature on the bullwhip effect combined with competitive markets can result in new understandings and reconceptualization of the topic, thereby expanding the research field and giving practical knowledge to practitioners interested in the topic. This literature review is exclusively based on secondary data and existing theories to answer the research questions and central question. The main concepts that are investigated are the bullwhip effect and competitive



markets.

The secondary literature, used as data for this literature review, are collected by using two electronic databases. These online library databases, used to search for relevant literature and publications, are Google Scholar (<https://scholar.google.nl>) and Wageningen University & Research Digital Library (<https://library.wur.nl>). These online databases are easily accessible and a great amount of literature can be found by using it.

The combination of the bullwhip effect and competitive markets is only described by Ma & Ma (2017). However, a large amount of literature about the phenomenon bullwhip effect is available. Also a lot of literature about competitive markets is available. Not all available literature is useful or of high quality. To be included in this literature review, the literature needs to be valid and reliable. However, when an article gives a new insight even though it is not very reliable or valid, then it can also be included. Of course it will then be explained why this particular article is used. Reliability is the consistency of the measure, this means that the articles used in this study must have an extensive references section that contains reliable sources. Validity is about measuring the right construct, the sources of the articles used in this study will be checked. Furthermore, to be included in this literature review, the literature should still be relevant today and relevant to the supply chain management research. Therefore recent studies will be used in this literature review. The quality of the literature will be judged on the amount cited by others, which references were applied and whether the article is peer reviewed, too judge whether the articles are still relevant today.

The literature search was conducted by using the following search terms:

Question 1: 'Bullwhip Effect', 'Defining Bullwhip Effect', 'Definition Bullwhip Effect', 'Causes Bullwhip effect', 'Factors leading to the bullwhip effect'

Question 2: 'Causes Bullwhip effect and Competition', 'Bullwhip effect and Competition', 'Consequences Market Competition', 'Competitive Markets', 'Bullwhip effect and Competitive Markets'

Question 3: 'Factors Competitive Markets', 'Drivers Competitive markets', 'drivers competition', 'Supply Chain Management and Competitive Markets', 'Supply Chain and Competitive Markets', 'Value Chain and competitive Markets', 'Operations and Competitive Markets', 'Demand and Competitive Markets', 'Lead Time and Competitive Markets', 'Price fluctuations and Competitive Markets', 'Order batching and Competitive Markets', 'Supply shortage and competitive Markets', 'Competitive Markets and Bullwhip Effect', 'Factors leading to the Bullwhip Effect', 'Innovation and Market Competition', 'Substitutes and Market Competition'

Question 4: 'Substitutes and Competitive Markets', 'Innovation and Competitive Markets', 'Price fluctuation and Competitive Markets', 'Degree of competition and Competitive Markets', 'Optimizing behaviour and Competitive Markets', 'Direct causes Bullwhip effect', 'Indirect causes Bullwhip effect'

Question 5: 'Reduce Bullwhip Effect', 'Managerial Implications and Bullwhip Effect', 'Managing Bullwhip Effect', 'Countermeasures Bullwhip Effect', 'Strategies for Minimizing Bullwhip Effect', 'Reduction Bullwhip Effect and Market Competition',

## Chapter 2 – The Bullwhip Effect and its Traditional Causes

In this chapter the following research question will be discussed: '*What is the bullwhip effect and what are the major causes?*'. First of all a clear definition of the bullwhip effect will be given in section 2.1. To give a better understanding of the topic the major causes of the bullwhip effect will be discussed in section 2.2. This chapter will be used to give a sound fundament for the other research questions, so later on in the study it can be investigated if and in what way market competition influences the traditional causes and the bullwhip effect.

### 2.1 Definition Bullwhip Effect

The bullwhip effect is one of the most popular and researched concepts in the field of operations- and supply chain management. The main incentive for minimizing the bullwhip effect is the related costs associated with this phenomenon. Even though extensive research has been done, supply chains still are not successful in effectively tackling the bullwhip effect.

In the current business environment the management and the strategic use of the supply chain becomes more common. In other words, organizations value the entire supply chain profit and well-being more than ever before (Chang et al, 2013). In order to be able to comprehend the bullwhip effect, the general description of a supply chain should be clear. The supply chain is the network of firms and facilities (suppliers, manufacturers, distributors and retailers), that are involved through upstream and downstream connections, in the transformation or value adding process and activities of the raw materials and services that are ultimately delivered to the customer as a finished good (Souza, 2014). In a supply chain there are financial, physical, and information flows among different firms participating in the supply chain. Successful supply chain management requires planning, managing and controlling these flows through the integration of key processes, from suppliers through manufacturers, retailers to the end-users, which produce value to the ultimate customer (Paik, Seung-Kuk & Bagchi, 2007). Well-coordinated and implemented supply chain management decisions can be directly beneficial for organizations by lowering transportation, sourcing, stock outs, storage, and disposal costs. To achieve this supply chain members must recognize that they are part of a complex network. All individual parts of the supply chain are interlinked. Every member of the supply chain will be affected if one single member changes its conditions. Within a supply chain each member relies heavily upon the information from its direct downstream member. This originates from the fact that each member orders immediately from their upstream supply chain member. All kind of inefficiencies within the supply chain can lead to the bullwhip effect (Wang & Disney, 2016).

The bullwhip effect is regarded as a common problem that exists in the supply chain. In order to fully understand the bullwhip effect, the definition of the bullwhip effect should be clear. The term 'Bullwhip Effect' was introduced to describe the effect by which moving consumer demand creates large swings in production for the upstream suppliers. The definition comes from the observation that a relatively small order variability at the

consumer level amplifies the orders for upstream players, this swing is likely to become wider upstream in the supply chain. This results in a gap between the orders issued by the upstream suppliers and the actual demand of the retailers or the sales volume (Lee et al, 1997). The distortion tends to increase as one moves upstream the supply chain. Figure 3 illustrates this order variability that becomes wider when one moves further upstream the supply chain.

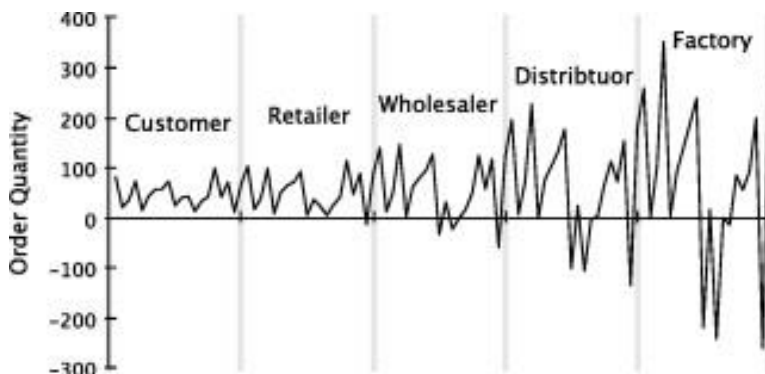


Figure 3: Illustration of the Bullwhip Effect

Due to increasing levels of variability and uncertainty, supply chain members often have no choice other than increasing the level of safety stock. In order to prepare for unforeseen demand fluctuations throughout the supply chain, companies need to build and manage so called safety stocks. Excessive safety stock can lead to increased inventory costs due to overstocking throughout the supply chain, inefficient use of resources, and subsequently results in poor customer service and lower profits for the entire supply chain (Paik et al, 2007)).

The bullwhip effect becomes significant when the cost from fluctuations in orders/production are higher than the cost for holding inventory. This means that transmission of information across members of the supply chain results in information distortion and unexpected demand fluctuations, which can result in variations of orders that are often larger than the actual sales. Costs related to the bullwhip effect are associated with hiring and firing of the workforce, setting up and shutting down machines, excessive upstream inventory, poor supplier/customer relationships, overtime in the workload and difficulty in forecasting and scheduling. The bullwhip effect can be found in almost every industry (Wang & Disney, 2016). Managers and consultants from several industries, among which the automotive, textile, and retail industries, have tried to deal with the bullwhip effect. Svensson (2005) describes how several industries try to deal with the bullwhip effect phenomenon: *'In the automotive industry the term just-in-time (Sugimore et al., 1977; Toyota, 1987) has been used, while in the textile and retail industries the terms quick response (Stern et al., 1996; Fernie, 1994) and efficient consumer response (Kurt Salmon Associates, 1993) have been applied. These terms, or business philosophies, aim at reducing the stocking level variability in supply chains, and in the end improve profitability, reduce costs and increase the overall performance of the supply chain beyond judicial boundaries as a whole.'* All these business philosophies reduced the bullwhip effect, but never entirely solved it (Svensson, 2005).

## **2.2 Causes of the Bullwhip Effect**

The need for controlling the bullwhip effect has become increasingly important (Chang et al, 2013). Organizations within the supply chain can only tackle the bullwhip effect if they are aware of the underlying factors causing this phenomenon. Lee et al (1997) identified five major causes of the bullwhip effect i.e. demand forecast updating, lead time, price fluctuations, order batching, and supply shortage. All these causes can be derived from information distortion somewhere in the supply chain (Lee et al, 1997). Each cause for the bullwhip effect in the supply chain will be discussed separately in the following sub sections.

### **2.2.1 Demand forecast updating**

The two main causes of distortion in demand information are inaccurate information- and demand forecast (Lee et al, 1997). Information sharing is about fully sharing demand figures and sensitive company data. Demand forecasts are based on the available data retrieved from supply chain members. Bad information sharing and incorrect demand forecasts leads to the manufacturer losing sight of the accurate demand in the market.

The demand forecast information of a firm is often based on past demand information. This means that forecasts for future demand relies on past data. If in a certain period a retailer, for example, experience a huge growth in sales, future demand forecasting will be influenced by this. However, this will not always mean that future demand will still be relatively high. The demand forecasts of a single member in the supply chain are based on its direct downstream partner, which can lead to inaccurate future demand forecasts (Lee et al, 1997). Because each firm has its own goals, demand forecasts tend to be manipulated. By creating incentives to align the goals of supply chain members biases in demand forecasting can be reduced. In order to avoid out of stock risk, firms for instance increase part of the inventory. This in case leads to demand inflation and the bullwhip effect follows (Dai et al, 2017). *'Demand forecast updating suggests that demand amplification occurs due to the safety stock and long lead time. As orders are forecasted and transmitted along the supply chain, the safety stocks are built up, and thus the bullwhip effect occurs.'* (Paik et al, 2007). This means that when a retailer processes the demand signals, original sales information will be distorted and this variance is further amplified when passed upstream to the supply chain and become even bigger as lead times and the length of the supply chain increase (because every firm adds extra safety stock as a result of their forecasts) (Dai et al, 2017). Within the supply chain there exist an information flow in the upstream direction, while there exists a physical flow of goods downstream. These flows are directed in an opposite way, however if one of the flows is distorted both flows are affected. If this happens chain members will base their demand forecasting on inaccurate numbers. This incorrect data amplifies moving further away from the end customer, causing the bullwhip effect (chen et al, 2000). Actions that can be taken to improve demand forecasts are lead time reduction and information sharing across the supply chain. To realize information sharing, demand information can be centralized and be made available for all members in the supply chain (Chen et al, 2000).

### **2.2.2 Lead time**

Lead time refers to the time it takes to deliver a product to the market. Delays in manufacturing, shipping and transmission of information through the supply chain are variables associated with lead time. It is the difference in time between the moment a

customer places an order to the moment the product or service is delivered to the customer. It is a critical tool for calculating safety stock inventory levels and for applying a fitting reorder formula.

Lead time typically includes two components, namely order lead time and information lead time. Order lead time can be described as the time it takes to produce and ship the item and information lead time refers to the time it takes to process an order (Rossetti & Unlü, 2011). In the supply chain each firm will place an order by its upstream member. A single product is mostly not immediately processed. The seller will mostly not immediately order the good from its supplier, but they often wait until a certain quantity is reached. This is because they will take into account the inventory and costs that occur when processing a single order (Dai et al, 2017). Because frequent orders will increase the costs and workload of suppliers, suppliers require the vender to create a cycle or a particular amount of orders that is beneficial (also called a bulk order) (Rossetti & Unlü, 2011). To achieve this, vendors increase the order quantity. The order information processing is normally following the upstream direction: Customer – Retailers – Wholesalers – Manufacturers – Suppliers. This process will certainly lead to delays in information and logistics due to the above described bulk orders and lack of information sharing across the supply chain. Often all parties involved in the supply chain will not immediately process their orders after they receive them, but work via bulk orders. These bulk orders and lack of information sharing increase the lead time, and the longer the lead time in a supply chain, the bigger the prediction error, the bigger the inventory levels, and the higher the bullwhip effect (Dai et al, 2017).

The major benefits of a reduction in the lead time are streamlined operations, reduced carrying costs, increased flexibility, ability to outpace competitors, faster replenishment of stock to avoid stock outs, and increases in cash flow because of an increased order fulfilment (Rossetti & Unlü, 2011). Possible actions to reduce the lead time are: the creation of a lead time contract with every supplier, order inventory more often instead of bulk orders, share sales date with your suppliers, and by automating your inventory management (Glock & Christoph, 2012).

### **2.2.3 Price fluctuations**

Price fluctuations are upward and downward swings in prices of products in the economy. These fluctuations can result from any type of promotion, like product promotions, price discounts, quantity discounts and consumer coupons. These price fluctuations eventually lead to demand distortion (Kolter, 1997). So, buying patterns can be distorted by price fluctuations which subsequently can cause bigger variability in demand (Dai et al, 2017). Pricing strategies are a marketing tool that has a major effect on demand. According to Lu et al (2012), temporary reductions in retail prices can lead to significant increase in demand, which results in short term sales spikes. Price fluctuations can happen either upstream or downstream the supply chain, since discounts can be given to any firm in the supply chain (Lu et al, 2012). To measure the impact of the bullwhip effect, a measure of order variance is taken. The more parties fluctuating their prices, the bigger the impact of the bullwhip effect resulting in more variances (Lee et al, 1997). Countermeasures against price fluctuations are every-day low prices and volume based discounts (Lee et al, 1997).

#### **2.2.4 Order batching**

According to Hussain & Drake (2011) members of the supply chain can have several conflicting objectives to order or produce in batches: *'a retailer might order a full truck or container load from the wholesaler to qualify for a quantity discount and to optimize transport costs by fully utilizing the fixed-cost truck or container. For a manufacturer, significant economies of scale can be achieved by producing in large batches, but the resultant large inventories will increase the stock holding costs. The inventory manager, however, always favours policies which meet the forecasted demand with minimal inventory. The rapprochement of these conflicting objectives is a fundamental aim of inventory management theory.'* Order batching refers to placing orders to upstream members of the supply chain in batches. Batching is a clustering of products or services for transportation, purchasing or manufacturing processes (Hussain & Drake, 2011).

Benefits of order batching are a decrease in ordering cost, beneficial sales incentives, and an advantage in transportation costs (full truck loads). Batching happens because significant economies of scale can be achieved (Hussain & Drake, 2011). It refers to ordering goods at a certain point in time, mostly because it has material, financial or logistic benefits. These time phased production or orders are mostly not synchronized with the actual demand. These periodic batching causes swings in demand at a specific time period, followed by periods of time with no or just little orders, and other time periods with huge demands (Lee et al, 1997). These batched cause major variabilities in demand and are amplified as it passes up the supply chain since the demand is rounded up to whole batch sizes. Leading to the bullwhip effect (Lee et al, 1997). Larger batch sizes lead to longer cycle and delivery times (Cachon & Lariviere, 1999).

Cachon and Lariviere (1999) have shown that demand variability caused by order batching can be reduced by smaller batch sized and a more balanced demand. There are several benefits of working with smaller batches: a company will know faster/better whether they build the right product (shorter cycle), less risk of delays, lower inventory costs due to smaller warehouses and more flexibility (Hussain & Drake, 2011).

#### **2.2.5 Supply Shortage**

Supply shortage occurs in a situation when demand significantly exceeds supply. A possible cause for supply shortage are miscalculated demand by members in the supply chain (Lee et al, 1997). This can result in an inability to keep up with demand, rationing or government policies.

An example of a situation of supply shortage is when a natural disaster destroys agricultural landscapes, which leads to shortage of the products produced on these landscapes. These situations often lead to higher prices of the concerned goods. Supply shortage also occurs in situations in which the customers place an order quantity higher then they need. Consider the release of a popular video game. For the customer the game is something he truly wants and he realises that the game might be in short supply. Therefore, the customer places a pre-order with several retailers (to be sure he has one) knowing that he will buy only one and cancel the other orders. As a result of these 'false orders' producers increase output, which amplifies further in the supply chain leading to the bullwhip effect (Lee et al, 1997). Furthermore, manufacturers often ration products to their customers based on what they

order (Lee et al, 1997). Facing this rationing policy, the customers place orders larger and more frequently than what they really need to ensure that their true demand is satisfied. This behaviour results in a distorted perception of demand for the supplier, which can lead to overproduction. This tendency is similar to excessive ordering without fully considering the orders that have been placed before but not yet received, resulting in distorted demand information and the bullwhip effect (Isaksson & Seifert, 2016).

Ways to reduce supply shortage according to Cui & Shin (2017) are eliminating uncertainty by shortening lead times and more accurate forecasting and improving inventory management to safeguard against stock outs.

### **2.3 Conclusion**

The term 'Bullwhip Effect' was introduced to describe the effect by which moving consumer demand creates large swings in production for the upstream suppliers. A relatively small order variability at the consumer level amplifies further in the chain, this swing is likely to become wider upstream in the supply chain. It can be concluded that the five major causes for the effect are inaccurate demand forecasts, long lead times, price fluctuations, order batching and supply shortage. These causes are determined so that later on in the study it can be investigated whether market competition leads towards these causes or directly to the bullwhip effect.

## Chapter 3 – The Bullwhip Effect under the presence of Competitive Markets

Beside the five traditional causes described in chapter 2, market competition is recently discovered as a major factor leading to the bullwhip effect. In this chapter the following research question will be discussed: *'How does the bullwhip effect manifest itself under the presence of competitive markets according to literature?'.* The only literature available which specifically combines the phenomenon bullwhip effect with market competition is the research of Ma & Ma (2017). Therefore section 3.1 will give an overview of the findings of Ma & Ma (2017). According to Ma & Ma (2017) market competition is a factor that directly leads to the bullwhip effect, just as the five traditional causes. Based on this theory, the conceptual model of figure 1 is correct. Section 3.2 will discuss the studies of Lee et al. (1997) and Geary et al. (2006), which state that market competition leads to the causes of the bullwhip effect. Which is in line with figure 2. In chapter 5 this study will go in further detail to investigate whether section 3.1 or 3.2 is more applicable to reality.

### 3.1 The Bullwhip effect under the presence of Market Competition

Until the study of Ma & Ma (2017) previous research had only focussed on one retailer in supply chain models. The bullwhip effect in more complex supply chains was never investigated. If there is just one retailer under consideration, then the market competition between two retailers will be ignored. To give a more realistic image of reality Ma & Ma (2017) incorporated market competition in their model.

To investigate whether and to what extend market competition has an effect on the bullwhip effect, a supply chain model with two retailers is built by Ma & Ma (2017). The retailers have no fixed market share, which means that they have different market shares at different periods. Certainly when the competition in the market is high market share varies a lot. A two-stage supply chain with one supplier and two retailers is taken into consideration. The two retailers face market competition. Therefore, this model is more realistic (more in line with the real market place) compared to previous research

In the study of Ma & Ma (2017) retailers face customer demand and place orders to the supplier respectively. In the model constructed by Ma & Ma (2017), retailers compete with each other in one market. Demand of one retailer may decrease if the demand of the other retailer increases and vice versa. Demand of retailer 1 is negatively correlated with demand of retailer 2. The correlation coefficient equals the degree of market competition, which means that a higher level of competition in the market leads to an even more negative correlation in demand between the retailers.

The inventory levels in the research of Ma & Ma (2017) are a function of the forecasts lead time, the standard error of the forecasts lead time, and the span of demand forecast. The optimal level of order-up-to inventory is determined by inventory holding costs and shortage costs. The greater the market competition, the greater the demand volatility between the retailers becomes. This means that forecasting the demand and lead time becomes harder due to an increase in market competition. Which in case can distort the optimal level of



inventories, because forecasts are not accurate. The bullwhip effect in a competitive market is a function with respect to the consistency of demand volatility between the retailers, lead time of retailers, span of forecast, and market competition (Ma & Ma, 2017). This means that market competition is a factor directly leading to the bullwhip effect, as shown in figure 1. So, as a result of an increase in market competition, demand volatility between retailers becomes bigger. Demand volatility between retailers is an important factor leading to the bullwhip effect. Lead time, span of forecast, market competition and demand volatility are important factors leading to the bullwhip effect, so these factors can cause a distorted perception of the real amount demanded by the customer. This distortion amplifies further upstream the supply chain (Ma & Ma, 2017).

In the study of Ma & Ma (2017) the two retailers face the same market, they face the same method of forecast and sell the same product. The two retailers face the same perfectly competitive market, in which their demands represents a negative correlation. The correlation coefficient is equal to the degree of market competition. The bullwhip effect in the study of Ma & Ma (2017) is a measure of the ratio of the variance of order quantity that the supplier faces, the variance in demand and the correlation coefficient. The higher the variance and correlation coefficient are, the higher the value of the bullwhip effect. Box 1 demonstrates how Ma & Ma (2017) measure the bullwhip effect.

$$\text{BWE} = \frac{H_1 \text{Var}(D_{1,t}) + H_2 \text{Var}(D_{2,t}) + H_3 \psi \sqrt{\text{Var}(D_{1,t}) \text{Var}(D_{2,t})}}{\text{Var}(D_{1,t}) + \text{Var}(D_{2,t}) + 2\psi \sqrt{\text{Var}(D_{1,t}) \text{Var}(D_{2,t})}} \\ = \frac{H_1 + H_2 \gamma^2 + H_3 \psi \gamma}{1 + \gamma^2 + 2\psi \gamma},$$

Box 1: Measure of the bullwhip effect

|                      |  |
|----------------------|--|
| Var(D <sub>i</sub> ) | Variance in demand of retailer i   |
| $\psi$               | Market competition   |
| H <sub>i</sub>       | Function of autocorrelation coefficient retailer i, order lead time retailer i, and the span of forecast |
| $\gamma$             | Demand volatility between two retailers  |

Table 1: Variables used in the Bullwhip effect equation

In Table 1 all the variables used in the bullwhip effect equation (shown in box 1) are explained.

The study of Ma & Ma (2017) investigates how each parameter affects the bullwhip effect. Table 1 shows these parameters. Ma & Ma (2017) investigate the following parameters in more detail to see what impact they have on the bullwhip effect: lead time of retailers, the span of forecast, demand volatility between two retailers and market competition.

- *The impact of lead time on the bullwhip effect:* When the lead time increases, the bullwhip effect increases as well. To lower the bullwhip effect, it can be useful for managers to reduce the lead time. However, a smaller lead time does not always lead

to a lower bullwhip effect. According to Ma & Ma (2017), the optimal lead time can be forecasted more precise by making more use of historical demand data.

- *The impact of the span of forecast on the bullwhip effect:* The bullwhip effect is decreasing because of the span of forecast. The less variance in the demand forecasts, the lower the bullwhip effect. This means that managers can reduce the bullwhip effect by lengthening the span of forecast.
- *The impact of demand volatility between two retailers:* Demand volatility between two retailers is decided by the demand processes and is hard to be controlled by managers. The bullwhip effect reacts in different ways on the demand volatility between two retailers. This is because demand volatility between two retailers can have different values. Box 2 shows how the bullwhip effect reacts on different values of the demand volatility between two retailers.

When  $H_1 - H_2 > 0$ ,  $2H_1 - H_3 \geq 0$  and  $2H_2 - H_3 < 0$ , we know  $\gamma_1^* > \gamma_2^* > 0$ . So, in the interval  $(0, \gamma_2^*)$ ,  $\frac{\partial BWE}{\partial \gamma} > 0$ ; in the interval  $(\gamma_2^*, \gamma_1^*)$ ,  $\frac{\partial BWE}{\partial \gamma} < 0$ ; in the interval  $(\gamma_1^*, +\infty)$ ,  $\frac{\partial BWE}{\partial \gamma} > 0$ . Hence, BWE is an increasing, decreasing and then increasing function with respect to  $\gamma$ .

When  $2H_1 - H_3 < 0$  and  $2H_2 - H_3 < 0$ , we know  $\gamma_1^* > 0$ ,  $\gamma_2^* < 0$ . So, in the interval  $(0, \gamma_1^*)$ ,  $\frac{\partial BWE}{\partial \gamma} < 0$ ; in the interval  $(\gamma_1^*, +\infty)$ ,  $\frac{\partial BWE}{\partial \gamma} > 0$ . Hence, BWE is a decreasing and then increasing function with respect to  $\gamma$ .

When  $H_1 - H_2 > 0$ ,  $2H_1 - H_3 < 0$  and  $2H_2 - H_3 \geq 0$ , we know  $\gamma_2^* > \gamma_1^* > 0$ . So, in the interval  $(0, \gamma_1^*)$ ,  $\frac{\partial BWE}{\partial \gamma} < 0$ ; in the interval  $(\gamma_1^*, \gamma_2^*)$ ,  $\frac{\partial BWE}{\partial \gamma} > 0$ ; in the interval  $(\gamma_2^*, +\infty)$ ,  $\frac{\partial BWE}{\partial \gamma} < 0$ . Therefore, BWE is a decreasing, increasing and then decreasing function with respect to  $\gamma$ .

Box 2: Reaction bullwhip effect under presence of demand volatility between two retailers

- *The impact of market competition on the bullwhip effect:* According to Ma & Ma (2017) the bullwhip effect under the presence of market competition shows the properties as shown in Box 3. The bullwhip effect is a monotone function in relation with market competition. From a managerial point of view market competition is therefore a simple factor to affect the bullwhip effect. It can be concluded that market competition is an important factor leading to the bullwhip effect, but it is hard for managers to adjust it to reduce the bullwhip effect (Ma & Ma, 2017).

(a) When  $(H_3 - 2H_2)\gamma^2 + H_3 - 2H_1 > 0$ , in the interval  $(-\infty, 0)$ ,  $\frac{\partial BWE}{\partial \psi} > 0$ . So, BWE is an increasing function with respect to  $\psi$ .

(b) When  $(H_3 - 2H_2)\gamma^2 + H_3 - 2H_1 = 0$ , in the interval  $(-1, 0)$ ,  $\frac{\partial BWE}{\partial \psi} = 0$ . So BWE is a fixed value.

(c) When  $(H_3 - 2H_2)\gamma^2 + H_3 - 2H_1 < 0$ , in the interval  $(-1, 0)$ ,  $\frac{\partial BWE}{\partial \psi} < 0$ . So, BWE is a decrease function with respect to  $\psi$ .

Box 3: Reaction bullwhip effect under the presence of market competition

### **3.2 Market competition as a factor leading to the causes of the bullwhip effect**

This section will discuss the studies of Geary et al. (2006) and Lee et al. (1997). These two studies do not specifically investigate the bullwhip effect under the presence of competitive markets. However, they do come with some interesting findings which suggest that market competition may give rise to the causes of the bullwhip effect (which is in line with figure 2). This is in contrast with figure 1 and the study of Ma & Ma (2017), which states that market competition is directly leading to the bullwhip effect. The findings of the two studies will be discussed in the following subsections.

#### **3.2.1 The bullwhip effect and marketplace behaviour**

Geary et al. (2006) investigated the extent of smooth material flow within 32 different supply chains. An effective and smooth material flow (value stream) can be seen as the inverse of the bullwhip effect. To assess the extent of smooth material flow they monitored operational features, organisational features and dynamic behaviour within organizations. Most supply chains under investigation concerned the automobile sector. They widely implemented 'lean production', which led Geary et al. (2006) suspect that these chains would score well. Each factor was monitored and scored according to the perceived uncertainty arising from the following sources:

- *Process uncertainty*: process uncertainty is associated with the internal ability of a firm to meet a production delivery target.
- *Supply uncertainty*: supply uncertainty refers to poor performing suppliers, which do not meet a firms requirements and therefore endanger the value-added process.
- *Demand uncertainty*: demand uncertainty is uncertainty that arises from the difference between the actual customer demand and the orders placed within an organization by its customers.
- *Control uncertainty*: control uncertainty concerns the information flow and the process in which an organization transforms orders into supplier raw materials and production targets.

The final score of each supply chain is the result of their performance on each of these four individual uncertainties. Figure 4 shows the outcome. The lower the degree of uncertainty, the lower the bullwhip effect in the value chain and the higher the integration (Geary et al, 2006)

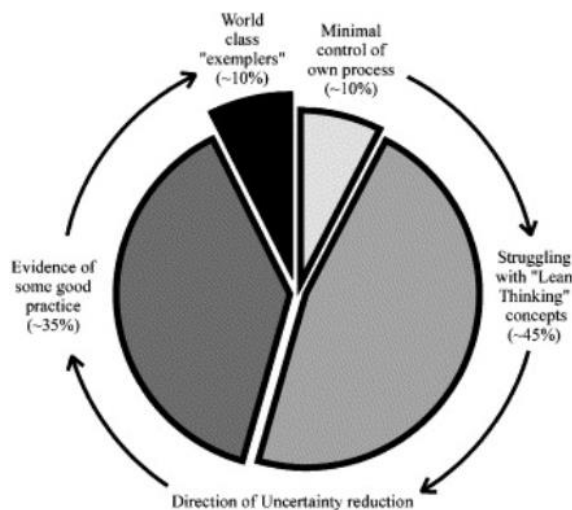


Figure 4: Supply chain audit scores based on uncertainty scores

The pie chart shows that 10% of the chains have minimal control over their processes, and have not successfully implemented proper material flows and lean thinking concepts in their activities. Approximately 45% have reduced some of the uncertainties, but still have major issues. Another 35% had significantly reduced uncertainty in their value stream. Finally, 10% is labelled as an effective supply chain. The main outcome for this paper is that the study of Geary et al. (2006) concluded from their investigation that volatility and uncertainty experienced by organizations within the supply chain was the result of the marketplace behaviour (market competition), beside the main factor value stream dynamics. The marketplace leads to uncertainties concerning processes, supply, demand and control functions. One of the main factors leading to the bullwhip effect is uncertainties within the chain (Wang & Disney, 2016). Therefore, the marketplace can give rise to the causes of the bullwhip effect, which is in line with figure 2.

### 3.2.2 The bullwhip effect and optimizing behaviour in the market

Lee et al. (1997) identified four sources of the bullwhip: demand signal processing, rationing game, order batching and price variations. The decision to choose these 4 drivers is dictated by the fact that they are general effects in supply chains. Retailers use demand signals in the market to predict demand. Subsequently these determined demand is used to batch orders to gain economies of scale in pricing and transportation. Demand signal processing and order batching are associated with one another due to the fact that they are outputs of traditional inventory management models at retail level. Rationing is common in product markets, when the product is in the growth phase of the life-cycle. In this phase demand often exceeds supply which leads to rationing. Price variations are related to mature product categories in which manufacturers try to gain market share. Price variations and rationing are related in the sense that they are both reactions to market forces. In the real market combinations of the four drivers characterize the marketplace (Lee et al. 1997). The study of Lee et al. (1997) states the following about the marketplace: *'it is important for all players in the supply chain to realize the impact of these market forces and take measures to improve the coordination among members in the supply chain.'* According to Lee et al. (1997) the bullwhip effect is an outcome of strategic interactions among rational supply chain members. Essential aspects in strategic interactions are the institutional structure and

optimizing behaviours of players in the chain. Lee et al. (1997) state that demand distortion arises when optimizing behaviour by members in the supply chain occurs. Members within the supply chain try to maximize their profits by for example planning shipments in their own interest, order in batches, and by constantly adopting their price in order to be competitive. This optimizing behaviour described by Lee et al. (1997) can be interpreted as market competition. So, a competitive market can make it possible that the traditional causes can pop up and give rise to the bullwhip effect.

### **3.3 Conclusion**

It can be concluded that there are two opposite findings concerning the way market competition influences the bullwhip effect. According to Ma & Ma (2017) market competition leads directly to the bullwhip effect. The higher the degree of competition in the market, the more significant the bullwhip effect will be. Furthermore Ma & Ma (2017) conclude that market competition is hard to be adjusted to reduce the bullwhip. On the other hand Geary et al. (2006) and Lee et al. (1997) state the following respectively: the marketplace causes uncertainties which leads to the causes of the bullwhip effect, and optimizing behaviour through market competition leads to the causes of the bullwhip effect respectively.

## Chapter 4 – The Underlying Factors of Competitive Markets

In this study it is researched how specific factors in the competitive market can lead to the bullwhip effect. For this reason it is important to clarify what the specific factors in competitive markets (that lead to the bullwhip effect) are. In this chapter the following research question will be discussed: *‘Which underlying factors in the competitive market have an influence on the bullwhip effect in the supply chain?’*. This chapter can be seen as a link between chapter 3 and 5. In chapter 3 the different thoughts about the bullwhip effect under the presence of market competition were explained (market competition that has a direct- versus an indirect impact on the bullwhip effect). Once this chapter determined the underlying factors in the market, chapter 5 will then be able to conclude whether each specific factor leads directly or indirectly to the bullwhip effect. First a detailed description of market competition will be provided in section 4.1. Subsequently in section 4.2 each specific underlying factor within the competitive market, that leads to the bullwhip effect, will be determined and discussed separately.

### 4.1 Market Competition

In the current society companies are facing a rising pace of competition, a shortening of product life cycles, intense competition in global markets and increased expectations of customers (Lu et al, 2012). These developments have focused the attention of companies on the need to invest in their supply chains. Supply chain management has emerged as one of the major areas for companies to gain a competitive edge (Lee, 2002). Due to this rising competition we face today, investigating the bullwhip effect under the presence of competitive markets responds perfectly to the current state of affairs.

Firm behaviour, within a supply chain, in a situation of market competition is probably one of the most fundamental subjects in economics. This is due to the fact that mostly all firms operate in a supply chain where markets are competitive, or at least to a certain degree (Gu, 2016). In order to fully understand how specific factors in the competitive market can lead to the bullwhip effect, the definition of market competition should be clear. Market competition is a situation in which companies try to be more successful than their competitors in offering the same or a similar good/service or a close substitute. According to BusinessDictionary (n.d.) market competition can be described as: *‘Rivalry in which every seller tries to get what other sellers are seeking at the same time: sales, profit, and market share by offering the best practicable combination of price, quality, and service.’* So, a competitive market is one in which multiple producers compete with one another to deliver goods and services to the customer. Not a single producer can dictate the market, neither consumers can. This means that a single producer or consumer cannot set the price of a product or decide the quantity produced.

According to Gu (2016) there are several conditions linked to the formation of market competition:

- The profit motive: market competition arises when the possibility of profits gives firms an incentive to enter the market.
- Principle of diminishability: stocks of goods will diminish when more products are purchased. Finally, stock will reach zero and prices will go up. Higher prices are an incentive to increase the production.
- Principle of Rivalry: market competition will only occur when consumers and firms compete with one another to secure the benefit of a good or service.
- Excludability: it is essential for market competition that consumers can be excluded from gaining benefits from consumption. If excludability is not met free-riding behaviour can occur.

If the combinations of the above described conditions are met, then competitive markets will establish. There are four basic types of market structures, these are: perfect competition, imperfect competition (or monopolistic competition), oligopoly and monopoly. Only in a monopoly there is no market competition, because a single firm controls the entire market and consumers do not have any alternatives. All the other mentioned market structures (perfect competition, imperfect competition and oligopoly) have a certain degree of market competition.

## **4.2 Underlying Factors in the Competitive Market**

Now that it is clear what a competitive market is, in this section each specific underlying factor within the competitive market that leads to the bullwhip effect will be determined and discussed separately. The study of Ma & Ma (2017) did not go into detail why the bullwhip effect becomes stronger when market competition increases. Therefore, it is important to look at the characteristics of the competitive market that can be associated with the bullwhip effect. By an extensive literature search the following underlying factors in the competitive market, that can be linked to the bullwhip effect, are found:

### **4.2.1 Market Structure**

Competitive markets experience different degrees of competition. This is important to understand, because the degree of market competition influences the bullwhip effect (Ma & Ma, 2017). As mentioned earlier in chapter 3, the higher the degree of market competition the greater the bullwhip effect in the supply chain (Ma & Ma, 2017). Therefore the market structure can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect. Based on the degree of competition the market structure can be classified. To understand the degree of competitiveness in a market it is useful to distinguish between four different market structures, namely: perfect competition, imperfect competition (or monopolistic competition), oligopoly, and monopoly.

### **4.2.2 Optimizing Behaviour**

Staying ahead of the competition is key to survive in a competitive market. To gain a competitive advantage chain members for example plan shipments in their own interest, order in batches and play with prices. All the parties involved in the supply chain have their individual goals, and try to maximize their own profits. This can be seen as optimizing

behaviour at the costs of others. Lee et al. (1997) claims that demand distortion occurs as a result of optimizing behaviours by players in the supply chain, and demand distortion is the main driver behind the bullwhip effect. Furthermore, optimizing behaviour leads to distortion in information sharing and collaboration within the supply chain and eventually to the bullwhip effect (Lee et al, 1997). Therefore optimizing behaviour can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect.

#### **4.2.3 Substitution behaviour**

In competitive markets mostly many substitution products are available for the customer. Firms in a competitive market try to be more successful than their competitors in offering the same or a similar good/service or a close substitute. In a market situation with multiple substitution products the bullwhip effect may exhibit different properties and magnitudes (Duan et al, 2015). According to Duan et al (2015) the bullwhip effect is not only affected by a products own characteristics but also by the factors of its substitute products. Therefore, substitution behaviour can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect.

#### **4.2.4 Pricing Strategy**

In a competitive market pricing strategies are used to gain a competitive advantage (Wang et al, 2014). It can be used to maximize profit, defend the market from new entrants, to increase market share within a market or to enter an entirely new market. Buying patterns can be easily distorted by certain pricing strategies which subsequently can cause bigger variability in demand causing the bullwhip effect (Dai et al, 2017). Therefore, pricing strategies can be seen as an underlying factor in the competitive market, which has an influence on the bullwhip effect.

#### **4.2.5 Innovation**

Another characteristic of the competitive market is the need to innovate. According to Boone (2001) a higher degree of market competition increases the incentive to innovate. Bonanno & Haworth (1998) compared different competitive environments to see whether a more competitive environment established a greater need for innovations. They compared a monopoly with a perfect competitive market, the outcome showed that in a perfect competitive market the incentive to innovate was higher because there was more to gain. Firms that feel comfortable with the status quo or ignore innovation will be left with excess inventory and distorted demand forecasts (Pérez et al, 2017). When the entire supply chain will be left behind compared to the innovators, the effect of demand distortion and excessive inventory will amplify through the entire chain, leading to the bullwhip effect (Pérez et al, 2017). Therefore, innovation can be seen as an underlying factor that has an influence on the bullwhip effect.

### **4.3 Conclusion**

Market competition is a situation in which companies try to be more successful than their competitors in offering the same or a similar good/service or a close substitute. In a competitive market rivals try to increase sales, profit and market share by gaining a



competitive advantage. Within the competitive market several factors are identified which have a significant influence on the bullwhip effect. These factors are: market structure, optimizing behaviour, substitutes, pricing strategies and innovation.

## Chapter 5 – Impact of each Underlying Factor on the Bullwhip Effect

Since chapter 4 identified the underlying factors in the competitive market that have an influence on the bullwhip effect. Now this chapter will elaborate on that by investigating the following research question: *‘What is the impact of each underlying factor of the competitive market on the bullwhip effect?’*. As mentioned in chapter 3 market competition can either have a direct impact on the bullwhip effect (figure 1), or an indirect impact (figure 2). This means that an underlying factor can lead directly to the bullwhip effect or a factor can lead to the causes of the bullwhip effect respectively. Section 5.1 will explain the differences between these two thoughts in more detail. Subsequently, section 5.2 will discuss what the impact of each underlying factor is on the bullwhip effect, so whether it has a direct or indirect impact.

### 5.1 Difference between a direct- and indirect impact

In this section the difference between figure 1 and figure 2 will be explained in more detail, which is the difference between market competition that has a direct impact on the bullwhip effect and market competition as an indirect impact on the bullwhip effect.

#### 5.1.1 Direct Impact

According to Ma & Ma (2017) market competition leads directly to the bullwhip effect. The higher the degree of competition in the market, the more significant the bullwhip effect will be in the supply chain. The effect is a function with respect to the consistency of demand volatility between the retailers, lead time of retailers, span of forecast, prices, order batching and market competition (Ma & Ma, 2017). So, market competition and the traditional causes are both leading to the bullwhip effect (Ma & Ma, 2017). Again, this means that market competition is a factor leading directly to the bullwhip effect. A visual representation of this conceptual model is illustrated in the figure below.

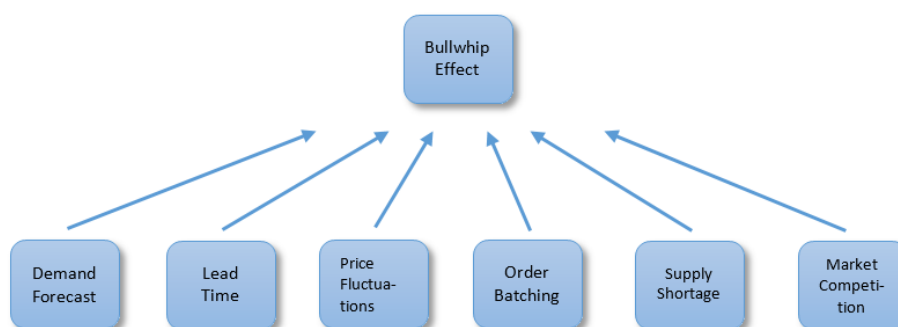


Figure 1: Market competition directly impacting the Bullwhip Effect

#### 5.1.2 Indirect Impact

According to Geary et al. (2006) and Lee et al. (1997) market competition has an indirect impact on the bullwhip effect. According to Geary et al. (2006) the marketplace leads to uncertainties concerning processes, supply, demand and control functions. One of the main

factors leading to the bullwhip effect is uncertainties within the chain (Wang & Disney, 2016). Therefore, the marketplace leads to the causes of the bullwhip effect, which is in line with figure 2. According to Lee et al. (1997) demand distortion arises as a result of optimizing behaviours by members in the supply chain and demand distortion is a major factor that causes the bullwhip effect. This optimizing behaviour can be interpreted as market competition. So, in a competitive market circumstances arise that create the traditional causes of the bullwhip effect. Figure 2 illustrates the indirect impact of market competition on the bullwhip effect as the findings of Geary et al. (2006) and Lee et al. (1997) state.

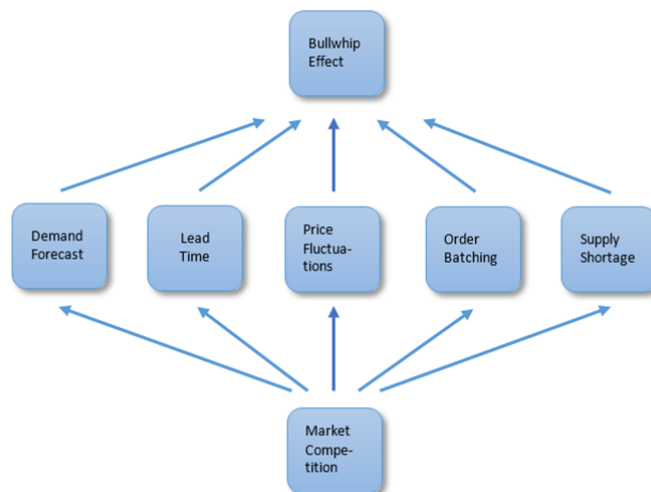


Figure 2: Market competition indirectly impacting the Bullwhip Effect

## 5.2 Impact of each underlying factor

Since market competition is hard to be adjusted to reduce the bullwhip effect (Ma & Ma, 2017), this paper investigated if underlying factors in the market are more determinative as factors leading to the bullwhip effect. In the following subsections it will be investigated whether each specific underlying factor has a direct- or indirect impact on the bullwhip effect.

### 5.2.1 Market Structure

Competitive markets experience different degrees of competition. This is important to understand, because the degree of market competition influences the bullwhip effect (Ma & Ma, 2017). As mentioned earlier in chapter 3, the higher the degree of market competition the greater the bullwhip effect in the supply chain (Ma & Ma, 2017). Therefore the market structure can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect. Based on the degree of competition the market structure can be classified. To understand the degree of competitiveness in a market it is useful to distinguish between four different market structures, namely: perfect competition, imperfect competition (or monopolistic competition), oligopoly, and monopoly. The following subsections will briefly discuss these four different market structures with different degrees of market competition, so it will be clear which different degrees of competition are linked to the bullwhip effect.

### **5.2.1.1 Perfect Competition**

Perfect competition is the market structure in which the competition in the market is the highest, it can be seen as the purest form of competition. Therefore it can be concluded that in a perfect competitive market the bullwhip effect will probably be most significant. This means that the closer the market structure is to perfect competition, the worse it is for the entire supply chain because of the costs associated with the bullwhip effect. A perfect competitive market is defined by certain conditions. According to Azevedo & Gottlieb (2017) the following conditions are met in a perfect competitive market:

- Many buyers and sellers.
- All firms sell an identical product, which means that the product is homogeneous and can be substituted at no cost.
- No actor is able to have an effect on the market price, they cannot influence the market price of the product.
- There is no preference between different sellers, which mean that customers do not have a preference for a certain seller of the product.
- Buyers have perfect information about the product sold and the prices charged by each firm.
- Firms can enter or exit the market without costs.
- Firms can only experience profits or losses in the short run.
- Resources are perfectly mobile.
- There are no transaction cost affecting the market.
- Buyers are rational, which means that buyers make no trade if it does not increase their utility.

### **5.2.1.2 Imperfect Competition or monopolistic competition**

The idea behind perfect competition is a hypothetical situation, which does not apply in the real world because it relies on too many assumptions. However, in almost all markets there is competition which is not 'perfect'. We call this a distorted market or imperfect competition. Imperfect competition is any departure from the ideal of perfect competition, this means that one of the conditions attached to perfect competition is not satisfied. This is in contrast with the economic agent trying to maximize social welfare, in case of a distortion (imperfect competition) social welfare goes down due to maximization of own interests (Skoorka, 2000). Asymmetric information, uncertainty, unequal market power, illiquidity of the market, non-rational behaviour by market participants, price fluctuations and market externalities are properties of imperfect competition. In reality many imperfect competitive markets exist, examples of imperfect competitive industries are: automobiles, telecommunications, soaps, cosmetics and technology. An imperfect competitive market experiences a relatively high degree of competition, and therefore the bullwhip effect in an imperfect competitive market will be relatively high. According to Investopedia (n.d.) Imperfect competition is defined by the following conditions:

- There are few to many players in the market.

- The goods sold are differentiated. This means that even though the customer has mostly the same needs, small differences in the product supplied by the firms allow customers to create preferences based on differentiation.
- Due to differentiation customers develop preferences for some companies. This means the customer is willing to spend more money for a specific brand or product.
- As a result of customer preferences, some firms may gain a certain degree of market power and charge a premium price. Hence, firms can directly influence the market price to a certain degree and are no longer price takers.
- Actors in the market have imperfect information and there are restricted possibilities to enter the market.

### **5.2.1.3 Oligopoly**

An oligopoly can be described as a market structure in which only a small number of firms dominate the market. However, it is not clearly defined what a 'small number of firms' exactly is. As a rule of thumb, mostly approximately 3-5 dominant firms are considered in an oligopoly. This leads to a state of limited competition. According to Investopedia (n.d.) the oligopolistic market structure builds on a few assumptions:

- Firms maximize their profit
- Firms in the oligopoly can set prices
- There mostly are relatively high barriers to enter or exit the market
- Product can be homogenous or differentiated
- Only a few firms dominate the market

### **5.2.1.4 Monopoly**

A monopoly refers to the market structure in which a single firm controls the entire market place. In this situation the firm has the highest level of market power. Consumers can only choose the monopolistic firm and therefore have no alternative to choose from. According to Investopedia (n.d.) the following assumptions are met in a monopoly:

- The monopolist maximizes profit
- The monopolist can set the price
- There are high barriers of entry and exit
- Only one firm dominates the market

A monopoly is the only market structure in which there is no degree of market competition. Therefore in case of a monopoly market competition cannot be a factor leading to the bullwhip effect. From a social perspective a monopoly is mostly not desirable. Monopolists often produce relative few products for relatively high prices, compared to a competitive market structure situation.

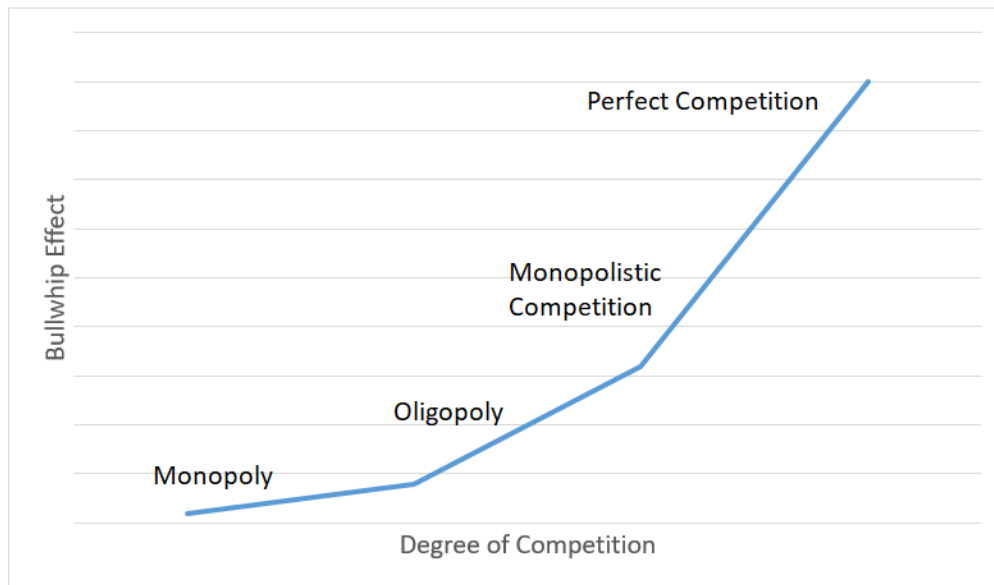


Figure 5: Market structure and the value of the Bullwhip Effect

According to Ma & Ma (2017) An increase in market competition results in an increase in the absolute value of the bullwhip effect in supply chains. This means that the degree of competition has a direct impact on the bullwhip effect. Based on the degree of competition, the market structure can be classified. It can be concluded that the market structure (with its specific degree of competition) is a factor that directly leads to the bullwhip effect, and not to one of the causes of the effect.

### 5.2.2 Optimizing Behaviour

Lee et al. (1997) claims that demand distortion occurs as a result of optimizing behaviours by players in the supply chain, and demand distortion is the main driver behind the bullwhip effect. All the parties involved in the supply chain have their own goals, and try to maximize their own profit. In order to maximize profits they can plan shipments in their own interest, order in batches and play with prices in order to gain an advantage against their competitors. Optimizing behaviour and staying ahead of the competition is key to survive in a competitive market. However, optimizing behaviour also leads to distortion in information sharing and collaboration within the supply chain and eventually to the bullwhip effect (Lee et al, 1997). Therefore optimizing behaviour can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect.

Nowadays companies no longer operate as an independent entity, but rather as supply chains. However, firms still often try to optimize their profits at the costs of their fellow supply chain members (Pacarizi & Hsu, 2013). According to Pacarizi & Hsu (2013) the main objective of supply chain management is to manage the entire supply chain and its related operations efficiently and effectively. This can be done by creating a seamless process between all supply chain member in which all the activities are coordinated and integrated in a smooth way. Wang & Disney (2016) point out that the integration, both upstream and downstream, of the different members in supply chain is crucial to establish a successful

supply chain. Supply chain integration can be described as two or more firms together agreeing and conducting on activities in the supply chain, which especially refers to information and organizational integration (Pacarizi & Hsu, 2013). Information integration means sharing information and knowledge about the flow of products, material and services. It aims at improving decision making through the sharing of essential information. Subsequently, organizational integration refers to the extent of integration in relationship between supply chain members and in organizational structure. According to Bagchi & Skjoett-Larsen (2003) information and organizational integration will ensure that supply chain members will have a better collaboration in their operational and planning activities, and will behave more like one unified entity instead of separate businesses.

Another definition of supply chain integration is given by Simatupang & Sridharan (2002), they point out that a number of objects such as decisions, actions, objectives and information should be in line with each other to achieve real supply chain integration. These objects are aimed at achieving chain goals. However, supply chain members operate independently. Each member has their own objectives, resources and planning, which in case leads to different goals and interests. Differences between supply chain members and uncertainties result in conflicts. Pacarizi & Hsu (2014) define conflicts as goals that are incompatible or in contrast among supply chain members. Poor supply chain integration, due to conflicting goals (which is a consequence of optimizing behaviour), can lead to dysfunctional operational performances and has a negative influence on the entire supply chain (Simatupang & Sridharan, 2002).

So, as a consequence of optimizing behaviour demand distortion in the chain occurs, subsequently demand distortion leads to the bullwhip effect (Lee et al, 1997). As a result of optimizing behaviour firms plan shipments in their own interest, order in batches and play with prices in order to gain an advantage against their competitors (Lee et al. 1997). Therefore, optimizing behaviour can be seen as a factor that leads to the causes of the bullwhip effect, and is not a factor that has a direct impact. Research did not come up with evidence that the more chain members elaborate in optimizing behaviour, the higher the bullwhip effect will become.

### **5.2.3 Substitution behaviour**

In competitive markets mostly many substitution products are available for the customer. Firms in a competitive market try to be more successful than their competitors in offering the same or a similar good/service or a close substitute. Substitution behaviour can be seen as an underlying factor in the competitive market that has an influence on the bullwhip effect. In a market situation with multiple substitution products the bullwhip effect may exhibit different properties and magnitudes (Duan et al, 2015). According to Duan et al (2015) the bullwhip effect is not only affected by a products own characteristics but also by the factors of its substitute products.

According to Investopedia (n.d.) a good is considered a substitution good when a consumer perceives this product as the same or very similar to another product. Particular characteristics or features should be related or similar to the substitution good. A distinction

can be made between perfect substitutes and less perfect substitutes. For example, consumers are relatively indifferent for certain brands when it comes to bananas. In this case price and availability are factors considered important when deciding whether or not to buy a certain banana. However, most products are not perfectly substitutable. The main problem for supply chains regarding substitution is the changing behaviour of consumers. Often substitution goods are seen as external factors in the competitive market that are outside the range of control (Rajaram & Tang, 2001).

Stock-outs and price changes are major factors leading to substitution behaviour and are major drivers for the bullwhip effect (Duan et al 2015). For example, stock-outs of the focal product result in an increase of the demand of the substitute product, and a price increase in the substitute product leads to an increase in demand of the focal product. According to Duan et al (2015) for both price changes and stock-outs there are two properties for the bullwhip effect: *'one is the effect of a focal product's own price changes or own stockouts on its bullwhip effect, and the other is the effect of substitute products' price changes and stockouts on the focal product's bullwhip effect.'*

Substitution behaviour as a consequence of price changes is measured by the price elasticity of that product. It refers to the responsiveness of the customer buying behaviour related to changes in price. Demand signal processing suggest that firms try to predict increases and decreases in demand, and accordingly adjust their forecasts. Substitution behaviour due to price changes make it more difficult for firms to correctly forecast the customer demand. Subsequently, this may lead to smaller or larger orders, and thereby resulting in a greater bullwhip effect (Duan et al, 2015). Both own price changes and price changes of the substitution good affect the bullwhip effect through the erroneous demand signal processing. Firms typically forecast and plan demand based on of own price changes, however changes in the price of substitute products are often not taken into account. This may lead to unforeseen variance of the effective demand quantity, resulting in incorrect forecasting and the bullwhip effect (Duan et al, 2015).

In addition to price changes, substitution behaviour can be strengthened by stock-outs. When demand is higher than expected, this may result in a shortage of inventory, resulting in stock-outs. Mostly stock-outs are more drastic than price changes, this is because in case of stock-outs all orders have to be cancelled. Stock-outs affect the bullwhip effect through behavioural causes (managers perceptual biases), which is different from price changes. Managers can for example overreact to certain signals, they tend to respond to optimistic to spikes in demand (they place even larger than usual orders in situations of demand spikes). When a firm experiences stock-outs managers tend to place larger orders than usual, which amplifies further upstream, resulting in the bullwhip effect (Duan et al, 2015). The results are increased internal cost, uncertainty, and volatility with respect to replenishment orders. In case there are frequent stock-outs for the substitution good, the demand of that good will decrease and shift to the focal product. Hence, changes in demand variations due to shifted demand from stock-outs of the substitution good result in changes in the bullwhip effect. The shifted demand toward the focal product increases the focal products demanded quantity, leading to demand spikes.



Substitution goods can influence the demand of a product, without any change to the inherent characteristics of the focal product (Duan et al, 2015). Unexpected switching behaviour (due to substitution goods) of consumers creates inventory build ups, especially upstream the supply chain, enlarging the bullwhip effect. Therefore the bullwhip effect within a supply chain is partly dependent on the substitution behaviour of consumers. Especially in innovative markets, where staying ahead of competitors is crucial. To stay ahead of the competition firms extend their product offerings. By offering a wider range of products, consumers tend to see these products more substitutable (Rajaram & Tang, 2001). Customer loyalty is a key goal of firms, therefore losing customers because of substitution can seriously threaten the entire supply chain (Rajaram & Tang, 2001).

So, unexpected switching behaviour (due to substitution goods) of consumers creates inventory build ups, especially upstream the supply chain, enlarging the bullwhip effect. Therefore, the bullwhip effect within a supply chain is partly dependent on the substitution behaviour of consumers, and can be seen as a factor that directly impacts the bullwhip effect. The higher the substitution behaviour, the more significant the bullwhip effect (Duan et al, 2015).

#### **5.2.4 Pricing Strategy**

In a perfect competitive market no single firm can influence the market price. Firms are set to be price takers, the price is decided by the market mechanism (the point where supply and demand meet each other). A single firm will not increase its price due to the fact that it will not sell any products above the market price. Furthermore a single firm will not decrease its price due to the fact that it is given that the firm can sell all its products at the market price.

However, as mentioned earlier perfect competition is a hypothetical situation. In reality a business can use a variety of pricing strategies when selling a product or service. In a competitive market pricing strategies are used to gain a competitive advantage (Wang et al, 2014). It can be used to maximize profit, defend the market from new entrants, to increase market share within a market or to enter an entirely new market. Buying patterns can be easily distorted by certain pricing strategies which subsequently can cause bigger variability in demand causing the bullwhip effect (Dai et al, 2017). Therefore pricing strategies can be seen as an underlying factor in the competitive market, which has an influence on the bullwhip effect.

To gain advantage over competitors retailers introduce price discounts and sales, this way they try to give sales a boost. During the promotional period a relatively large quantity of products is sold, which is often followed by a low level of sales after this period. Figure 6 refers to the dynamic situation which shows that when the price is reduced during a promotional period, the demand increases significantly.

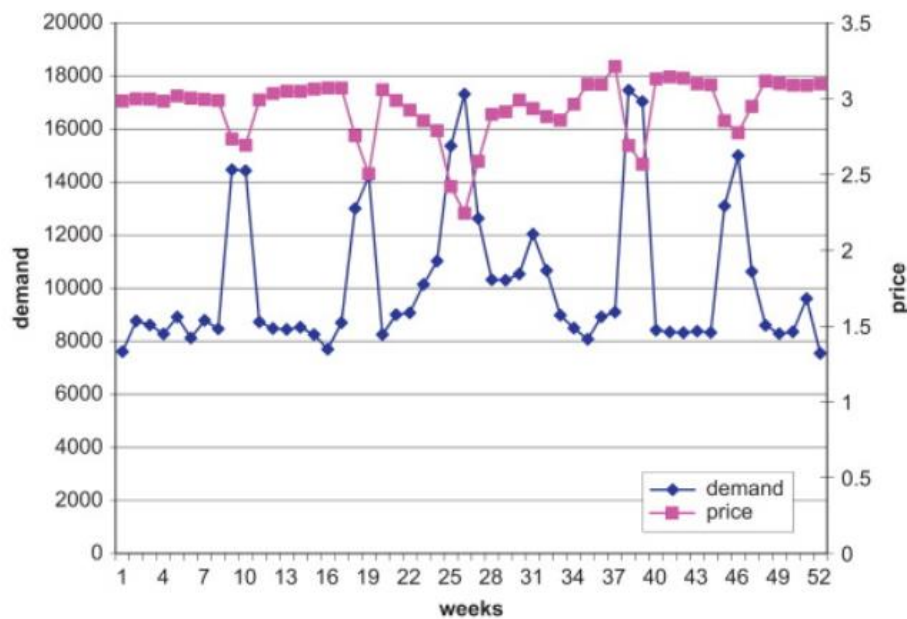


Figure 6: Demand and price during promotions

In a competitive market the firms decision on the price of the product and the pricing strategy impacts the decision of the rational consumer. The rational consumer is sensitive to price changes, this means that the price of the product is an important factor in deciding whether or not to but a product. Therefore, one of the main marketing strategies with a significant impact on demand is price fluctuation (Lu et al, 2012). As price fluctuates during time, the rational consumer may purchase more in advance to reduce its future needs in anticipation of higher prices in the future, or the consumer may decide to delay a purchase in anticipation of a lower future price (Wang et al, 2014). This means that the demand in a certain period is the function of both the price in that period and prices in the past and future.

To stay ahead of the competition firms must be attentive to competitors actions. This may lead to all kind of promotions like temporary price discounts, consumer coupons, quantity discounts or firms even get caught up in price wars. Through these price fluctuations customers evolve in price forecasting behaviour, which leads to spikes in demand in certain periods (a distorted demand) (Wang et al, 2014). These causes the tendency of orders to increase in variability as one moves further down the supply chain, leading to the bullwhip effect (Wang et al, 2014). Price fluctuations can occur both upstream and downstream in the supply chain, this means that discounts are offered to customers along the chain. Another unintended consequence of price discounts, particularly when there are offered frequently, is that customers are going to expect these discounts. Subsequently customers only buy items when they are on sale, leading to an even bigger distorted demand (Wang et al, 2014). Overall pricing strategies that concern any kind of promotion are harmful for the entire supply chain.

So, buying patterns can be easily distorted by certain pricing strategies which subsequently can cause bigger variability in demand causing the bullwhip effect (Dai et al, 2017). Price fluctuations are already seen as one of the traditional causes that lead to the bullwhip effect.

Therefore, it can be concluded that the factor 'pricing strategies' leads directly to the bullwhip effect.

### **5.2.5 Innovation**

Another characteristic of the competitive market is the need to innovate. According to Boone (2001) a higher degree of market competition increases the incentive to innovate. Bonanno & Haworth (1998) compared different competitive environments to see whether a more competitive environment established a greater need for innovations. They compared a monopoly with a perfect competitive market, the outcome showed that in a perfect competitive market the incentive to innovate was higher because there was more to gain.

In highly competitive markets, the so called 'neck-and-neck' sectors, innovation is crucial to survive and is aimed at escaping the competition (Bonanno & Haworth, 1998). Escaping the competition can be done by a disruptive innovations. A disruptive innovation refers to an innovation that creates an entirely new market, leading to new supply chains, and new ways of collaboration. Thereby disrupts the existing market and value network (Pérez et al, 2017). Disruptive innovations are different from sustaining innovations, that only tries to improve existing products by targeting existing customers. The disruptive innovation first takes roots in the bottom of the market and then relentlessly moves up and penetrates the market, ending up in displacing the established competitors (Pérez et al, 2017). An example is the mass-produced automobile which disrupted the transport market. Another example is the introduction of the electric car, which disrupts the supporting network for gas driven cars (network of gas stations). Testing the boundaries of the market has become the new norm and therefore disruptive innovations become more and more common (Pérez et al, 2017). Blockchain technology, autonomous vehicles, virtual reality, internet of things, drones, 3-D printing and renewable energy are some more examples of disruptive innovations. In the long run implications for the adoption of disruptive innovations can be truly profitable.

Once a disruptive innovation changes the established product or service a radically new way of doing things is introduced. Mostly it takes a while for the 'old product or service' network to adapt to the new situation. Just like any innovation, a disruptive innovation has to go through some phases in the supply chain: adoption, acceptance and implementation. However, the fact that disruption can take time explains why incumbents frequently overlook disrupters. Firms that feel comfortable with the status quo or ignore trends will be left with excess inventory and distorted demand forecasts due to the disruptive innovation (Pérez et al, 2017). When the entire supply chain will be left behind compared to the disruptive innovation, the effect of demand distortion and excessive inventory will amplify through the entire chain, leading to the bullwhip effect.

So, firms that feel comfortable with the status quo or ignore innovation will be left with excess inventory and distorted demand forecasts (Pérez et al, 2017). This means that innovation can lead to the causes of the bullwhip effect and can be seen as a factor that indirectly influences the bullwhip effect. Research did not find any evidence that an increase in the incentive to innovation leads to a higher value of the bullwhip effect. Nevertheless, innovation does lead to one of the traditional causes of the bullwhip effect, namely distorted demand forecasts (Pérez et al, 2017).

### **5.3 Conclusion**

Each factor that is identified as an underlying factor of the competitive market can either have a direct- or indirect impact on the bullwhip effect. The difference is that a factor can directly cause the bullwhip effect, or a factor can lead to the causes of the bullwhip effect. Market structure, substitution behaviour and pricing strategies are ranked as factors that directly lead to the bullwhip effect. However, optimizing behaviour and innovation results in the causes of the bullwhip effect and therefore have an indirect impact on the bullwhip effect.

## Chapter 6 – Measures to Reduce the Bullwhip Effect

Chapter 4 identified the underlying factors in the competitive market. Subsequently, chapter 5 established whether each specific factor either has a direct or indirect impact on the bullwhip effect. The purpose of this literature study is to create useful and applicable literature for managers operating in the supply chain. For managerial implications it is crucial to understand how these factors influence the bullwhip effect, so that managers can come up with strategies to tackle the bullwhip effect. Therefore, this chapter discusses the following research question: *‘What are possible managerial implications to reduce the bullwhip effect, under the presence of competitive markets, in the supply chain?’*. Section 6.1 will explain the benefits of bullwhip reduction, subsequently section 6.2 will discuss several general strategies to reduce the bullwhip effect. Finally section 6.3 will determine how each specific factor in the competitive market can be tackled to reduce the bullwhip effect.

### 6.1 Benefits of Bullwhip Reduction

The bullwhip effect is a common problem in supply chains. The effect is in contrast with the a major objective of an effective supply chain, namely the creation of value for customers and just-in-time product availability without waste (Lee et al, 1997). The bullwhip effect has multiple negative consequences for the supply chain and is in contrast with the above described major objective of an effective supply chain. It impacts the supply chain on several levels, all of which can cause extra costs for individual members of the supply chain and for the supply chain as a whole. Costs related to the bullwhip effect are associated with hiring and firing of the workforce, setting up and shutting down machines, excessive upstream inventory, poor supplier/customer relationships, overtime in the workload and difficulty in forecasting and scheduling (Wang & Disney, 2016). Variables leading to the bullwhip effect can cause either an excess or a lack of inventory. Misguided forecasts result in inadequate inventories. On the one hand excess inventory can lead to extra inventory holding costs, wasted resources, and inefficient production (Wang & Disney, 2016). On the other hand a lack of inventory (stock outs) can lead to poor customer service, due to unfulfilled orders and unavailable products. Lost sales are also a cause of stock outs. Furthermore poor customer service due to stock outs damage the public image and lowers the loyalty of customers (Wang & Disney, 2016). Moreover, the bullwhip effect can cause pressure on suppliers, which may result in tensed relationships between suppliers. Managing demand variability also brings extra cost due to the repeated hiring (training costs) and dismissal of temporary employees. Overall the bullwhip effect increases logistical costs and lowers the competitive ability and is negatively evaluated by all the members in the supply chain (Nienhaus et al, 2006).

An efficient supply chain means reducing the bullwhip effect. As described above, the bullwhip effect has a lot of negative consequences for the supply chain. The benefits of reducing the bullwhip effect are lower inventory cost, production costs, transportation costs and improved customer service throughout all different stages involved in the supply chain network (Sarimveis et al, 2008). These are typical benefits accruing from the reduction of the bullwhip effect. However, when reducing the bullwhip effect other performances within the

supply chain simultaneously improve. According to Sarimveis et al. (2008) important to emphasize is that (when the bullwhip effect is reduced) the bullwhip induced production and operations are substantially improved as well. Furthermore, according to Miragliotta (2006) reducing the bullwhip effect has a positive effect on the profitability of a firm. It is proven that, strongly dependant on the business context and its cost structure, reducing the bullwhip effect can lead to an increase in product profitability up to 30% (Miragliotta, 2006). Finally, Rinks (2002), showed that entirely eliminating the bullwhip effect may reduce supply chain costs up to 50%.

## **6.2 Strategies to Reduce the Bullwhip Effect**

As mentioned in section 6.1 there are many negative consequences and costs associated with the bullwhip effect. For this reason it is beneficial for firms and their supply chains to apply solid strategies to reduce the bullwhip effect, and thereby increasing profitability and reducing costs (Miragliotta, 2006). In the following sub sections three general strategies to weaken the bullwhip effect will be discussed.

### **6.2.1 The establishment of supply chain strategic alliances**

To overcome inaccurate demand forecasts and a lack of information sharing, a supply chain can adopt the strategy of 'establishing supply chain strategic alliances' (Dai et al, 2017). Upstream supply parties can only obtain demand information from downstream suppliers. A more stable supply chain can be established by forming strategic alliances in which information is shared up- and downstream the chain. The information must be transparent and synchronized, so that the accuracy of the forecast can be improved. A great example of a strategic alliance refers to Wal-Mart and Procter & Gamble. P&G is the world's biggest manufacturer of daily necessities and Wal-Mart is world's largest retail operation. They together formed a special cooperation team with people from production, finance, circulation and many more departments. The team was established to form a collaborative management to take advantage of logistics. They implemented all kind of systems to create a more effective supply chain. Examples are an electronic data interchange system and satellite communication to increase the understanding of the information in the network. With the use shared information systems they were able to keep up-to-date data concerning sales, inventory and prices. This accurate information base made it possible to develop their product and R&D plans in line with the market demand. This consequently prevented excessive inventory, stock outs and made timely deliveries possible. Dai et al. (2017) effectively summarized the strategic alliance between Wal-Mart and P&G: *'Wal-Mart and Procter & Gamble's production and marketing strategic alliance, to reduce unnecessary inventory, save the cost of circulation, to achieve the information sharing and elimination of information game, making the two companies get a win-win situation, have an absolute effective control of the bullwhip effect.'*

### **6.2.2 Application of the Internet of Things**

The internet of things is a network that consist of physical devices, home appliances, vehicles and other items linked through radio frequency identification, infrared sensors, global positioning systems, laser scanners, software, and other information sensing equipment. The connectivity between these factors enable these objects to connect and exchange data

through the internet. The goal of the internet of things is the exchange of information, and communication to achieve object identification, tracking, location, monitoring and management (Dai et al, 2017). The internet of things is used in the logistics network of supply chains. Because the entire system is built via the internet, the system has unlimited openness and transparency, can quickly exchange data and an enormous capacity. Through the internet of things the information flow up- and downstream the chain is more accurate. Furthermore scale advantages are obtained through the internet of things, which reduces the operational costs of the system (Dai et al, 2017). Overall, with the implementation of the technologies that come with the internet of things information flows can be improved, making the supply chain more rapid and smooth.

### **6.2.3 Establish a supply chain effective model**

According to Geary et al. (2006) a more effective supply chain that exhibits a greatly reduced bullwhip effect can be achieved by the following routine: understand-document-simplify-optimize (UDSO). This routine can be seen as a supply chain re-design tool. It identifies and eliminates all factors leading to poor material and information flows. There are several examples in the real business world in which this procedure reduces the bullwhip effect by 50% (Geary et al, 2006). Furthermore with the UDSO procedure stock holding costs decreased, customer service levels simultaneously increased, and the standard deviation of delivery variation decreased by 70% (Geary et al, 2006).

Business process reengineering is also an often used tool to establish an effective supply chain. This method aims towards an integrated supply chain with much better visibility, which lowers uncertainty and increases performances. Note that lower uncertainties lead to higher integration, which decreases uncertainties further (cycle continuous), resulting in smooth information and material flows and a minimal bullwhip effect (Gairy et al, 2006).

Forrester and Burbidge where the pioneers in bullwhip reduction, the study of Geary et al. (2006) summarized the findings of Forrester and Burbidge and came up with five principles to reduce the bullwhip effect and establish a more effective supply chain:

- Control system principle: To achieve targets members in the supply chain must select the most appropriate control system that best suits their desires. This means taking unnecessary guesswork out of the system.
- Time compression principle: To establish an effective supply chain without the bullwhip effect, every operational activity taken in the supply chain should be in the minimum time needed to achieve task goals. This means getting rid of non-value added time activities in the system, and delivering orders just in time.
- Information transparency principle: All supply chain members should have unlimited access to up-to-date data, free of noise and biases, concerning inventories, flow rates and other essential information. This increases the visibility in the chain and creates an holistic overview for the members.
- Echelon elimination principle: Minimizing the number of echelons creates more transparency and helps in achieving chain goals. The aim of this principle is to optimise the level of inventories and stock them at the right place at the right time.

- Synchronisation principle: Synchronisation of activities and operations in the supply chain are critical to reduce the bullwhip effect. Events must be synchronised so that deliveries and orders are visible at specific points in time. This can be done by continuous synchronised orders.

### **6.3 Tackling the Causes of the Bullwhip Effect**

Since section 6.2 discussed some general reduction strategies, this section will go more into detail by using these strategies to tackle all the causes (traditional causes, market competition and the underlying factors in the market) leading directly or indirectly to the bullwhip effect. According to Ma & Ma (2017) reducing the bullwhip effect under the presence of market competition can be done by tackling the five traditional causes. The factors that directly lead to the bullwhip effect need to get priority to minimize the effect. Therefore the major countermeasures to reduce the bullwhip effect according to Dai et al. (2017) are: *'achieve information sharing, avoid the multi-demand forecast; implementation of outsourcing services to shorten the lead time; reduce bulk orders; reduce price promotions, avoidance of variability; circumvent short game situations; Inventory responsibility and so on.'*

In the following subsections different measures will be discussed to reduce the bullwhip effect by tackling the five traditional causes and market competition, and by tackling the underlying factors of the competitive market that lead directly or indirectly to the bullwhip effect.

#### **6.3.1 Traditional Causes and Market competition**

##### **6.3.1.1 Demand Forecasting**

Distortion in demand information occurs when demand forecasts by the retailer is updated in deviation from the real customer demand. Consequently the manufacturer loses sight of the actual demand in the market, leading to an inefficient production schedule. As the number of players in the channel increases, the distortion gets amplified further upstream the chain. An appropriate solution for this problem is to provide access to demand data (Dai et al, 2017). Electronic data interchange systems used by all members is an effective way to share demand information. These systems grant easy and quick transmission of demand data up- and downstream the chain. The computer industry is increasingly requested to make such sell-through data systems. However, access to a common data set for forecasting demand is not the total solution to reduce distortion in demand. Demand distortion and fluctuations in orders will still appear when firms use different forecasting methodologies. Therefore to eliminate the bullwhip effect a centralized forecasting method must be established (Dai et al, 2017). A single member in the chain executes the forecast and orders for all the other parties. This is a so called centralized multi-echelon inventory control system, which is superior to independently operating site based inventory control systems (Lee et al, 1997). Furthermore the elimination of intermediaries in the channel can smoothen the demand forecasts. Another countermeasure for the bullwhip effect is the shortening of lead times. Lead time reduction leads to better forecasts due to the fact that



less time is needed for orders to reach the customer, so orders are more in line with the real demand of the market.

#### **6.3.1.2 Lead Time**

Order information goes through the following phases: retailers, wholesalers, manufacturers, suppliers. This process will certainly lead to delays in logistics and information. Delays in logistics and information are the reason for upstream firms to increase their safety stock. The longer the lead time, the larger the demand prediction error. This leads to the bullwhip effect and is unfavourable for the entire chain. Countermeasures to reduce the lead time are: lead time contracts with every supplier, increase order frequency, share sales data with suppliers, automate inventory management and provide forecasts to your supplier (Chen et al, 2000). The benefits of a reduction in lead time are more flexibility during rapid shifts in the market, ability to outpace competitors, avoidance of stock outs, and increased cash flow due to an increased order fulfilment (Chen et al, 2000).

#### **6.3.1.3 Price Fluctuations**

To minimize the bullwhip effect price fluctuations must be reduced. Both the frequency and the depth of promotions must be lowered to reduce the effect. An effective strategy to accomplish this is everyday low prices (EDLP). Price fluctuations can happen either upstream or downstream the supply chain, since discounts can be given to customers along the supply chain (Lu et al, 2012). Therefore, everyday low prices must be implemented throughout the chain to be effective.

Another way to reduce the negative effect of price fluctuations are purchase contracts (Dai et al, 2017). Strategic buying occurs because discounts are offered in a short period of time. This is beneficial for the buyer, but negatively evaluated by the manufacturer due to uneven production schedules, distorted demand information and unnecessary inventory costs. When both the buyer and the manufacturer engage in a purchase contract, then the manufacturers 'pain' and the buyers 'gain' do not have to occur at the same time. In fact, manufacturers may keep up their high-low pricing strategy, by synchronizing their delivery and purchase schedules. This means that the buyer agrees with a large quantity bought at a certain discount rate, but the products are then delivered in several future time periods. Orders are more evenly spread this way. Overall the buyer can still maintain their strategic buying and the manufacturer can plan production more efficiently. So, the bullwhip effect can be reduced and both parties can save inventory holding costs.

#### **6.3.1.4 Order Batching**

Batching happens because significant economies of scale can be achieved (Hussain & Drake, 2011). It refers to ordering goods at a certain point in time, mostly because it has material, financial or logistic benefits. These time phased production or orders are mostly not synchronized with the actual demand due to upstream time delays. Periodic batching causes swings in demand. Periods of time with no or just little orders, and other time periods with relatively large orders (Wang & Disney, 2016). These batched cause major variabilities and are amplified as it passes up the supply chain, leading to the bullwhip effect (Wang & Disney, 2016). Reducing transaction costs lowers the need for order batching, and can therefore be seen as a countermeasure. Mostly high transaction cost arise from processing requirements

and paperwork needed to generate an order. As a result of lower transaction costs the chain orders batches in smaller sizes and more frequent, which results in a lower level of demand distortion up- and downstream the chain. Moreover, more efficient production and delivery schedules can be accomplished and the bullwhip effect can be minimized. Another way to influence batching decisions is to coordinate delivery schedules. This can be achieved by allowing retailers to order an assortment of goods to fill a truckload or get a volume discount. Furthermore the introduction of time slots and third party logistics can balance the orders (Dai et al, 2017).

#### **6.3.1.5 Supply Shortage**

There are several possibilities in which information distortion can occur in a situation of supply shortage. The first one is when information distortion results from retailers who see the possibility of being placed on allocation by manufacturers due to shortage. In this setting orders placed by retailers has little value to the manufacturer, because orders placed by the retailer are based on strategic decision (retailers place a higher order to be sure to have enough products available) and not based on real demand. To avoid this problem manufacturers can come up with different allocation systems, to supply their retailers in a shortage situation (Dai et al, 2017). One of them is allocation based on market share or on historical sales data. An even more efficient solution is to work with contracts which restrict the buyers flexibility. Contracts make sure that the choices of order quantities, free return and order cancellation is constrained (Geary et al, 2006). Shortage gaming will be restricted and risks are lowered. Moreover, risk and shortage gaming can be prevented by sharing risk and demand information. This can be done when firms reserve a suppliers product or capacity way ahead of time, so that both parties are secured.

Another situation in which the bullwhip effect arises due to supply shortage is when retailers try to protect themselves against imaginary shortage. Manufacturers can prevent this from happening (to a certain degree) by sharing their inventory and production information with their downstream partners. This information sharing can take away the imaginary shortage and therefore retailers motivation for shortage gaming.

#### **6.3.1.6 Market Competition**

Market competition is difficult or even impossible to be adjusted to reduce the bullwhip effect (Ma & Ma, 2016). This is due to the fact that the market structure (degree of competition) is impossible to be changed by managers.

### **6.3.2 Underlying factors of the competitive market**

#### **6.3.2.1 Optimizing behaviour**

Optimizing behaviour and staying ahead of the competition is key to survive in a competitive market. Lee et al. (1997) claims that distortion in demand, information sharing, and collaboration occurs as a result of optimizing behaviours by players in the supply chain. This distortion will lead to the bullwhip effect (Lee et al, 1997). If parties involved in the supply chain operate independently and have their own objectives, resources and planning, this leads to different goals and interests. Poor supply chain integration due to conflicting goals

can lead to dysfunctional operational performances and has a negative influence on the entire supply chain (Simatupang & Sridharan, 2002). A good example of optimizing behaviour in the supply chain and conflicting goals are Wal-Mart and P&G. They experienced a 'cold war', trying to steal each other's market share and trying to control each other's sales prices and conditions. However, the two soon realized the benefits of cooperation and started a strategic alliance, which in case delivered them a win-win situation (Dai et al, 2017). Problems in supply chains are mainly the results of people (80%) and only 20% technology based (Dai et al, 2017). Managers often ignore the consequences of their behaviour and are not objective enough to make good decisions. So, the countermeasure of optimizing behaviour is the recognition of the benefits of cooperation in the chain. Optimizing behaviour only leads to short term benefits. However, in the long term collaboration is way more beneficial (Dai et al, 2017). Wang & Disney (2016) point out that the integration, both upstream and downstream, of the different members in supply chain is crucial to establish a successful supply chain. According to Bagchi & Skjoett-Larsen (2003) information and organizational integration will ensure that supply chain members will have a better collaboration in their operational and planning activities, and eventually lead to higher profits for the entire chain.

#### **6.3.2.3 Substitution behaviour**

The two main drives for substitution behaviour in the market are stock outs and price changes. The biggest problem arising from stock-outs is the harm in trustworthiness of the firm. *'Stock-outs adversely impact not just the profits earned on the out-of-stock item, but also other items in that order.'* (Anderson et al, 2006). For service or multiproduct firms, this can seriously harm their service and product lines. Consumers expect to get what they ordered at the time promised to them. If this is not happening for product A, consumer may lose confidence in both product B and C as well. Note that additional orders may possible even become irrelevant to consumers. Certainly when it concerns complementary goods. A lack on consumer confidence will, in the long run, lead to a decline in consumer loyalty, sales and public image. To prevent this from happening, firms could offer discounts in the hope that customers backorder. This is always more beneficial than a cancelled order. Furthermore firms could keep a higher safety stock, in order to prevent substitution behaviour due to stock outs from happening (Anderson et al, 2006).

Substitution behaviour resulting from price changes occurs primarily when the customer is focusing on the price. Critical in tackling this substitution is making customers aware of the value added and the potential benefits of the good. The supply chain should focus on positioning the product or service in such a way that consumers value this particular good or service more than that of the competitors. Gebauer et al. (2011) states the following: *'Manufacturing companies are redirecting their efforts towards customer centricity and innovativeness, and also from goods to services. Instead of only innovating products, companies are investing in service differentiation'*. This means that a firm which is consumer focussed is less likely to be victim of substitution behaviour due to tight personal connection with the customer. This in case leads to customer loyalty. To escape the competition and substitution behaviour in a competitive market, the principle of differentiation is key (Gebauer et al, 2006). This refers to shifting from product focus to service focus. Beside

delivering a quality product, differentiation based on service can increase the satisfaction of the customer. Perceived service quality of consumers is highly subjective and, therefore, hard to copy for potential competitors with substitute products (Gebauer et al, 2006).

#### **6.3.2.4 Market Structure, Pricing Strategy, and Innovation**

According to Ma & Ma (2017) market competition is hard to be adjusted to reduce the bullwhip effect. This is due to the fact that the degree of competition in the market is established by a certain market structure, and changing the entire market structure is something managers are not able to do (Gu, 2016).

Innovation is viewed by managers as something that adds value in economic and social perspective and is positively evaluated by the entire supply chain (Pérez et al, 2017).

Managers view innovation as a tool to gain competitive advantage. Therefore, reducing the incentive to innovate to reduce the bullwhip effect is not logical from a managerial point of view. Furthermore, pricing strategies are already discussed in section 6.3.1.3.

#### **6.4 Conclusion**

The benefits of reducing the bullwhip effect are an increase in product profitability, lower inventory cost, production costs, transportation costs and improved customer service throughout all different stages involved in the supply chain network. However, when reducing the bullwhip effect other performances within the supply chain simultaneously improve. General bullwhip reduction strategies that can be applied are: establishment of supply chain strategic alliances, application of the internet of things and the establishment of a supply chain effective model. These general strategies can be used to tackle all the causes leading to the bullwhip effect.

## Chapter 7 – Conclusion and Discussion

### 7.1 Conclusion

The term 'Bullwhip Effect' was introduced to describe the effect by which moving consumer demand creates large swings in production for the upstream suppliers. The main incentive for minimizing the bullwhip effect is the related costs associated with this phenomenon. In order for chain members to reduce the bullwhip they must be aware of the underlying factors causing it. The study identified five major causes of the bullwhip effect: demand forecast updating, lead time, price fluctuations, order batching, and supply shortage (five traditional causes).

Recently market competition is also identified as a factor leading to the bullwhip effect, just as the five traditional causes. The higher the degree of market competition, the more significant the bullwhip effect will be in the chain. However, some studies suggest that market competition does not directly contribute to the bullwhip effect. As a result of market forces the causes of the bullwhip effect may appear. So, there are two opposite thoughts concerning the way market competition influences the bullwhip effect.

If market competition truly leads directly to the bullwhip, then the bullwhip effect should be present in almost every market. However, this is not the case. Therefore, the underlying factors in the competitive market were investigated to see whether they are more determinative for causing the bullwhip effect, instead of the competitive market as a whole. The bullwhip effect exhibits different properties and magnitudes due to multiple factors in the market. The major factors in the market that exercise an influence on the bullwhip effect are: market structure, optimizing behaviour by chain members, substitution behaviour, pricing strategies, and innovation. It can be stated that factors in the market are determinative for causing the bullwhip effect.

The findings of this study suggest that market structure is a factor that directly leads to the bullwhip effect, just like substitution behaviour and pricing strategies. Optimizing behaviour and the incentive to innovate can be defined as factors that lead to the causes of the bullwhip effect, and therefore have an indirect impact on the bullwhip effect.

An efficient supply chain means reducing the bullwhip effect. Market competition is hard to be adjusted to reduce the bullwhip effect. For managerial implications several countermeasures are found for bullwhip reduction by means of diminishing the negative consequences of the underlying factors in the market. Furthermore the establishment of strategic alliances, application of the internet of things and an effective supply chain model are promising strategies for bullwhip reduction.

To answer the central research question: 'How can specific factors in competitive markets lead to the bullwhip effect in the supply chain?' it can be concluded that multiple factors in the competitive market can either directly or indirectly lead to the bullwhip effect. This happens because market forces in the competitive market lead to a variety of inefficiencies, which are harmful for the entire supply chain. The factors market structure, substitution behaviour and pricing strategies lead directly to the bullwhip effect in the supply chain. Optimizing behaviour and innovation can be ranked as indirect factors leading towards the causes of the bullwhip effect. To overcome all the negative consequences originating from

the bullwhip several strategies to reduce the bullwhip are discussed for managerial purpose.

## **7.2 Discussion**

Considering the validity of the findings in this literature study some things have to be acknowledged. Validity is about measuring the right construct. This means that the underlying factors in the competitive market (that lead to the bullwhip effect) found in this study have to be well founded by research and correspond to practice. These factors were not defined yet in existing literature. Therefore, multiple studies were combined to come to new insight and conclusions. Based on an extensive literature search it is assumed that these underlying factors in the market truly influence the bullwhip effect. However, it might be that a literature search is not sufficient enough to come to this conclusion. This can be seen as a limitation of the study. Further research can therefore investigate the competitive market in more detail, to come to stronger empirical evidence concerning 'underlying factors in the competitive market'.

The five traditional causes of the bullwhip effect are already extensively researched. Multiple studies came to the conclusion that inaccurate demand forecasts, long lead times, price fluctuations, order batching and supply shortage lead the bullwhip effect. However, this paper suggests that market competition is also a factor leading to the bullwhip effect. Only the study of Ma & Ma (2017) found evidence for this finding. In their model two retailers compete in a perfect competitive market. Future research can establish a model in which several degrees of market competition are included. Perhaps in a market structure with a lower degree of competition the bullwhip effect exhibits different properties and magnitudes. Also the findings in this study are based on competition between two retailers which sell the same product. To make the model more realistic a higher amount of retailers can be considered and substitutes can be taken into account. Substitutes probably have an effect on demand forecasts.

It can be concluded that the study of Ma & Ma (2017) is an important article for this paper. Based on the questions concerning the findings of Ma & Ma (2017), this study came up with an alternative figure (figure 2), which declares that market competition is not a factor leading directly to the bullwhip effect (but indirectly). The findings of this study suggest that factors can have either a direct or indirect impact on the bullwhip effect. Possible follow-up research can be done to clearly distinguish between factors that directly- and indirectly lead to the bullwhip effect.

Existing literature provides many strategies to reduce the bullwhip effect. However, these strategies are not explicitly made for bullwhip reduction, under the presence of market competition. These are more general bullwhip reduction strategies. Therefore, managerial implications that are provided in this study are based on general bullwhip reduction strategies. Future research could explore bullwhip reduction strategies, specially designed for competitive markets.

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