BACHELOR THESIS

Sales and Operations Planning (S&OP) and the Bullwhip effect

Reducing the Bullwhip effect through Sales and Operations Planning.

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Faculty: Economics and Business Administration

Department: Organization and Strategy

Supervisor: O. Cleeren

Author: P. Kolsteeg

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MANAGEMENT SUMMARY

In today's volatile market, it becomes more important for companies to meet customer demand at the right place and at the right time. Besides the fact that it becomes more important, it is also more difficult for companies adjust their demand forecasting, inventory levels and capacity levels on today's markets. In case of increasing demand, a company could decide to expand their capacity and production, but in a volatile market, the situation could be changed quickly.

This study targets Sales and Operations Planning (S&OP) as a helpful way to reduce the Bullwhip effect (BWE). The process of S&OP mainly focus on balancing supply and demand of products for a company and the BWE is about demand order variations that becomes amplified when they move upstream in the supply chain. An accurate forecasting of demand is one of the important activities within the S&OP process because of the fact that a company's supply depends on this forecast of demand.

The purpose of this study is to link the S&OP process with the phenomenon of the BWE and check whether and how the S&OP process could reduce the BWE. This should be achieved be reviewing the existing literature on the field of S&OP and the BWE and finally link both concepts to each other and formulate a conclusion on how S&OP can help in reducing the BWE.

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1 INTRODUCTION

According to Grimson and Pyke (2007), it becomes more and more important for companies to distinguish into their forecasting's, adjustments to different demand levels, reduction of inventory costs and optimizing their profits. Many companies already made remarkable progress in recent years, although there remain opportunities for continued cost reduction in operations and for revenue growth in sales.

1.1 Problem indication

Sales and Operations Planning (S&OP) and the Bullwhip effect (BWE) are two much-discussed concepts in the field of supply chain management. There is already a lot of knowledge about both concepts, but many articles and results of investigations are outdated (Grimson and Pyke's exploratory S&OP framework is written in 2007 and Lee, Padmanabhan and Whang's study about the BWE is written in 1997). The problems of the current volatile markets have also influenced strategies and objectives of different companies and their supply chains. The most important objectives of companies and supply chains are more shifted to 'cost reduction' to maintain their profit margins.

Nowadays, S&OP can play an important role in maximizing profits for companies. Controlling (or maybe lowering) inventories and forecasting supply and demand, could have a positive influence on 'cost reduction' and besides that, on profit optimization (Grimson and Pyke, 2007).

Proctor & Gamble (P&G) examined the order pattern of one of their products and came to the conclusion that the demand order variability in the supply chain was strengthened as they moved up in the supply chain. P&G called this phenomenon the 'Bullwhip effect'. Companies can effectively reduce the BWE by understanding its underlying causes (Lee et al., 1997).

Because of the fact that many investigations and studies on these two concepts are outdated, there is need for a more up to date literature study. This study focuses on both concepts and examines how S&OP can help in reducing the BWE.

1.2 Problem statement

How can Sales and Operations Planning (S&OP) help in reducing the Bullwhip effect (BWE)?

1.3 Research questions

The following research questions will provide an answer to the problem statement, as defined above.

- What are the characteristics of Sales and Operations Planning (S&OP)?
- How is the Bullwhip effect (BWE) explained?

1.4 Relevance

This research provides new insights in the field of S&OP in combination with the BWE. There is already a lot of knowledge about the concepts of S&OP (Grimson and Pyke, 2007) and the BWE (Lee et al., 1997) separately, but this study gives a review of the literature on both concepts and link them to examine how S&OP can help in reducing the BWE. So there is relevance from an academic perspective. From a managerial perspective, the conclusions and recommendations of this study can be used to formulate an adjusted S&OP strategy and besides that, it may help companies to reduce the BWE in their supply chain by providing these companies a way to forecast demand more accurately.

1.5 Research design and data collection

This exploratory research investigates the concepts of S&OP and the BWE, besides that, this research takes a deeper look at the relation between both concepts and how S&OP can help to reduce the BWE. During this research it will be explained what the relevance of both concepts is in today's volatile markets (van de Rakt and Bouman, 2009) and also in which area or point in the supply chain these concepts show up the biggest problems.

The information and conclusions of this research are completely based on secondary data. First of all, scientific articles are used to describe separately the concepts of S&OP and the BWE (about nine articles per concept) and the link between both concepts. The main focus is on how S&OP can facilitate in reducing the BWE. Based on the used scientific articles, at the end of this research it is possible to formulate in which area or point in the supply chain the problems of both concepts are the biggest.

The scientific literature will be found in the Tilburg University article/journal database and at the website of 'logistiek.nl'. There will be also used some articles which are used in the course Supply Chain Management given at Tilburg University (one of the lectures and the material of it is completely based on the concept of the BWE).

2 SALES AND OPERATIONS PLANNING (S&OP)

In this chapter, section 2.1 gives three definitions of S&OP to give clear view of the "basic" meaning and objectives of this process. The rest of chapter 2 will be based on one of these basic definitions. Section 2.2 describes an example of a S&OP integration framework and section 2.3 links S&OP with capacity management. Section 2.4 is about the meaning and importance of forecasting for S&OP. Section 2.5 is about possible problems within S&OP. The final part, section 2.6 gives some conclusive remarks.

2.1 Definitions of S&OP

Grimson and Pyke (2007) describe S&OP as a business process that links a company's strategic plan to their daily operations plans and facilitates in balancing demand and supply for their products.

Beerens (2009) describes S&OP as a management activity in which a company tries to adjust demand and supply of their products to achieve an optimal financial result. The most important objective of the S&OP process is an accurate planning of production and logistics, and at the same time striving for maximizing profitability.

"S&OP is the long-term planning of production levels relative to sales within the framework of a manufacturing planning and control system. Within the S&OP, resource planning is used for determining the appropriate capacity levels in order to support the production plan" (Olhager, Rudberg & Wikner, 2001:215).

The above definitions show similarities about the fact that S&OP is about balancing supply and demand, Olhager et al. (2001) and Beerens (2009) put more focus on planning of production. However the definition of Grimson and Pyke (2007) will be used in the rest of this study because this is the most straightforward description of S&OP.

2.2 S&OP integration framework

According to Grimson and Pyke (2007), a common S&OP process follows a five step procedure:

1. Sales employees draw up a baseline demand forecast (what could be sold to customers) without taking into account what a company can produce.
2. The operations team collects information about inventory strategies and the company's capacities.

3. The S&OP team comes together and formulates an operating plan for the next period.
4. The distribution and implementation of the final plan.
5. Measurement of effectiveness and results of the company's S&OP process (important information for the improvement of a company's S&OP process).

Based on experience, literature review and company interviews, Grimson and Pyke (2007) developed a S&OP integration framework which can be used to evaluate a company's current level of S&OP integration. The framework consists of 5 different dimensions: The first three dimensions are business processes, namely Meetings & Collaborations, Organization and Measurements. The other two dimensions are information processes, namely Information Technology and S&OP plan integration. Grimson and Pyke's framework uses a 1 to 5 ranking (Stage 1 to Stage 5) for each of the five dimensions to evaluate the companies participated in their company interviews. Stage 1 means 'a company without S&OP practices' on this dimension, Stage 2 'Reactive', Stage 3 'Standard', Stage 4 'Advanced' and the top rating of Stage 5 means 'Proactive' on this dimension. Grimson and Pyke (2007) applied their framework to fifteen manufacturing firms, none of the companies were currently at Stage 5 at one of the dimensions. Their opinion is that Stage 5 is the ultimate stage a company can achieve in the future. The two most important conclusions of Grimson and Pyke's investigation are listed below:

- Representatives from Sales, Operations and Finance must participate in the S&OP team.
- The frequency of the S&OP meetings is dependent on volatility of the production environment and the market.

2.3 The importance of S&OP for capacity management

For a manufacturing firm, 'capacity' is one of the seven key decision categories on which a company must have a suitable strategy and policy (Olhager et al., 2001). One of the aspects of S&OP is drawing up a sales plan based on demand forecasts. This sales plan must be translated into a corresponding production plan and capacity requirements plan. Important for S&OP is that it has to work within the boundaries of the capacity strategy. There is an interrelationship between S&OP and capacity management. For instance, a strategic decision to expand a company's capacity strongly influences the possibilities for S&OP, but besides that, a decision from S&OP can also create a need for more capacity. The main conclusion of the research of Olhager et al. (2001) is that both decisions on S&OP and capacity must be integrated in each other. According to van de Rakt and Bouman

(2009), it is important to integrate operational decisions with financial decisions to make sure that the capacity planning corresponds with the financial budget.

2.4 Forecasting

S&OP becomes a more critical organizational function within organizations and to remain profitable, an organization needs to meet customer demand (Kapp, 2000). Meeting this demand at the right place and at the right time is not possible with the old fashioned "production planning" process. According to Kapp (2000), using a S&OP process provides a company a helpful way to balance their supply and customer's demand. Wouters (2009) adds to this statement that the S&OP process and the supply chain must be customer focused.

"While there is no standard for the sequence of decisions made in the S&OP process, a general representation of such a sequence may be given as follows: (1) demand planning, (2) supply planning and (3) demand/supply review" (Chen-Ritzo, Ervolina, Harrison & Gupta, 2010:605).

In both statements of Kapp (2000) and Chen-Ritzo et al. (2010) planning and forecasting demand plays an important role within S&OP. In Kapp's statement forecasting the right demand is necessary in remaining profitable for a company. For Chen-Ritzo et al. (2010), forecasting the right demand is important because the supply plan is dependent on it. So, inaccurate or bad forecasting means no optimal financial result and/or wrong supply from a company. Chen-Ritzo et al. (2010) emphasizes the importance of the third "review" step after a miscalculation, in which it is possible to adjust a company's demand plan. This adjusted demand plan is called the "commitment-to-sales" (CTS).

The importance of an accurate demand forecasting is also emphasized by a recent investigation of Capgemini, which concluded that inaccurate forecasting could lead to a wrong inventory level at a wrong moment and a deterioration of the delivery reliability (Wouters, 2009).

For companies who arranged their S&OP process in a right way, it is easier to adjust to oscillations in demand (van de Rakt and Bouman, 2009). Van de Rakt and Bouman (2009) gave an example to support their statement: in the area of domestic machines, over the past two years the demand increased, while many companies expected a decrease in demand. Apparently, consumers first cut down their expenditures on costly holidays and cars and because of that, a consumer spends more time at home. As an alternative, consumers spend more money on (relatively cheaper) domestic machines. This example explains the importance of an accurate demand forecasting. According to van de Rakt and Bouman (2009), this is the responsibility of the departments of Sales, Marketing and Operations. The statement of Beerens (2008) makes this more complete by saying

that the success of an S&OP process is determined by the mutual talks and decisions of these departments. Afterwards, the Sales department could have forecast the growth in demand for domestic machines by maintaining contact with retailers, Marketing could forecast growth in demand by doing a market investigation and Operations could forecast it by analyzing the results of earlier oscillations.

Aertsen (2009) did some research about the timing of the forecasting of forty high-tech industry companies. Aertsen (2009) came with a remarkable conclusion: the upstream companies in the supply chain already forecasted a decrease in demand in July 2008 and the downstream companies forecasted this decrease just at the end of 2008. The upstream companies adjusted their forecasting based on macroeconomic indicators where the downstream companies still used their forecasting which was formulated at the beginning of the year. In chapter 3 (the Bullwhip effect), there is more information about fluctuation in demand and how this is handled within the supply chain.

Van de Rakt and Bouman (2009) gave three possibilities for improvement in forecasting the right demand for companies:

- A company should analyze the demand downstream in the supply chain, especially companies who have a very upstream position in the supply chain.
- In cases of inaccurate demand forecasting, the timing and frequency of the forecasting should adjusted.
- The departments of Sales, Marketing and Operations should make agreements which are more understandable and more concrete for all departments.

Beerens (2009) agrees with the other S&OP experts about the importance of an accurate forecast of future demand. Beerens (2009) states that the forecasts must be based on the expectations of sales employees and calculations of computer software like Enterprise Resource Planning (ERP) software.

2.5 S&OP problems

This subparagraph is about possible S&OP problems and difficulties in the implementation of the S&OP process. “One of the real selling points of S&OP is that it is simple. However, even though the S&OP process is easy to understand, it is difficult to implement successfully” (Kapp, 2000:68).

Grimson and Pyke (2007) argue that the difficulty of the implementation of the S&OP process do not only lie in the change of the business process, but also in the change of the complete company culture. Before the implementation of the S&OP process, different functional areas within an organization operated very separated and each area had their own goals and objectives. According to Grimson and Pyke (2007) the "functional silos" must be broken down and there must be clear and overlapped goals for each functional area, in achieving an optimal implementation of the S&OP process.

As mentioned above, the implementation of a S&OP process causes a forced cooperation between employees from different departments. These departments usually have very conflicting issues (e.g. the Sales department wants flexibility while the Operations department wants efficiency). Wouters (2009) concludes that the main problem in the implementation process is the entire focus on the integration and harmonization of different departments, through which the main S&OP objectives (e.g. exchanging the planning reports and collating the KPI's) are neglected. Wouters (2009) also describes the problem of using different indicators and characteristics by different departments within a company. This phenomenon makes it very difficult to combine and integrate the information from these departments.

According to van de Rakt and Bouman (2009), one thing is really important in avoiding or reducing the risk of S&OP problems: "a company must have a solid implementation action plan with the right focus and supervision."

2.6 Conclusive remarks

The S&OP process is mainly about balancing supply and demand of a company's products. The most important parties involved in this process are the departments of Sales, Operations and Finance. Representatives from these departments should participate in a S&OP team. Forecasting demand plays an important role within S&OP. Companies who arranged their S&OP process in a right way are better able to adjust to oscillations in demand. The importance for companies to adjust to these oscillations will be illustrated in the next chapter about the BWE.

3. THE BULLWHIP EFFECT (BWE)

In this chapter, section 3.1 gives two basic definitions of the BWE to explain this phenomenon. Section 3.2 and 3.3 are respectively about the history and the common causes of the BWE. Section 3.4 describes the well-known Beer Game and the shortcomings of it and section 3.5 describes the phenomenon Reverse Bullwhip Effect (RBWE). Finally, section 3.6 gives some conclusive remarks.

3.1 Definitions of the BWE

According to Lee et al. (1997), the BWE is a phenomenon by which demand order oscillations in a supply chain becomes amplified when they move upstream. Some symptoms of the BWE are excessive inventories, bad forecasting, wrong capacities, poor service and incorrect production planning (many high cost corrections). Companies first need to understand what exactly creates the BWE before they can counteract it.

Towill, Zhou and Disney (2007:444) use the notion BWE to describe "demand amplification of orders as they pass up the supply chain from marketplace to raw materials supplier."

In some industries the BWE is also called the Whiplash effect or the Whipsaw effect. In this research just the term BWE will be used. Despite the fact that the above definitions show many similarities (especially the fact that it is about an amplification upstream in the supply chain), the definition of Lee et al. (1997) will be used in the rest of this research because this is the most straightforward and obvious one.

Figure 1 below shows a clarifying graphical representation of the BWE of Rong, Shen and Snyder (2008).

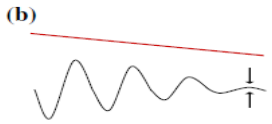

Figure 1: Graphical representation the BWE (Rong et al., 2008)

3.2 History of the BWE

According to Towill et al. (2007), Jay Forrester played an important role in explaining the BWE. In 1961, Forrester demonstrated the BWE and also suggested some ways of how to reduce it. He did this with a simple supply chain simulation model with just five entities: factory, distributor, wholesaler, retailer and the final customer. This model turned out to be a good basis for distribution games (like The Beer Game which is described in section 3.4). According to Rong et al. (2008) the phenomenon explained by Forrester was called the BWE for the first time by Procter and Gamble (P&G) and introduced into the literature by Lee et al. (1997). P&G observed the order pattern of one

of their products, Pampers. P&G came to the conclusion that this product with, relatively stable demand, created a wave of changes upstream in the supply chain due to very small changes in demand.

3.3 Causes of the BWE

Lee et al. (1997) identified the four principal causes of the BWE. In combination with the supply chain infrastructure and the decision making of managers, each of the four causes create the BWE. As mentioned before, managers need to understand the causes of the BWE before they can counteract it. For that reason, each of the four major causes described by Lee et al. (1997) will be explained below.

- Demand forecast updating: as mentioned in chapter 2, product forecasting is a very important activity for companies in a supply chain. These forecasts give necessary information for production, inventory and capacity. Usually, forecasting is just based on the order history from the direct customer of a company. In case of fluctuating demand, it is difficult for companies to forecast the amount of production and inventory. Because of the fact that companies also adjust their safety stocks to future demand, the orders that a company places with their supplier show bigger swings. Chen, Drezner, Ryan and Simchi-Levi (2000) investigated that these swings could be reduced by sharing information about customer demand, however they also state that the BWE can even exist in a supply chain with complete demand information sharing and an equal inventory policy. Rong et al. (2008) confirm that even if demand is stable the BWE can exist. Tjalsma (2008) agrees with Chen et al. (2008) and Rong et al. (2008) about the fact that it is possible to reduce the BWE but it is impossible to completely remove it. Beerens (2007) preconceive that it is indeed impossible to totally solve the problem of the BWE. Tjalsma (2008) explains that the BWE is abatable by reducing the uncertainty in demand and shortening the lead time. Figure 1 below gives an overview of orders from a dealer to a manufacturer. The orders placed show much more variability that the actual change in demand.

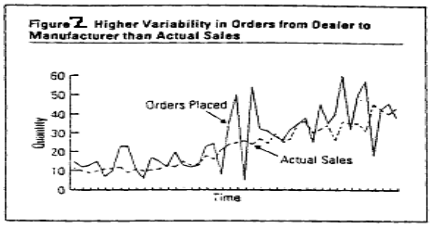

Figure 2: Order overview from dealer to manufacturer (Lee et al., 1997)

- Order batching: when demand comes in and there is not enough inventory, a company has to place an order with an upstream supplier. Often, a company does not directly place this order but batches or accumulates demands. In case of periodic ordering, companies order per week, per two weeks or even per month. For companies, it is relatively more expensive to order frequently. Besides that, "periodic ordering amplifies variability and contributes to the BWE" (Lee et al., 1997:96). Beerens (2007) emphasize that the suppliers often wrongly interpret the signals from their customer. For a company it would be ideal when customer's orders are spread throughout the week or month, because than, the BWE would be less intense. However, most of the companies place an order at the beginning or end of the month, which causes a high variability in demand and a stronger BWE.

- Price fluctuation: manufacturers and distributers sometimes make use of different promotions like for instance price discounts. These fluctuations in price often lead to forward buying, where products are bought in advance because of the temporary price discount. These discounts could also cause a temporary discount for the final customer. The result is that many customers buy more products than they actually need and place it in stock for the future. When the price of the product returns to the normal level, customers stop buying and use the products in stock. So, the buying pattern does not correspond with the consumption pattern and the variations in buying behavior are much higher than the variations in consumption. This often finally leads to the BWE.

- Rationing and shortage gaming: during a period of short supply, customers order more than they actually need. Customers hope to get a sufficient part of the (insufficient) total supply. In this situation it is difficult for suppliers to estimate the real customer demand. Tjalsma (2008) also emphasizes that indeed the uncertainty in demand is one of the most important reasons for the BWE. When demand stabilizes, customer's orders will disappear and cancellations will show up, which could be another cause of the BWE.

Next to the main causes identified by Lee et al. (1997), there are many studies (Beerens, 2007) that focus on possibilities to reduce the problems caused by the BWE. Beerens (2007) mentions five main areas where improvement is possible:

- Understand customers and their corresponding environment.

- Measure the exact influence of the BWE on the supply chain.

- Share information with supply chain partners.

- Involve customers and suppliers in forecasting demand.
- Integrate demand management and supply management.

3.4 The Beer Game

Many studies (Lee et al. 1997) mention the well-known Beer Game as the best way to illustrate the BWE. According to Rong et al. (2008), Sterman (1989) was the one who introduced the Beer Game and together with the theoretical study of Lee et al. (1997), it caused an increase in studies on the BWE. The participants of the Beer Game are people from all levels, mostly managers and students. The essence of the Beer Game is that these participants play the roles of customers, retailers, wholesalers and suppliers of a beer brand. Each party in this supply chain should base their order decisions just on the orders the receive from their direct downstream customers. There is no possibility for communication between the different parties/participants. An often returning phenomenon in the ordering pattern is the higher variability upstream in the supply chain compared with downstream in the supply chain. This is exactly the phenomenon that is described in section 3.1, the BWE. Sterman (1989) accomplished many Beer Game simulations and "Sterman's experiments showed that human behavior, such as misconceptions about inventory and demand information, may cause the BWE" (Lee et al., 1997:95).

According to Cleeren (2010), there are some shortcomings in the BWE which are caused by premises done in the Beer Game. Cleeren (2010) listed four shortcomings of the Beer Game:

- The Beer Game presumes volatility and uncertainty just on the demand side. Besides that, the Beer Game presumes there is always enough supply and infinite volume flexibility possible on the supply side, which is not a realistic assumption.
- As mentioned above, the Beer Game is mostly done by students. Usually these students are not familiar with the BWE do not know how to handle in such situations.
- Compared with the supply chain of the Beer Game, in a real supply chain, many companies have long term relationships which are based on trust. In the Beer Game, the different participants mostly do not have any relation with each other, which is not a realistic supply chain situation.
- The Beer Game gives a centralized outcome, however in a decentralized supply chain it is more common that a company first secure their own results because each company regularly have their own KPI's (variables to analyze a company's performance).

Cleeren (2010) emphasized that, despite his remarks, the Beer Game is still useful, however it is too premature to draw conclusions from the Beer Game that immediately count for the supply chain as a whole.

3.5 The Reverse Bullwhip Effect (RBWE)

Özelkan and Lim (2008) mention price variations as the most important cause of the classical BWE and presume that these variations have a negative influence on supply chain performance. Besides that, they mention the influence of price variations upstream in the supply chain on the downstream retail prices as the RBWE.

According to Rong et al. (2008), the opposite of the classical BWE is the RBWE. The RBWE is caused by disruptions in supply and, in comparison with the BWE, the order variability increases when it moves downstream instead of upstream in the supply chain. Besides that, Rong et al. (2008) investigated that in many industries the RBWE is dominant (53 percent) over the classical BWE (47 percent). As a clarification, Rong et al. (2008) give a graphical representation of the RBWE which is shown in figure 3 below. In this relatively simple graph, the downstream amplification is visible.

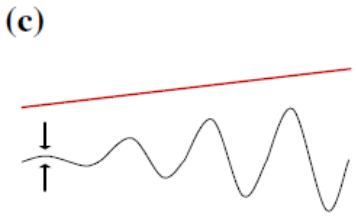

Figure 3: Graphical representation of the RBWE (Rong et al., 2008)

Cleeren (2010) explains that the RBWE is about a disruption at the supply side, whereby supply uncertainty and overestimated inventories cause the RBWE. Some industries which are susceptible for the RBWE according to Cleeren (2010) are industries with complex supply chains, seasonal products, assembly products and industries which are dependent on very specific products.

Many studies (Rong et al. 2008, Cleeren 2010) illustrate the RBWE with a practical example of the situation after hurricane Katrina of 2005. After hurricane Katrina, it was impossible for some oil drilling and refining companies at the U.S. coast to drill and refine oil (10 percent of capacity was unavailable) which caused panic under consumers. Many consumers reacted to the potential problems in availability of oil. The gasoline demand was very volatile and besides that, the production was stable because of the fact that the companies reached their maximum amount of production. Some results of this situation were rising prices and long rows for the filling stations. Cleeren (2010) states that consumers filled their tanks to a higher level because of their anxiety for

higher prices, what is a typical example of panic buying. The higher volatility in demand compared with the volatility in supply, according to Rong et al. (2008), clearly describes the RBWE.

Rong et al. (2008) also identifies some main causes of the RBWE. They state that supply side disruptions could be explained by two mechanisms: pricing and rationing. Both mechanisms cause problems in capacity. In the pricing mechanism the volatility in demand is caused by consumer's worries about increasing prices in the future. In the rationing mechanism consumers are worried about the future availability of products. According to Rong et al. (2008) it is possible to mitigate the RBWE by expanding the information sharing at the supply side. In mitigating the RBWE, Cleeren (2010) emphasizes the importance for a company to analyze the critical suppliers and preparing for potential problems with these suppliers.

3.6 Conclusive remarks

The BWE is broadly described as a phenomenon by which demand order variations becomes amplified when they move upstream in the supply chain. The Beer Game is a good way to illustrate this BWE. The main causes of the BWE described by Lee et al. (1997) are demand forecasting updating, order batching, price fluctuation and rationing & shortage gaming. Besides that, companies could possibly reduce the BWE by involving their customers within the forecasting process and by sharing information with supply chain partners. Finally, the opposite of the BWE is the RBWE what is described as: disruptions in supply which causes order variability's that increase when it moves downstream in the supply chain.

4 CONCLUSION AND RECOMMENDATION

4.1 Answer to research question 1: *What are the characteristics of Sales and Operations Planning (S&OP)?*

In this study, the definition of Grimson and Pyke (2007) is used to describe the S&OP process: S&OP is a business process that links a company's strategic plan to their daily operations plans and facilitates in balancing demand and supply for their products. To illustrate this definition, Grimson and Pyke (2007) give a five step procedure that a common S&OP process should meet in being successful. The most important parties involved in this process are the departments of Sales, Operations and Finance. Representatives from these departments should participate in a S&OP team. The frequency of the meetings of this team depends on both the volatility of the market and the production environment. On the other hand, the cooperation of these representatives is also one of the potential problems of the implementation of the S&OP process, because these departments usually have very conflicting issues. Olhager et al. (2001) mention that it is important to take into account that the S&OP practices have to be implemented within the capacity boundaries of a company. Kapp (2000) states that using an old fashioned "production planning" process is not sufficient in meeting today's customer demand and because of that, S&OP becomes a more critical organizational function within organizations. Besides Kapp (2000), many other studies (Wouters, 2009 and Chen-Ritzo et al., 2010) emphasize the importance of an accurate forecasting for S&OP. Inaccurate forecasting could lead to wrong supply, wrong inventory levels, deterioration of delivery reliability and ultimately, no optimal financial result. According to Beerens (2009), computer software like ERP and employees from Sales could play an important role in formulating an accurate forecast.

4.2 Answer to research question 2: *How is the Bullwhip effect (BWE) explained?*

In this research the definition of Lee et al. (1997) is used to give a description of the BWE. They broadly describe the BWE as a phenomenon in which demand order variations becomes amplified when they move upstream in the supply chain. Lee et al. (1997) mention four major causes of the BWE: demand forecasting updating, order batching, price fluctuation and rationing & shortage gaming. In 1961, Forrester explained the BWE with a supply chain simulation model with five entities: factory, distributor, wholesaler, retailer and final customer. This simulation model was a good bases for the Beer Game, which was introduced by Sterman (1989). The essence of the Beer Game is that participants play the roles of the above mentioned parties (except from the final customer). A frequent outcome of the Beer Game with respect to the order pattern is a higher variability upstream in the supply chain, compared with downstream in the supply chain, which is described as a typical

example of the BWE. According to Cleeren (2010) there are some shortcomings in the BWE effect which are caused by the Beer Game. It is too premature to draw conclusions from the Beer Game that count for the whole supply chain, besides that, he still thinks the Beer Game useful to illustrate the BWE.

The opposite of the classical BWE is the RBWE which is described by Rong et al. (2008) as: disruptions in supply which causes order variability's that increase when it moves downstream in the supply chain. The two main causes of the RBWE identified by Rong et al. (2008) are the pricing mechanism and the rationing mechanism. In these mechanisms, volatility in demand is respectively caused by consumer's worries about increasing prices and consumers worries about future availability of products.

4.3 Answer to the problem statement: *How can Sales and Operations Planning (S&OP) help in reducing the Bullwhip effect (BWE)?*

To give an answer to the problem statement it is important starting to link the concepts of S&OP and the BWE.

As mentioned in this research, the S&OP process is mainly about balancing supply and demand of a company's products. An important activity in balancing supply a demand is an accurate demand forecast because a company's supply plan is dependent on it. The BWE is about the phenomenon in which demand order variations becomes amplified when they move upstream in the supply chain. Besides that, the RBWE is the opposite of the classical BWE. One of the main causes of the BWE is an inaccurate forecast of demand.

Mostly companies just base their demand forecast on the order history of their direct customers in the supply chain and do not analyze customer's order patterns more downstream in the supply chain. This is one of the potential problems in forecasting the wrong demand (which could lead to the BWE). In case of fluctuating demand of final customers it is difficult for downstream companies forecast this real customer demand because the upstream companies also adjust their safety stocks to future demand. If upstream companies have more insight in decisions of downstream companies and the order pattern of the final customer, than it is possible for the upstream companies to adjust their decisions on it. The S&OP teams of different companies should share their supply and demand information with other S&OP teams operating in the same supply chain. Besides that, the S&OP team of supply chain companies should involve customers in forecasting demand. A more accurate forecasting of demand could lead to a reduction of the BWE.

In case of the RBWE, it is important for S&OP teams to forecast the influence of customer's worries about prices and availability of products on their demand ordering pattern. This could also be achieved by sharing information between the S&OP teams of different companies of the supply chain and involving customers in forecasting their demand. Besides that, supply chain companies and their S&OP teams should map out their critical suppliers and prepare for potential problems with these suppliers. In case of problems with these suppliers, companies can adjust very quickly and make sure the supply of products still remain at a sufficient level what helps to reduce, or maybe remove, the effects on the ordering pattern of final customers.

4.4 Limitations and recommendation for further research

This research provides a literature review on the concepts of S&OP and the BWE and link both concepts to examine how S&OP can help in reducing the BWE. However, the amount literature available on the link between both concepts is limited. Besides that, there is also no literature available on exact (numerical) influence of the BWE on a supply chain. In this study it was not possible to do an empirical research on the exact influences of the BWE on a supply chain and how S&OP activities can help in reducing it by improving the process of demand forecasting in a supply chain.

Therefore, a suggestion for further research could be a more in depth study on the numerical influences of fluctuations in demand on different companies operating in the supply chain. This could be done by analyzing supply and demand numbers of different companies operating in a simple supply chain in case of fluctuating customer demand. After that it should be checked what the exact influence is on company's inventory levels and supply orders. With this numerical information it is possible to check what influence a more accurate forecasting (through information sharing) could have on the results of these companies.

4.5 Managerial implication

In this research, the importance of an accurate demand forecasting is described. As mentioned above, this could be achieved by using a well operating S&OP team. To be successful for a company in implementing S&OP practices (like forecasting demand), it is important that representatives Sales, Operations and Finance participate in the S&OP team. Sales should think about 'what could be sold', Operations about 'what could be produced' and Finance should take into account what is financially possible for a company. Besides that, the members of the S&OP team must partly put away the issues of their own departments (functional silos must be broken down) and should take into account the issues of the overall company's performance. It is necessary for the

S&OP team to plan an accurate amount of meetings in which they inform each other about the department's performance and discuss new insights. The amount of meetings depends on the volatility of the production environment and the market. In a very volatile market, it is necessary to plan a frequent amount of meetings. Based on the information that comes from the meetings, the whole S&OP team is responsible for forecasting the right demand and adapting a company's supply to it.

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Figure 1: Graphical representation the BWE

Rong, Y., Shen, Z. J. M., & Snyder, L.V. (2008). The impact of ordering behavior on order-quantity variability: a study of forward and reverse bullwhip effects. *Flex Serv Manuf J,* 20, 95-124.

Figure 2: Order overview from dealer to manufacturer

Lee, L., Padmanabhan, V., & Whang, S. (1997). The Bullwhip Effect in Supply Chains. *Sloan Management Review*, Spring 1997.

Figure 3: Graphical representation the RBWE

Rong, Y., Shen, Z. J. M., & Snyder, L.V. (2008). The impact of ordering behavior on order-quantity variability: a study of forward and reverse bullwhip effects. *Flex Serv Manuf J,* 20, 95-124.