“Information Distortion Influencing the Supply Chain”

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Management Preface:
The main issue in this thesis is to give an answer on the question whether the information distortion in supply chains have an influence on the performance of the supply chain. This thesis is an descriptive research and is done with use of other literature already available on the bullwhip effect and its specific variables. The (reverse) bullwhip effect is the effect that the variation in demand is higher upstream in the chain with respect to the downstream variation. This variation in demand orders is called the information distortion. When this variation in demand orders are used for inventory levels, than these levels are bigger than the actual demand is in the supply chain for the products. Dealing with the information distortion has different causes. The two main causes of information distortion is information sharing and demand forecast.

Information sharing is the sharing of full information about demand figures and other company data. In order to share a high degree of this information about the company and its forecasts they can use Electronic Data Interchange (EDI). This computer based way of sharing information can be used for the supply chain alignment. With EDI supply chains are able to share precise data in a very fast way. The consequence of the interchange of demand information and operations activities reduces the variation to the upstream actors in the supply chain.

Demand forecasts is part of the data actors within a supply chain share. With use of the right forecasts companies can predict their future production and inventory levels. Demand forecasts tend to be manipulated because each business activity has its own goals. These goals should be in line with the company in order to prevent the bias in demand forecasts which leads to a higher degree of variation. An important conclusion is that the (reverse) bullwhip effect pretend to be visible in every supply chain. Due to the fact that all business activities have to deal with uncertainty and customer demand, the variation also comes up. The perfect share of information is not available in supply chains. Companies have to deal with all the information they get from all the actors of the chain they are in. In this way are communicating and collaborating the keys for successful reducing the bullwhip effect.
Foreword:
The choice for writing my bachelor thesis on the aspects of supply chain management was made during the supply chain management course. In this course the bullwhip effect was explained as one of the most important issues of the course. The bullwhip effect took my attention because it has effect on all the business activities in a company. First I wanted to describe the reverse bullwhip effect but there is not much information available about this subject and it is too specific. When I read a couple of papers, the information sharing concept, which is one of the causes of the bullwhip effect, was the most important factor each time. Quite a lot of supply chains have to deal with information sharing and collaboration in order to stay competitive. This was interesting to me because it was a more a universal problem in nowadays supply chains. During the group meetings another group member discussed the bullwhip effect also partly in his bachelor thesis and in this way we could benefit from each other in sharing the sources for the thesis. Also I want to thank my supervisor Drs. Onno Cleeren for his advice and support during the writing of my bachelor thesis.
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1. Introduction

"There are many examples of the benefits of coordination activities to the individual members in a supply chain. One important mechanism for coordination is the information flows among members of the supply chain. These information flows have a direct impact on the production, scheduling, inventory control and delivery plans of individual members in the supply chain. However, distortion of information is found to be a major problem" (Balan, Vrat, & Kumar, 2009, p.576 – 593).

1.1 Problem Indication

Production, scheduling, inventory control and delivery plans are parts of supply chain management (SCM). These facets of supply chain management have to be measured and controlled in order to be competitive. Competition is now taking place between separate supply chains rather than between individual organizations (Holland, 1995). In these collaborative chains there is need for an up to date system of information sharing. There is now a general belief within industry that capturing and sharing real-time demand information is the key to improved supply chain performance (Cachon & Fisher, 2000). This information flow and the distortion thereof are a major problem for supply chains nowadays. Fluctuating demand results in a distortion of information to the upstream suppliers. The bullwhip effect refers to this phenomenon where orders to the supplier tend to have a bigger variance than sales to the buyer (Heikkilä, 2002). This variance that starts downstream, amplifies upstream in the supply chain (Lee, Padmanabhan and Whang, 1997). In contrast to this upstream variance, there is also a bigger downstream variance, which is known as the reversed bullwhip effect (Özelkan and Lim, 2008).

Most of the research on the (reverse) bullwhip effect is about the existence and causes. These main causes of the (reverse) bullwhip effect: supply shortages, demand forecasting, lead times, batch ordering and price variations are clarified and identified by Lee et al. (1997). This study however wants to clarify the influence of information distortion on the (reverse) bullwhip effect, because little is known about the causes and consequences (especially of the reverse bullwhip effect). Because this distortion of information affects the whole supply chain (Lee et al., 1997), “The distortion effect gets amplified as the number of intermediaries in the channel increase”. This study investigates the causes of this information distortion and how it affects the (reverse) bullwhip effect.
1.1 Problem statement
“To what extend does information distortion cause the (reverse) bullwhip effect and how can it be reduced?”

1.2 Research Questions
In order to give an answer to the problem statement this research first has to give an answer to the next sub-questions.

- “What is the (reverse) bullwhip effect and how is it explained?”
- “How does information distortion influence the performance of the supply chain”
- “What are the possible solutions to reduce information distortion on the supply chain?”

1.4 Research Design
The research is descriptive and is done with use of existing literature. Parts of the research question are already described in other literature studies. In particular the bullwhip-effect is a “popular” subject in the logistics research but in contrast to this effect less research is done on the reverse bullwhip effect. This research combines the findings on these studies and comes with a refined conclusion on the central question in this research.

1.5 Data collection
The literature used to make this research comes from the different information catalogues available on Tilburg University. This research will combine different findings and results of this secondary literature in order to come to a clear answer to the main question.
2. Introduction

Chapter two takes a closer look at the bullwhip effect (2.1) and how it is explained. The second part is about the contra effect of the bullwhip effect, namely the reverse bullwhip effect (2.2). Part three (2.3) explains the consequences for the supply chain when dealing with the (reverse) bullwhip effect.

2.1.1. The bullwhip effect

Towill (1996) stated that one of the key attributes of a successful winner in today’s highly competitive marketplace is the ability to respond rapidly to end consumer demand. To maximize competitive advantage all members within the supply chain should “seamlessly” work together to serve the end consumer. When these members of the chain work together there is no variation in demand orders information to the upward stream in the supply chain. This amplification in variation of orders towards upstream suppliers is known as the bullwhip effect.

The bullwhip effect concept has its origins in a series of case studies done by Forrester (1961) where he points out the causes of the effect. Forrester (1961) writes that there are basic forms and policies used by an organization that give rise to undesirable behaviours in the supply chain. These undesirable behaviours are described by Lee et al. (1997) as the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer, and this distortion propagates upstream in an amplified form. This amplified variance tends to have a negative effect on the whole supply chain performance. In order to get a better understanding of this effect, a closer look to the cause and existence of this bullwhip effect is needed.

Sterman (1989) formulated the bullwhip effect according to the “Beer distribution Game” and writes that the decision-making task is straightforward: actors in the supply chain seek to minimize total costs by managing their inventories appropriately in the face of uncertain demand, but the simulated environment is rich, containing multiple actors, feedbacks, nonlinearities and time delays with consequences for their performance. Sterman (1989) shows that the bullwhip easily can be triggered, and that it is in every decision making task, with respect to inventory management and demand orders. The experiment of “the beer game” and its distribution involves four players who make independent choices about their inventories. Each player has its own management style and decisions regarding the benefits for the company. They cannot get information from other
players in the chain and they are only relying on orders from the previous player as a source of information. Because this information is very poor, the orders have an amplified reaction towards upstream suppliers. When the game is played more often the “suppliers” begin to learn how to deal with the demand distortion and how to react with this with the linkage to their inventory. The distribution game that introduces the bullwhip effect has consequences for the inventory and performance of a company.

### 2.1.2. Causes of the bullwhip effect

As mentioned before there are a few causes for the bullwhip effect. Lee et al. (1997) come up with the following causes: supply shortages, demand forecasting, lead times, batch ordering and price variations. These causes start downstream in the supply chain and consequentially, with the beer distribution game in mind, are starting points for the bullwhip effect. The figure below shows these main causes and the counter measures, for the supply chain management, on the bullwhip effect.

<table>
<thead>
<tr>
<th>Causes</th>
<th>Contributing factors</th>
<th>Counter-measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand signaling</td>
<td>No visibility of end demand</td>
<td>Access sell-thru or POS data</td>
</tr>
<tr>
<td></td>
<td>Multiple forecasts</td>
<td>Single control of replenishment</td>
</tr>
<tr>
<td></td>
<td>Long lead-time</td>
<td>Lead-time reduction</td>
</tr>
<tr>
<td>Order batching</td>
<td>High order cost</td>
<td>EDI &amp; CAD</td>
</tr>
<tr>
<td></td>
<td>FLI economics</td>
<td>Discount or assorted truckload consolidation by 3rd party logistics</td>
</tr>
<tr>
<td></td>
<td>Random or correlated ordering</td>
<td>Regular delivery appointment</td>
</tr>
<tr>
<td>Fluctuating prices</td>
<td>High-low pricing</td>
<td>EDLP</td>
</tr>
<tr>
<td></td>
<td>Delivery &amp; purchase asynchronozied</td>
<td>Special purchase contract</td>
</tr>
<tr>
<td>Shortage game</td>
<td>Proportional rationing scheme</td>
<td>Allocate based on past sales</td>
</tr>
<tr>
<td></td>
<td>Ignorance of supply conditions</td>
<td>Shared capacity &amp; supply information</td>
</tr>
<tr>
<td></td>
<td>Unrestricted orders &amp; free return policy</td>
<td>Flexibility limited on time, capacity reservation</td>
</tr>
</tbody>
</table>

Figure 1: The causes and counter-measures of the bullwhip effect  (Lee et al., 1997)

The fifth cause is the overall problem that attracts all these other causes namely the distortion of demand information. Lee et al. (1997) write that it implies that the manufacturer who only observes its immediate order data is misled by the amplified demand patterns and this has serious cost implications. Lee et al. (1997) also claim that demand distortion may arise as a result of optimizing behaviours by players in the supply chain. Players within the chain try to maximize their profit. In order to do so they can; order in batches, plan shipments to their own interest and play with their price in order to be competitive. This distortion of demand information makes it possible that these other causes can pop up and give rise to the bullwhip effect. One of the solutions
to overcome this bullwhip effect is information sharing. Information sharing and other solutions to this effect are discussed in chapter four.

2.2 The reverse bullwhip effect

The term "reverse bullwhip effect" has first been used by Svensson (2003, p. 103 - 131) and he writes that this reverse bullwhip may occur when there are uncertainties upstream in the supply chain, e.g. limited production capacity, product quality deficiencies, unreliable deliveries/transport or inaccurate information sharing. These uncertainties start upstream in the supply chain and amplify downstream. According to Rong et al. (2008) does demand variability increases as one moves downstream trough the supply chain (in contrast, the classical bullwhip effect refers to the amplification as one moves upstream). Rong et al. (2009) write also that the forward and reverse bullwhip effects act as a system because a sudden increase in demand gets amplified if it goes upstream, creates shortages which in turn amplifies downstream. The uncertainty of upstream suppliers and the relation with the bullwhip effect, are both causes of the reverse bullwhip effect.

2.2.1 Causes of the reverse bullwhip effect.

Lee et al. (1997) show that the cause of the bullwhip effect lies in price fluctuations. The demand variation fluctuates with price variation and has consequence on the supply chain as it moves upwards. As we can see in the figure below this effect is drawn in example (b). Figure 1 (c) shows the reverse bullwhip effect and how it starts from upstream in the supply chain with demand vibration. The reverse bullwhip effect can be interpreted as the opposite of the bullwhip effect. Price variation is one of the causes of the reverse bullwhip effect but as already shown there are more uncertainties than create the reverse bullwhip effect.

![Figure 2: Customer demand](image)

Figure 2: Customer demand **a:** with no amplification, **b:** with a demand vibration and bullwhip effect, **c:** with a supply shock and reverse bullwhip effect. (Rong et al., 2008)
Rong et al. (2007) show that the competition for scarce resources cause the reverse bullwhip effect in the upstream position and has an impact on the buying behaviour of the customers at the end of the chain. In order to overcome this fluctuation full information is needed from downstream suppliers about the competitors of their suppliers in the upstream. This competition results in different prices which are calculated to the end-consumer and can result in demand variation. Again this demand variation can result in a bullwhip effect back to the upstream.

2.2.2 Consequences for the supply chain
In the research of Lee et al. (1997) it is stated that the result of the fluctuations, the (reverse) bullwhip effect, in the order quantities over a time period can be much greater than those in the demand data. This increase in inventory brings serious harm to the supply chain because more products are made for inventory than actually the demand is. Most of the companies aspire low inventory levels to minimize costs, although this cannot always be realised when demand is not known. A balance needs to be found, so that inventory management does not hinder sales when a forecast is difficult. In this balance there should be taken care of batch orders, shipments and competition in the upstream of the supply chain. All these different consequences come down to the cost management principle that should work together with the inventory management in order to be profitable. The alignment of information and collaboration should prevent these increases in variation in demand.

Summary
The (reverse bullwhip) effect is the amplified variation in demand regarding the supply chain. Different causes of the (reverse) bullwhip effect are discussed and show that it can be a serious problem in supply chains. The main cause of this amplified effect is the distortion of information within the supply chain. Lee et al. (1997) show that this distortion can lead to the increase of demand variability in as one moves upstream in the supply chain.
3. Introduction
Chapter three explains the information distortion influence on supply chain performance. Part (3.1) takes a closer look to information distortion. Part (3.2) explains how information distortion affects the performance of the supply chain.

3.1 Information distortion
The amplified variation in demand is, due to information distortion or the lack of information sharing, one of the main causes of the bullwhip or Forrester effect. “Potential causes of demand amplification are seasonal retail sales variation, random fluctuations in sales, advertising and price discount policies, factory capacity limitations that encourage over-ordering in times of shortages and inventory policies that over-react to perceived changes in the demand pattern” (Sahin & Robinson, 2002). The information distortion affects the sales and operations performance of the company and has also influence on the inventory levels. Information distortion gives actors in the chain the wrong incentives and is the opposite of sound collaboration and communication within the chain. This distortion of information is split up in information sharing and demand forecasting in order to come to a reasoned clarification of the influence of the bullwhip effect in organizations and the supply chain.

3.1.1 Information sharing within the supply chain
Information sharing is a very broad concept. It is possible to explain information sharing on different levels and with different means. Barret & Konsynski (1982) formulate information sharing as following: “the interchange of information, whether subtle or concrete, it forms the basis of all organizational activity”. Information sharing within and between organizations has different spheres and actions. It takes place because it regulates and coordinates the different players within the chain in order to allocate the inventory, keep on track with sales and gives knowledge of the bottlenecks within the chain. As the products flow downstream in the supply chain, the information sharing works up- and downstream. These two ways of information sharing take some part of uncertainty away between partners in the chain and it reduces the costs.

The different levels of information sharing give a clear understanding how companies can express the information between each other. The “no information sharing” level is the more traditional level. The only demand data the supplier receives are actual orders from its immediate customer. With the “full information sharing level”, complete information is available to support the specific decision-
making environment. This could include one or more of the following: production status and costs, transportation availability and quantity discounts, inventory costs, inventory levels, various capacities, demand data from all channel members and all planned promotional strategies (Sahin & Robinson, 2002). In order to influence and draw back the negative amplifications of the variation in demand orders, the players within the chain need to adapt at both levels. The full information sharing process keeps track from customer towards the upstream partners in the chain and back.

Besides these different levels in information sharing, the way the company is perceived and is controlled by different perspectives of the actors gives another way of looking towards information sharing. Companies have to deal with information sharing between different business units within the company itself and the information sharing with other companies that are related within the supply chain.

### 3.1.2 Information sharing within the company

Lee et al. (1997) conclude that the bullwhip effect is a result of the rational decision making of different actors within a supply chain. According to Svensson (2003) this rational decision making might also be based upon the relationship between actors within a company. Svensson (2003) also shows that the bullwhip effect can exist within companies because of the speculation on the inventory management of inbound and outbound inventory flows due to different business practices. In order to prevent this bullwhip effect in companies the business practices need to collaborate and share their information.

Because of the rise of new technologies, electronic data interchange, enterprise resource planning and advanced planning and scheduling systems became possible. “The electronic data interchange is the exchange of structured data between the computer systems of business partners” (Parfett, 1993, p 13). The electronic resource planning takes this interchange of data to a higher level. The enterprise resource planning has enabled real-time collaboration between supply chain partners, providing organizations with forward visibility, thus improving inventory management and distribution (Su et al., 2010). In order to prevent the complexity of planning, inventory management and information sharing within different business units, these new technologies can be adapted.
Figure 3 shows differences between the two information and planning systems. Both have their strengths and weaknesses but “the persistent weaknesses encountered when using ERP systems have revealed the need for optimized tools to manage the logistics chain (advanced planning systems: APS)” (Ling, 2000). The enterprise resource planning is about how business is done at the moment but the advanced planning systems give a more optimal solution on the way the company should be doing business. APS represent a quantitative model-driven perspective on the use of information and communication technology in supporting supply chain management (Kumar, 2001). The value of the information creates, with use of these systems, a stronger collaboration that enables improvements on inventory planning and performance. Machuca et al. (2004) show that there is a drop in EDI procurement and implementation costs when selecting the right way of EDI, together with a reduction in costs resulting from a decrease in the bullwhip effect on the inventory of a company. It also reduces uncertainties that influence the partnership of companies in such a way that the focus of doing business comes down to inventory management and reducing the bullwhip effect.

### 3.1.3 Forecasting demand

Demand forecasting is the process of predicting the demand figures in the future. “Forecasts, therefore, provide information which enables policy makers and planners to make decisions before the advent of the predicted happenings which affect, or are affected by, their actions” (Archer, 1980). Forecasting can be approached in two different ways. The quantitative approach is the use of mathematical or numerical models based on the right information for better objective forecasts, but the qualitative approach is the judgement about which
data is relevant, which method is appropriate and which market knowledge to consider and to incorporate (Aertsen and Kicken, 2008). Lee et al. (1997) give the quantitative approach as a cause of the bullwhip effect. The main problem is that the generated demand information is gathered from a downstream player in the supply chain with perhaps another way of inventory management. The consequence is the variation in demand figures which leads to inventory amplification. Sterman (1989) and Aertsen and Kicken (2008) see human decision makers or other human influence as the major cause of the bullwhip effect. Lee et al. (1997) show that the bullwhip effect occurs even in a supply chain where the decision making process is done in a completely rational way. Besides these two approaches it can be seen that more communication and better demand information sharing can reduce the bullwhip effect. However, forecasting is always done by human behaviour and it involves different professionals with different views and social backgrounds within a company. These different interpretations due to human behaviour result in differences in demand forecasting.

![Figure 4: Different forms of bias in forecasting (Aertsen and Kicken, 2008)](image-url)

It is in the forecaster’s interest to present the right demand information to management. Figure 4 shows that there are intentional and unintentional behaviours from forecasters, influenced by organisational politics, blind spots, management experience etc., that does not give the right forecast figures. There are a variety of tactics, manipulations, and other adjustments used by forecasters which will lead to bias in the demand forecast (Aertsen and Kichen, 2008). These tactics and manipulations are put forward in figure 5.
The manipulations as shown in figure five all lead to the wrong incentives from the company towards other actors in the supply chain. The consequences of more biased and less forecasts will lead to less quality of strategic decisions, investment decisions and negative effects on the inventory turnover (Aersten and Kicken, 2008). All these negative consequences for the company have a bad influence on the performance of the supply chain.

3.2 Information distortion affecting the supply chain

Demand forecasting and information sharing are two ways of collaborating within the supply chain that can reduce the bullwhip effect. But Holweg et al. (2005) write that despite the sharing of operational and forecast information, few companies are really able to fully exploit the advantage of collaboration in their supply chains. These companies deal with distortion of information due to bad communications and relations with other companies within the supply chain. Cooperation along the supply chain can influence the performance positively but if a company keeps the local stock-performance as priority, only limited improvement for the supply chain performance is available (Wadhwa et al. 2008).

In order to create a better performance for the supply chain, companies have to subordinate their own politics and adapt it from the supply chain and the actors within a chain need alignment of their chain incentives. By using the shared information, each supply chain actor can make better decisions on ordering, capacity allocation and production/material planning so that the supply chain dynamics and performance can be optimized (Huang et al. 2003). The research of Metters (1997) finds that eliminating the seasonal bullwhip effect alone can increase product profitability by 10% - 20% while decreasing the bias of the forecasts and eliminating the seasonality can increase profits by an average of 15% - 30%.
Summary
Information distortion is the main cause of the bullwhip effect. It can be separated in information sharing and demand forecast. Electronic data interchange is needed for companies in order to share their information on demand and production. Holweg et al. (2005) write that not all the companies benefit from the full collaborating because not all companies know how to handle the manipulation in forecasts and the right EDI programs to fully share the companies information.
4. Introduction
Chapter four is divided in two parts. Part (4.1) explains possible solutions for the (reverse) bullwhip effect and part (4.2) explains possible solutions to overcome the information distortion on the supply chain.

4.1.1 Possible solutions (reverse) bullwhip effect
Solutions for the (reverse) bullwhip effect do not completely eliminate the effect but they can only reduce or partly prevent it. There are some main causes for the bullwhip effect. “A lack of inter-company communications combined with large time lags between receipt and transmittal of information are at the root of the problem” (Metters, 1997). Lee et al. (1997) made a typology, that was based on the four main causes for the bullwhip effect, namely demand forecast updating, order batching, price fluctuation, and rationing and shortage gaming, which provides remedies to discuss ways of controlling the bullwhip effect. Lee et al. (1997) writes that this typology is upon the underlying co-ordination mechanism in terms of information sharing, channel alignment, and operational efficiency. The performance of the supply chain and solutions towards the causes of the bullwhip effect does not only depends on collaboration and information sharing but needs also practical solutions in order to overcome or reduce the effect.

Figure 6 gives the causes and initiatives in order to overcome the bullwhip effect.

<table>
<thead>
<tr>
<th>Causes</th>
<th>Information Sharing</th>
<th>Channel Alignment</th>
<th>Operational Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Forecast Update</td>
<td>Understanding system dynamics</td>
<td>Vendor-managed inventory (VMI)</td>
<td>Leadtime reduction</td>
</tr>
<tr>
<td></td>
<td>Use point-of-sale (POS) data</td>
<td>Discount for information sharing</td>
<td>Echelon-based inventory control</td>
</tr>
<tr>
<td></td>
<td>Electronic Data Interchange(EDI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internet</td>
<td>Consumer direct</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer-assisted ordering (CAO)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order Batching</td>
<td>EDI Internet Ordering</td>
<td>Discount for truckload assortment</td>
<td>Reduction in fixed cost of ordering by EDI or electronic commerce CAO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delivery appointments</td>
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<tr>
<td></td>
<td></td>
<td>Consolidation</td>
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<td></td>
<td></td>
<td>Logistics outsourcing</td>
<td></td>
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<tr>
<td>Price Fluctuation</td>
<td>Continuous replenishment program (CRP)</td>
<td>Everyday low price (EDLP)</td>
<td></td>
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<tr>
<td></td>
<td>Everyday low cost (EDLC)</td>
<td>Actively-based costing(ABC)</td>
<td></td>
</tr>
<tr>
<td>Shortage Gaming</td>
<td>Sharing sales, capacity, and inventory data</td>
<td>Allocation based on past sales</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6: Causes and initiatives to prevent the bullwhip effect. (Yung et al. 1999)

Conclusion of figure six is that investments done in marketing and electronic data interchange, have a positive relation towards the reduction of the bullwhip effect.
The interchange of electronic data is in the three initiatives provided as one of the main ways to prevent or reduce the bullwhip effect. Lee et al. (1997) state that EDI provides rapid transmission and sharing of accurate, reliable information throughout all the stages of the supply chain and in this way countering another cause of the bullwhip effect. According to Machuca (2003) this information sharing through EDI creates greater stability in orders placed with the factory and this will lead to more stable production levels which in turn leads to more efficient production planning, less need for expensive corrections and hence a reduction in the cost for the supply chain. Lee et al. (1997) also write that computer assisted ordering also can reduce the bullwhip effect. This way of ordering uses historical and current data which leads to less bias in the measure of demand forecast.

4.2 Possible improvements information distortion
Lee et al. (1997) write that access to accurate information and the sharing of this information can prevent the bullwhip effect. Sahin and Robinson (2002) also have researched that different aspects of information, that all contribute to full information sharing, have a positive effect on the supply chain. But this collaboration and information sharing does only have effect when the information is available for every stage in the supply chain. Lee et al. (1997) writes that demand data at the downstream site needs to be available to the upstream site and Chen et al. (2000) also show that providing each stage of the supply chain with complete access of the customer demand can reduce the increase in variability of demand. Companies need to adapt EDI that makes this information available from downstream to upstream in the supply chain. Machuca et al. (2004) provide in the perspective of EDI another view: “more frequent replenishment of material requirements in smaller batches reduces distortions in demand information with a subsequent reduction in the bullwhip effect and the excessive costs it generates”. Companies need to adapt EDI and share their full information in a transparent way in order to improve their communications and reduce the information distortion.

As stated by Lee et al. (1997) the quantitative approach is the reason the bullwhip effect exists in companies. Aertsen and Kicken (2008) name also the human behaviour in relation with the quantitative approach as the contributor to the biased demand forecasts which creates the bullwhip effect. The unintentional and intentional behaviour of humans adds bias to the forecasts. These biased forecasts show the wrong data and have serious impacts on the performance of the supply chain. Eliminating these errors and bias can reduce the (reverse)
bullwhip effect and improve the demand forecasts. Aertsen and Kicken (2008) researched the high tech industry and gives ways to prevent these manipulation of demand forecasts:

- **Management should accept changes.** Management should not accept a consensus in their forecasting process. Showing the financial consequences to the management of their consensus politics can turn it towards accepting changes in demand forecasts.
- **Lost sales are lost sales.** The forecasts that are not realised at the end of the month are accepted as loss and should be deleted out of the forecasting system. In this way the company prevents the bulldozing effect.
- **Neutral body responsible for the forecasts.** When there is a neutral business unit that is responsible for the forecasts, they are able to give information that is not manipulated and biased.
- **Monitoring and measuring changes in forecasts.** With use of the Forecast Value Add is it possible to measure every value add to the demand forecast process. With use of the FVA is it possible to recognize the bias and corrective actions can be made.

Aertsen and Kicken (2008) writes also that the reliability of the forecasts should be measured and rewarded. Rakt and Bouman (2009) come up with perspectives in order to improve the demand forecasts:

- Companies should get their demand data downstream in the chain especially when the line to the end-consumer is big.
- Companies should change, if necessary, the timing and frequency of the forecast cycle.
- Sales and Operations should make agreements about demand manipulation in order to reduce the inventory.

These ways of better communications due to electronic data interchange and better forecasts improve the reducing of the information distortion.

**Summary:**

Chapter four explained possible solutions to prevent or reduce the bullwhip effect in supply chains. The improvements of EDI leads to impressive improvements in the supply chain performance (Cachon et al. 2004). Also the prevention of biased forecast improves the ability to influence the supply chain performance.
5 Introduction
Chapter 5 is divided in the conclusion (5.1) of this research and recommendations (5.2) in the second part.

5.1. Conclusions:
The (reverse) bullwhip effect can be a serious problem for supply chains because it decreases the profitability and performance of the supply chain. The main cause of this bullwhip effect can be found in the distortion of information. Information distortion can lead to amplifications of demand in the upstream supply chain. The (reversed) bullwhip effect works in contrast to the bullwhip effect from the upstream, due to inventory management or scarce resources, to the downstream of the supply chain. The (reverse) bullwhip effect also has impact on the inventory levels, costs, lead times and consequently the performance of the supply chain. The first conclusion is that every supply chain has to deal with information distortion and the following bullwhip effect. Supply chains should collaborate and communicate intensively in order to reduce the information distortion. This can be done with use of electronic data interchange. Advanced planning systems regulate the different MRP of the companies within the supply chain and can show how business should be done in the chain. Another conclusion can be made on the fact that EDI improves the collaboration and information sharing which in turn reduces the influence of the distortion. The demand forecasts, part of the information distortion, should be established free of bias and manipulation. This is the third conclusion in order to reduce the influence of distortion. The influence of information distortion on the supply chain creates big problems for companies and should not be overlooked. Because every company, and every business practice, has to deal with information distortion it can be concluded that there is a big influence on the supply chain and it is deeply rooted. The key to prevent this influence on chain is to collaborate and communicate with other actors within the chain. However, companies should adapt their business practices to the supply chain and his way of doing business. The company needs to become a sub-ordinate of the chain in order to decrease the influence of information distortion.

5.2. Recommendations
This research is focused on information sharing and demand forecasts that influence the supply chain. Future research should be done on the influence on the supply chain of other causes of the (reverse) bullwhip effect. These other causes have also effect on information sharing and demand forecasts and this also should be researched.
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Figure 1

Figure 2

Figure 3

Figure 4 and 5

Figure 6