Solving the Bullwhip Effect in Supply Networks by incentivizing behaviour through decentralized Forecast Accuracy Discount agreements

A simulation case study within the Supply Chain of the Technische Unie and Legrand Nederland

Master thesis
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Free markets and democracy are alike: They create fluctuations and instabilities, which result in tremendous wastes of resources, however, they also distribute power and are able to approximate the continuously changing optima's in our inherently dynamic society.

Where the resolution of local disturbances by the paradigms of control and efficiency seems rational in the short term, one must always remind that adaptiveness is the key to long term survival in the uncertain, changing environment of these complex networks.

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Summary

The Bullwhip Effect refers to the amplification of variations of orders as one moves upstream Supply Chain and is a well-known operational problem that lead to higher costs and lower service levels throughout Supply Chains. Extensive research has been done towards its existence, quantitative effects on Supply Chain performance, its causes, importance of specific operational Supply Chain aspects and the effectiveness of various solutions. Most researchers have focused their research on the direct systemic causes of the Bullwhip Effect that lie within the dynamic outcomes of operational policies regarding ordering, forecasting and inventory management, as well as the direct behavioural causes due to the bounded rationality of operational planners and their resulting biased behaviour. The majority of solutions that have been proposed by scholars is based upon the synchronization of operations by integration of coordination to solve systemic causes and creating information transparency to reduce errors in decision making due to information asymmetry and wrong perceptions. Although scientific literature is rich in solid demonstrations of the effectiveness of these solution, actual implementation remains scares.

Complication of current solutions to the Bullwhip Effect
Although strategic behaviour has been identified as a direct cause for the existence of the Bullwhip Effect, it has rarely been explicitly considered as a barrier to implementing solutions by Supply Chain parties and effectively a cause of the persistence of the Bullwhip Effect. We believe there are several reasons why the physical and institutional nature of modern Supply Networks and organizations lack incentives for individual companies to implement most integrative solutions proposed by scholars. First of all, the complexity of today's Supply networks makes integrative solutions unfeasible, because companies have too many suppliers and customers to cooperate with, centralized coordination in networks creates delineation and interface problems and the inherent dynamics of Supply Networks makes high investments too much of a risk. Secondly, a barrier lies within the self-optimizing nature of companies. Any improvement a company can make to reduce the Bullwhip Effects benefits upstream Supply Chain parties, but is sub-optimal for themselves. Unless compensation is offered for their deterioration in performance, a company has no incentives to reduce the Bullwhip Effect. The third barrier lies within the competiveness of commercial relations. In an operational sense, companies can both benefit when sharing operational information, however from a strategic perspective this information is sensitive with regard to commercial negotiations. This causes companies to be unwilling to share this information with suppliers and customers. Finally, the internal coordination structures of companies don't provide direct incentives for their managers to solve inter-organizational problems, since the domain of their responsibilities and authorities are often internally focused on specific company activities.

Research approach
In order to overcome these barriers we have approached this research by investigating the possibilities of inter-organizational agreements as a solution to the Bullwhip Effect which incentivize customers to reduce the fluctuations in their orders. The decentralized nature of agreements is more suitable within the complex nature of Supply Networks and appropriate external incentives have the capabilities to create productive self-optimizing behaviour and drive managers to look beyond the scope of their internal responsibilities. Local agreements also don't necessarily require the transparency of sensitive information.

We have approached this research by conduction as theoretical analysis and a case study analysis toward the Technische Unie in which we have defined 1) the systemic and behavioural factors that contribute to the Bullwhip Effect in order to understand the mechanisms that lead to the existence and persistence of the Bullwhip Effect, 2) the goals that have to be achieved by solving the Bullwhip Effect and the requirements for the design in order to be able to assess whether the design would be effective and realistic, 3) the available solution elements for the design of operational agreements in order to define the solution space and 4) the available design frameworks for operational agreements in order to structure the design process. Based on these findings we have defined the design of Forecast Accuracy Discount (FAD) agreements and built a simulation model of the specific Supply Chain of the Van Geel product group of Legrand Nederland towards the Technische Unie. Using this simulation model we have analysed the effectiveness of the FAD agreements in solving the Bullwhip Effect and answered out main research question:

"What are the effects of Forecast Accuracy Discount agreements between supply chain parties on the behaviour of actors in Supply Chains and the Bullwhip Effect?"

Exploratory research results

First we have identified the systemic and behavioural factors that contribute to the Bullwhip Effect by defining a generic systems model that captures the systemic processes and flows of goods, information and funds on Supply Network, organization and site level and that captures the behavioural interactions of companies on Supply Network level and divisions on organizational level. We have applied this model to the case study used the results in combination with the theoretical study to define a model containing the problem perspectives towards the existence and persistence of the Bullwhip Effect.

We have defined the competitiveness of Supply Chains to be the overall goals to which solving the Bullwhip Effect should contribute and the improvement of customer satisfaction through service levels and total cost reductions through reducing investments costs, operational costs and contingency cost to be the two major goals within the scope of the Bullwhip Effect. Because the oscillations of inventories and production are closely related to and influenced by the Bullwhip Effect and its goals, we have defined the design to be effective when it achieves a combined change in oscillations of orders, inventories and production which leads to a total cost reduction of all Supply Chain parties, while maintaining or improving their service levels. For the design of the arrangement we have defined requirements for the acceptability of the design for all involved and related parties, the feasibility of the design within current Supply Networks and general applicability for most products and within most common Supply Networks and companies.

Furthermore, we have analysed solutions for the Bullwhip Effect from literature to define and structure the possible design elements for the Bullwhip Effect. These design elements could either require integration of activities among companies or have a local domain. The local solution elements that were suitable for the design of agreements were selected here. Because suitable design frameworks for operational agreements have not been found, the design was structured by defining a design philosophy and operationalizing the ideas using the solution space.

Forecast Accuracy Discount agreements

The Forecast Accuracy Discount agreement is based on the idea of providing customers with financial incentives to smoothen orders through providing them discounts when their orders are accurate towards earlier provided forecasts of their expected orders. During the agreement the customer provides the supplier with forecasts of expected total order quantities of future time intervals, for example weeks, which must be defined before a deadline of a certain number of these time intervals, for example four weeks, called the forecast sharing horizon. The customer remains free to order any quantities, however the discount percentage he will receive over the orders within an forecast interval depends on the deviation towards his forecast. Both parties have to agree upon the value of the forecast sharing horizon, the maximum discounts and the deviation bounds. Orders with larger deviations from the forecasts than these bounds, no discounts will be given anymore. Deviations within these bounds will result in a discount that is a fraction of the maximum discount, equal to the fraction of the deviation towards the set bounds. This is visualized in Figure 1.

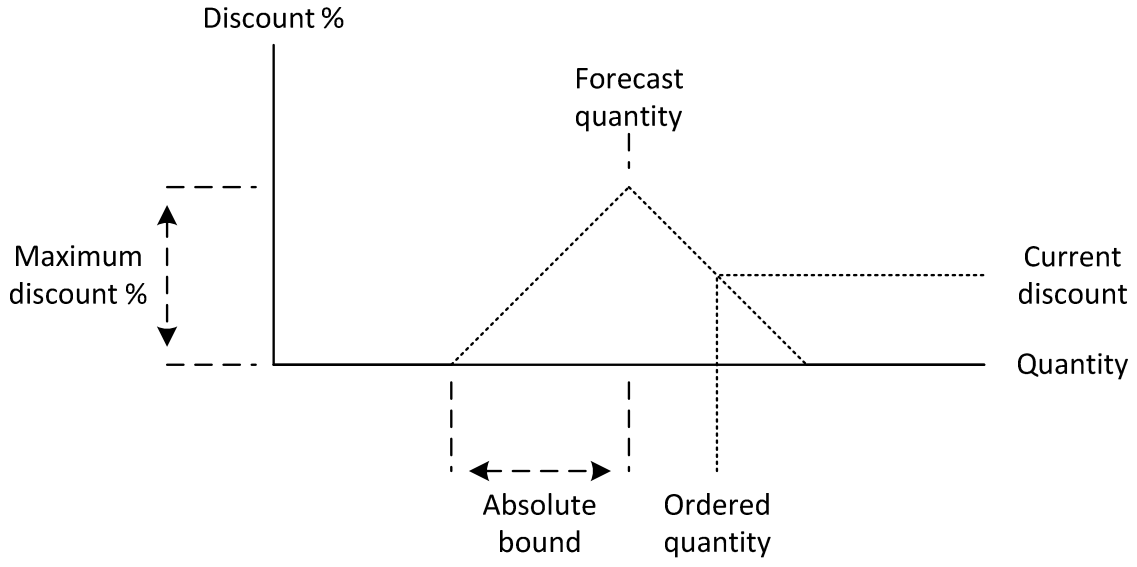


Figure 1: Visualization of the mechanism of Forecast Accuracy Discounting agreements

The FAD mechanism incentivizes customers to order as much as possible according to their given forecasts, unless higher orders are strictly necessary. Initially, customers are incentivized to share their actual expected orders according to their ordering policies and planning systems, however customers are also incentivized to share forecast that will increase their expected discounts and adopt their operations to be better able to order according to their forecasts. Forecast sharing time intervals, horizons, discount bounds and the maximum discounts are parameters which are periodically renegotiated by the two parties. Both parties have interests in short forecast sharing time intervals, because it enables the customer to spread its odds and increase expected discounts and it will provide the supplier with more accurate information. For the discount bounds and the maximum discount, both parties have conflicting interests and therefore an optimum is expected to result from negotiations on the terms of the agreement. For the forecast sharing horizons we have used the simulation to determine that it is in the interests of both parties to apply longer horizons, because its increases the accuracy and discounts and has the best results on the operational performance. In addition to the parameters of the FAD mechanisms, the parties will have to negotiate additional condition upon reducing order increments when they constrain the freedom of the customer, removing lead times of the supplier where possible and abandoning arrangements which provide counterproductive incentives such as quantum discounts and rationing policies based on order registration dates.

Simulation approach an results

The effects of the FAD agreements on the Bullwhip Effect have been tested using a empirical, discrete, event based simulation model of the case study: The Van Geel product group supplied by Legrand Nederland to the Technische Unie. In the model both the Technische Unie and Legrand Nederland are simplified as respectively single production and distribution locations and processes are calculated over 2012 using a discrete, incremental time logic of days. Every simulation day the model calculates the flows of goods between storage nodes based on schedules, then calculates the new inventories and backlogs at these nodes and finally revises the schedules. This model contains the empirical policies for inventory management and ordering, however the demand of the end market and forecasts are given model inputs based on historical data. For the actors behaviour within the FAD agreements a number of heuristics are defined: The Technische Unie shares its expected orders according to its actual expectations and orders according to its forecasts unless higher quantities are necessary and Legrand updates its forecasts by replacing the expected order quantities of the Technische Unie by their forecasted quantities. The structure of the model has been validated by consultation of experts within the Technische Unie and Legrand Nederland

The simulation is performed for 6 Van Geel products that the Technische Unie purchases, which are representative for the variations in relative lengths of lead times in relation to order intervals, the levels in which order increments constrain the freedom of ordering and the classification of the products being either fast or slow movers. For these six products the empirical demand data is used to validate the outcomes towards historical behaviour of both parties. Then for each product a total of 25 simulation cases are performed with 1000 simulation runs per case using samples of representative demand distributions in order to test the sensitivity towards the demand input. In these cases the increments, order intervals, lead times and forecast sharing horizons were varied to assess their effects. We have assessed the effects of the cases on Key Performance Indicators for service levels, inventory turnover rate, the Bullwhip Effect and specifically for inventories, order and production we have defined KPI's for their fluctuations and capacity need.

The overall results of the simulations indicate that Legrand Nederland and the Technische Unie are able to simultaneously reduce the Bullwhip Effect and fluctuations in inventories, production and orders, while maintaining their service levels by adopting Forecast Accuracy Discount agreements with long order forecast sharing horizons of 5 weeks in combination with alleviating constraining increments ,reducing the order intervals of the Technische Unie and lead times of Legrand to an equal level of 13 or 7 days and raising the safety stock levels of both parties to maintain an acceptable service level. Higher inventories may be a result of these changes, however the related increased inventory holding costs are compensated by lower capacity investment costs and contingency costs due to lower fluctuations in orders, inventories and production. Because Legrand Nederland is located in an upstream Supply Chain position towards the Technische Unie and is a manufacturer with more expensive investments in production capacity, they are expected to benefit the most, however the discounts within the FAD agreements are expected to compensate this inequality. This results in the possibility of a Pareto Improvement in total operational costs and service levels for both parties.

These results provide incentives for Legrand Nederland and the Technische Unie to adopt the Forecast Accuracy Discount agreements in which their set the forecast sharing horizon to the longest useful value, which is the total throughput time of operations of Legrand from initiating replenishment orders to delivery at the Technische Unie. For the discount bounds and maximum discounts both parties are expected to arrive at acceptable values through negotiation. Also, both parties are

incentivized to reduce order increments, order intervals and lead times as much as possible and adapt their physical operational systems to accommodate these changes.

Conclusions

The effects of Forecast Accuracy Discount agreements on the behaviour of the supplier and buyer within the agreement can be stated on operational, tactical and strategic level. At operational level, the customer is incentivized to order according to its shared forecast unless higher orders are necessary to maintain service levels and share forecasts honestly according to its own expectation or at least towards the long term average demand. In order to be able to order as much as possible according to its own forecast the customer is incentivized to increase its safety stocks. This operational behaviour reduces the fluctuations in orders and increases the demand predictability for the supplier.

At a tactical level both the customer and the supplier have incentives to alleviate constraining order and production increments, shorten lead times and order intervals and forecast sharing internal to an equal level, extent the forecast sharing horizon towards the total operational throughput time of the supplier and negotiate mutual acceptable maximum discounts and discount bounds

Finally, at strategic level, both parties are incentivized to adopt and maintain Forecast Accuracy Discount agreements and adapt the physical structure of its operational system to suit smaller series sizes, order increments, lead times and order intervals. The customer has incentives to revise its ordering policies towards a system with fixed order intervals and variable quantities to suit the nature of the Forecast Accuracy Discount agreements.

Barriers for adopting FAD agreements remain the old industrial paradigms from which some organizations operate, the internal distribution of authorities and responsibilities, preoccupation with other issues and unequal power balances between suppliers and customers. The agreements are not able to overcome these barriers, however their simple nature makes them easy to understand and implement and their focus on cooperation and mutual benefits makes them suitable instruments for improving relationships and opening up new doors for cooperation.

Recommendations

From a scientific perspective we recommend further research toward the Effects of Forecast Accuracy Discount agreements to gain more solid knowledge on their effects, such as additional simulation case studies for more general knowledge, analytical research to arrive at more certainty on the systematic effects of the agreements and Serious Gaming Experiments to arrive at more certainty on the strategic behaviour of parties negotiating the conditions for the agreements and applying them. Specifically we propose to perform additional research on the effects of adjusting safety stocks, additional quantitative research on the effects of costs and additional research on the effects of interactions of multiple agreements within a Supply Network.

For implementation by the Technische Unie we recommend to initiate by assessing the products for which they would like to implement the FAD agreements. We recommend to assess whether the Bullwhip Effect is a problem by defining the Bullwhip Effect value for each product along with an assessment whether lead times are longer than order intervals and order increments constrain the freedom to order to obtain insight in the specific causes. In addition we recommend to assess the strategic importance of products by assessing their relative share in value, inventory space, sales quantities and handling operations. Based on this analysis we propose to first select strategic products with problematic Bullwhip Effect values. We then advice to assess the suppliers that provide this product selection and select suppliers with a sufficient number of products of interest. Based on the relationship status with these suppliers we advise to choose the desired level of cooperation starting at only redefining increments, lead times and order intervals to remove the initial causes of the Bullwhip Effect and furthermore implementing the actual FAD agreements and later on agreements on further information sharing and communications for suppliers of high strategic importance.

1. Introduction

The concepts of Operations Management and Supply Chain Management find their roots in the industrial era and have evolved over time according to the changes in the technological, economic and social landscape. The classical production paradigm, well known as mass production, was driven by the technological developments in steam and internal combustion engines. The concepts of productivity and efficiency is at the core of the classical paradigm and are today still the backbone of Operations Management and Logistics Management (Hollander 1987). Increasing speed of operations, also known as the Time Compression paradigm, is the main method to increase productivity. Efficiency is achieved by reducing the need of resources and increasing asset utilization. The classical production paradigm includes the standardization of products and production systems, most commonly recognized by the use of production lines, to achieve scales of economies and reduce costs. The asset utilization paradigms led to the use of heuristics such as Economic Order Quantities and full truck load transportation planning. These heuristics were all based on local cost optimizations. In the late 19th and early 20th century the classical paradigm worked relatively well since products were relatively simple, innovation cycles were longer, Supply Chains were simpler and more vertically integrated, markets were locally oriented and the speed of transportation and communication was slower (Mentzer, DeWitt et al. 2011).

All of these aspects changed especially after WWII. Technological developments enabled more complex products and accelerated the innovation of products. Driven by emerging marketing paradigms, companies focused their strategies on providing more variety and customization of products, a trend that continues up to today (Simatupang and Sridharan 2002). Political forces enabled companies to extent their markets on a global scale. The emergence of Lean Manufacturing by Toyota was a response to these changes(Holweg 2007). The principles of Kanban Production and Just-in-Time management allowed them to better align the operations internally and interfacing with customers and suppliers This enabled integrated intra-organizational cost optima's, while producing a wider variety of product by the principles of mass customization. The quality of both products and operations were enhanced by new quality paradigms, such as Six Sigma and Total Quality Management. As a response to Lean Manufacturing, Eliyahu Goldratt developed the Theory of Constraints (Goldratt and Cox 1984) to change the American automobile industry and become more competitive against the Japanese Lean Manufacturing principles. His concept was based on systems thinking and the overall effectiveness of companies. He criticizes the faults of the classical efficiency oriented paradigms and advocates to focus on bottlenecks or constraints which limit the effectiveness of companies. He states the goal to improve the productivity of companies as systems as a whole by the repetitive innovation process of finding constraints, exploiting them and alleviating them. Similar theory on innovation cycles were developed by scholars such as the Deming Circle (Deming 1993).

During these developments in 1950-1980, Forrester developed the first principles of system dynamics and in his book "Industrial Dynamics" (Forrester 1961) he focused on the operational behaviour of companies. He describes the increase of variability of placed orders at suppliers in relation to the received orders by customers and contributes the effect to the lack of inter Supply Chain coordination and the incompetence of managers to cope with the complex non-linear interactions. With this observation, Forrester became known as the first author to describe the phenomenon that would become known as the Bullwhip Effect. In the fifties there was however little attention for this coordination problem between companies, since most companies had their focus on the optimization of internal processes facing the difficulties of increasing product complexity and variety and the emergence of global markets. On the other hand the structures of Supply Chains were still relatively simple and vertically integrated (Mentzer, DeWitt et al. 2011). Scholars trying to research and simulate industrial dynamics were limited by the technology of analogue computers (Zymelman 1965). As a result, the Bullwhip Effect was perceived as a minor issue.

During the eighties this changed. The emergence of more complex electronics made it very difficult for companies to maintain all product knowledge and competences in order to manufacture an end product from raw materials. The large conglomerates, required to fully exploit all the possibilities of its technology, became difficult to coordinate and suffered from diseconomies of scale. Smaller, specialized companies were able to produce semi-finished products much cheaper, because they fully exploited the possibilities of their specialized competences. The problem of coordination of large firms in globalized markets with larger geographical distances led to decentralization in the form of fragmentation and outsourcing of business operations (Tsay and Lovejoy 1999). This disintegration caused Supply Chains to become Supply Networks. Not only had they become longer in terms of operations and number of autonomous organizations. The number of suppliers and business customers had also increased, especially upstream Supply Chains. These development had changed the focus from intra-organizational towards inter-organizational aspects and the Bullwhip Effect became a serious point of attention (Mentzer, DeWitt et al. 2011). In 1989, Sterman conducted the famous MIT Beer Game experiments, which demonstrated

the severity of the Bullwhip Effect and how paradigms and practices of Operations Management caused players of this game to induce the phenomenon. (Sterman 1989)

In the same era, the emergence of IT systems revolutionized the operations of companies. Computer systems allowed much faster, cheaper and accurate planning and communications (Lee 2004). It also enabled further globalization, driven by cost pressure and global customer demands, because it enabled better interconnectivity of geographical remote operations (Yu, Yan et al. 2001). The increased availability of data also enabled researchers to study operational dynamics in more depth. In the nineties the Bullwhip Effect was extensively studied using the empirical data from companies. It was Procter & Gamble that invented the name "Bullwhip Effect" during a research toward the amplification of variance in the orders of diapers, which was remarkable considering the very stable market demand of Pampers (Lee, Padmanabhan et al. 1997). Other well-known case studies on the Bullwhip Effect are conducted at Hewlett-Packard and Barilla (Simchi-Levi, Kaminsky et al. 2003). These studies aimed at empirically demonstrating the existence of the Bullwhip Effect. In the late nineties focus on the Bullwhip Effect shifted towards finding the causes and according solutions for the phenomenon.

In the 21th century, research on Supply Chain Management further emphasizes on the networked structure of Supply Chains and the implications for managers. In his article "The Triple-A Supply Chain", Lee describes the challenges for successful Supply Chain Management in this new era. Supply Chains should be agile to respond to short term disturbances and adaptable to long term changes (Lee 2004). These two concepts are based on the paradigm of responding to external influences rather than the old paradigm of control. The third aspects Lee advocates is alignment. Companies should align themselves to optimize overall Supply Chain performance. He urges information sharing, cooperation and incentivizing as the main strategies to achieve these goals. The first two strategies are extensively researched as solutions for the Bullwhip Effect, however the importance of alignment is neglected. In the light of current developments in research towards Supply Chain Management it is remarkable to observe that solutions for the Bullwhip Effect are always based on systematical behaviour and the principles of centralized coordination. Authors of the extensive literature on the phenomenon rarely consider Supply Chains to be networks with autonomous actors which have their own interest which can conflict and therefore oppose a barrier to cooperation and information sharing. Most researchers demonstrate in which extent their solutions improve the overall Supply Chain performance and very often also benefit all involved parties. This can be the reason most researchers consider incentives for cooperation are naturally present. However, the networked structure of modern Supply Chains implies systematical and behavioural barriers to collaborate. Lee et all (1997) conclude that there remains a challenge to arrive at agreements among Supply Chain parties to implement the proposed solutions. Companies do focus their strategies on Supply Chain cooperation and synchronization (Anderson and Lee 1999) and the quantity and quality of shared information in Supply Chains increases (Croson and Donohue 2006). Reality, however, also shows that companies are hesitant to initiate collaborative programs. Tsay and Lovejoy (1999) conclude that implemented solutions for synchronization of Supply Chains have often turned out to result in counterproductive outcomes. The main causes for the lack of cooperation and counterproductive outcomes are due to the lack of knowledge, competence, trust and incentives of actors in a networked environment to behave in a productive manner.

Based on these insights this research approaches the Bullwhip Effect from another perspective than most researchers thus far. Organizations are considered as autonomous actors in a dynamic socio-technical network with individual interests and which are prone to bounded rationality and strategic behaviour. In contrast to the centralized, control oriented approaches of most scholars, this research focuses on decentralized agreements between two actors in a supplier-buyer relationship which incentivizes behaviour rather than instructing procedures. This local behaviour should then create Supply Network wide emergent behaviour which reduces the Bullwhip Effect. This approach has also been considered by other authors in the field of inter-organizational coordination and contracting (Whang 1995; Lariviere, Tayur et al. 1999; Tsay and Lovejoy 1999). The effectiveness of contractual structures have been shown to replicate the efficiency of centralized control. Tsay and Lovejoy (1999) reference a large number of articles and papers that report on the efficiency of contractual structures in buyback/return arrangements. Lee, Padmanabhan et al. (1997) suggest that companies who want to gain control over the Bullwhip Effect are best served by attacking the institutional and inter-organizational infrastructure. Ostrom (2010) reveals that decentralized self-governance of networks is more effective than centralized governance. The focus on incentivizing by arrangement in solving the Bullwhip Effect in this research does not exclude the necessity of the concepts of knowledge, competence and trusts. They are important factors since actors should be able to understand how the agreements will solve the Bullwhip Effect, the actors should be capable of implementing the agreement and the agreement should be acceptable within the common levels of trust in supplier-buyer relationships.

In this research the possibilities of incentivizing inter-organizational arrangements are explored as a solution to the Bullwhip Effect and we propose the design of Forecast Accuracy Discount (FAD) agreements as a solution for the Bullwhip Effect within this scope. FAD agreements are essentially a discounting arrangement provided by suppliers to customer, which are based on the accuracy of the total order quantities within predefined time intervals in relation to previous forecast given by the customer about the expectations of his own orders. These agreements incentivize customers to smoothen both their order and order forecasts in order to provide more accurate and predictable demand which eventually results in more stable order patterns which reduce the operational costs of suppliers.

The FAD agreements are tested using a simulation model of the specific case study: The Van Geel product portfolio manufactured by Legrand Nederland and distributed by the Technische Unie. The simulation is performed on a selection of seven Van Geel products which are representative for the entire portfolio. The Technische Unie is a wholesaler in technical components for installations used in buildings and utilities which focuses on the Dutch market only and has a leading role among wholesalers in its market segment. It is part of the Sonepar Group, a European based consortium of wholesalers with the main focus on electrical materials. Legrand is a global supplier of components for electro technical installations and data networks and one of their major suppliers. Using a simulation model of this case the FAD arrangements are tested and evaluated. Although the results are only valid within the specific case study situation, a sensitivity analysis indicates a more general effectiveness of FAD arrangements in reducing the Bullwhip Effect.

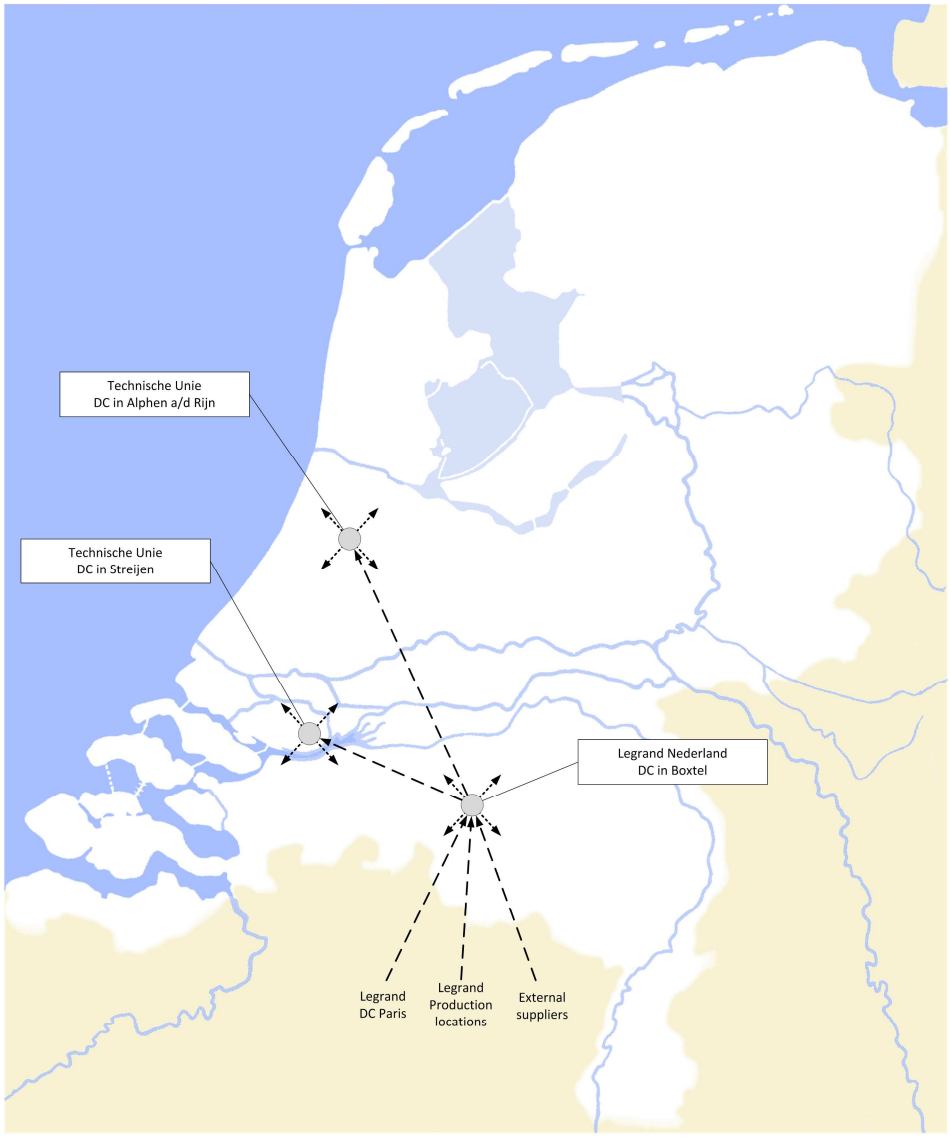


Figure 2: Geographical map of logistical locations of the Technische Unie and Legrand Nederland

The Technische Unie is a wholesaler with a very broad assortment of about a million technical installation components for about 90.000 customers in the Netherlands where they are the market leader. They offer extensive logistical services which are focussed on fast and flexible services towards their market. In order to do this the Technische Unie has two distribution centres in Alphen a/d Rijn and Streijen , 37 service centres and 22 transhipment points throughout the country. Their organization focusses mainly on the processes of purchase, sales and logistics, backed up by the departments of IT, finance and Human Resources. From a supply chain perspective the Technische Unie can be considered to be in the last downstream echelon delivering directly to the end consumer, because their business clients essentially consume the products in their construction process. The Technische Unie buys the products directly from about 700 end manufacturer without changing the products or its first tier packaging. Therefore the form of their supply chain can be considered many-to-many: Purchasing vast amounts of products from a large number of suppliers and selling them to an enormous market of individual clients.

Legrand is a global manufacturer of electrical and digital infrastructures for buildings located in Paris. They produce systems for the control, transport and distribution of electricity and data. Their worldwide assortment consist of 178.000 product within 98 product families. In 2004 Legrand acquired Van Geel, a manufacturer of cable ducts located in Boxtel, which became Legrand Nederland B.V. Today Legrand Nederland still manufactures the Van Geel cable ducts and in addition functions as a distributor of Legrand products to the Dutch market. Products are sold both to wholesalers as the installation companies who essentially consume the products in their operations. Their supply chain form can be considered heavy outbound or little-to-many, however wholesalers as the Technische Unie are large customers which individually hold a significant market share.

Nowadays Supply Chains continue to become more dynamic and volatile (Wilding 1998; Fiala 2005). They will behave more like networks that become longer, more complex, interdependent and interconnected. Due to these development fluctuations in orders are higher and faster in most markets than before (Lee 2004). This will increase the importance of reducing the Bullwhip Effect as it is likely to increase even more in the future. Because Supply Chain are becoming more complex networks it will also become more increasingly important to find solutions for the Bullwhip Effect that are feasible and effective in this environment. I believe the approach of this research contributes to the right approach on solving the Bullwhip Effect in the Supply Chains of today and tomorrow.

1.1. Reading guide

The next chapter will outline the research definition of this thesis by explaining the research questions, methods and the scope around the case study. Chapter 3 reports on the exploration of the problem by summarizing the current state of research and conclude on a clear definition and quantification method for the Bullwhip Effect. This method is used to define and interpret the current state of the Bullwhip Effect for the products in the case study. This chapter concludes by defining the goals to be achieved and general requirements for the to be designed agreements. Chapter 4 contains an analysis of the mechanisms which contribute to the Bullwhip Effect. This chapter will define a generic systems model which captures the coherency of both the systemic as behavioural aspects related to the Bullwhip Effect. Then a number of problem perspectives are stated that explain the existence and persistence of the Bullwhip Effect within the logic of the defined systems model. Four problem categories are defined here. Again these two conceptual models are applied to the case study of this research. In Chapter 5, the solution space for the Bullwhip Effect is explored. First, existing solutions are structured towards the four problem categories defined in the previous chapter in order to understand how these solutions address the Bullwhip Effect. Secondly this structure is used to select the solution elements that are suitable for the definition of decentralized arrangement and finally these elements are structured into the solution space for decentralized arrangement. In chapter 6 the design of Forecast Accuracy Discount agreements are elaborated. Because of the lack of a suitable design framework, first a general design philosophy is described, stating the idea behind the FAD agreements. Then the design is elaborated. Chapter 7 describes how the application of the systems model to the case study is translated into the simulation model which is used to test the FAD agreements. The conceptual and physical structure of the simulation model is explained and the selection of Van Geel products for the simulation is discussed. Finally the chapter covers how the simulation model was validated and which systemic approach was used to test the FAD agreements. Chapter 8 reports the results of this simulation and analyses which behaviour the outcomes incentivize. Chapter 9 evaluates the FAD agreement design according to the defined goals and requirement using the simulation results. Also the FAD agreements are positioned within other existing solutions and the scope in which design is applicable and effective is assessed. In Chapter 10 the main research question and sub questions of this thesis are answered and finally Chapter 11 cover both the scientific recommendations for further research and the practical recommendations for implementation of the FAD agreements by the Technische Unie.

2. Research definition

This chapter will define and delineate the research. First it will describe its scientific relevance and social relevance in general and for the specific case study. Then it addresses the problem statement and delineation from which the research initiated. This has led to a number of specific research questions which have been defined ex ante. These are described in the third paragraph, followed by the used research and design methods. Finally the scope of the research and design process is elaborated.

2.1. Scientific and social relevance

As illustrated in the historical context in the introduction of this thesis, constraining the Bullwhip Effect will become increasingly important to maintain the stability in Supply Chains which is needed to secure the availability and affordability of products and services. This research also contributes specifically to the competiveness of the Technische Unie and Legrand Nederland by creating insight in the causes for operational instabilities in their Supply Chains and offering them solutions to solve these problems and create more stable and cheaper Supply Chains, creating a competitive advantage towards their competitors. From a scientific perspective this thesis contributes to the research towards the Bullwhip Effect and operational Supply Chain coordination: A literature based discussion on the desired ends towards solving the Bullwhip Effect, a generic model for operational Supply Chain behaviour assuming independent self-interested actors, a framework for structuring the problem perspectives on the Bullwhip Effect, an empirical demonstration and quantification of the Bullwhip Effect and its specific causes for over 1700 individual products, a structured overview of current solutions for the Bullwhip Effect proposed in literature, the extension of this the solution space with Forecast Accuracy Discount arrangements and the evaluation of the effectiveness of these arrangements in the case study. More indirectly the research is also a contribution in the fields of Supply Chain coordination, emergent behaviour in networks and the design of institutional agreements that steer behaviour by forming incentives.

2.2. Problem statement and delineation

This research is initiated from the following question:

"How can institutional agreements be a feasible and realistic solution for the Bullwhip Effect by creating incentives for cooperation which effectively copes with the complexity of actual supply networks and its dynamic environment?"

First this problem is delineated around the solution approach. The focus is on decentralized arrangements which can be formalized in contractual terms or informally enforced. The aim is to have local arrangements which lead to effective self-organization in Supply Networks according to the definition of self-organization by Prehofer and Bettstetter (2005): "…an organizational structure that does not need any external or central coordination". Another important delineation is the approach to define agreements that incentivize effective behaviour by aligning the right system wide decisions with the individual interests of actors within their given action situation. Ostrom (2010) advocates the approach of self-organization to solve social dilemmas instead of the need of external intervention by scholars and the government officials. Tsay and Lovejoy (1999) have also approached the Bullwhip Effect by contractual arrangements, which they position under the terms vertical restraints in Classical Economic literature, channel coordination in marketing literature and agency theory in New Institutional Economics.

Secondly the problem is delineated around situations to which the Bullwhip Effect is applicable. These are typically relatively stable market structures in which frequent ordering occurs. It consists of products with long life cycles and stable demand patterns, which can be altered in shape by manufacturing processes, but there should always be a trail from raw material towards an end product. The products should be tangible, storable and have distinguishable discrete units which are traded in large volumes. If any of these conditions are not met, the applicability of the Bullwhip Effect is questionable.

Thirdly the research delineates around the case study. The case study is specifically delineated to the Van Geel product brands sold by Legrand Nederland to the Technische Unie. The motivations for the choice of a case study are pragmatic. The operational Supply Chain environment in which the Bullwhip Effect occurs is very complex and consists of a large number of elements, which can create a vast amount of theoretical Supply Chain configurations. In order to deal with this one has the choice to either simplify the Supply Chain model, as many Operations Research analysts have done, or to maintain the complexity by studying a specific, but representative, case. Since the approach of this research criticises the simplification of human behaviour in other research, the use of a single, specific case study is perceived a necessary approach.

Initially the research has been delineated around the 1733 stock products the Technische Unie has of four important suppliers: Draka, Legrand, Remeha and Itho Daalderop. For these products the Bullwhip Effect was calculated and analysed. The results of this analysis is used to further define a specific case: The Van Geel product group of Legrand Nederland. The Legrand products were excluded, because the operations of these products is centrally coordinated by the Legrand Holding in France. The Van Geel products are manufactured and coordinated from the location in Boxtel. For the simulation seven products, which are representative for the Van Geel portfolio of the Technische Unie, are chosen. The effects of Forecast Accuracy Discount arrangements are simulated for these seven products in the specific supply chain of Legrand Nederland and the Technische Unie. Annex II contains an overview of the 1733 products which are initially analysed and Annex XIII displays the details of the seven products used for the simulation study.

2.3. Research questions

The main research question answered in this thesis is formulated as:

"What are the effects of Forecast Accuracy Discount agreements between supply chain parties on the behaviour of actors in Supply Chains and the Bullwhip Effect?"

Because the design of Forecast Accuracy Discount agreement, explained in chapter 6, is a result of the design process, the main research question in this form was stated during post-ante. Therefore the sub questions contain explorative questions which have led to the formulation of the main research question:

1. What are the systemic and behavioural factors which contribute to the Bullwhip Effect?
2. Which goals related to the Bullwhip Effect have to be achieved by the Forecast Accuracy Discount agreements and which requirements are there for the institutional design?
3. Why are Forecast Accuracy Discount agreements suitable institutional agreements to achieve the stated goals and requirements?
4. What are the effects of Forecast Accuracy Discount agreements on the Bullwhip Effect for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland?
5. What is the sensitivity of the effects of Forecast Accuracy Discount agreements to changes in the Supply Chain coordination system for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland?

2.4. Research and design method

This research uses a mixed qualitative and quantitative method using a pragmatistic epistemology, which contains both the principles or rationalism and empiricism. This method best supports the choice for a case study using a simulation model. The design method contains three phases which are consistent with Sage and Armstrong (2000):

1. Problem definition
2. Solution development
3. Solution testing

Every phase is structured by four steps, following a spiral approach:

1. Collection of data
2. Analysis of data
3. Interpretation of analysis outcomes
4. Conclusion

Because this research approach contains the design of decentralized arrangements which influence system wide behaviour, the focus of the design process should rather be on the effects of these arrangements on local behaviour and system wide outcomes than on the internal structure of the design itself. Therefore there is no need for more elaborate design methods.

The three phases of the design have been leading in the research and design process. The following steps are identified during this process:

1. Define systemic and behavioural factors which contribute to the Bullwhip Effect.
2. State the goals which have to be achieved by the institutional design and state the requirements and constraints for the design.
3. State the design elements which are relevant for creating an institutional design to reduce the Bullwhip Effect.
4. State which institutional design frameworks are relevant for creating an institutional design to reduce the Bullwhip Effect.
5. State which institutional design is the most promising for creating an institutional design to reduce the Bullwhip Effect.
6. Create a simulation model which is valid for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland.
7. Model the effects of the institutional designs en collect the results.
8. Interpret the effects of the institutional designs on the Bullwhip Effect for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland.
9. Check to which extent the effects of the institutional designs are sensitive towards the specific case study situation of the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland.

Figure 3visualizes the major project activities that have resulted from the research and design process and structures them according to the spiral design approach

The verification of the designs effectiveness towards the stated goals is quantitatively done by the outcomes of the simulation model. The verification towards its requirements is done qualitatively. The simulation model is validated using historical data and expert opinions. Validation of the design itself is outside the scope of the research.

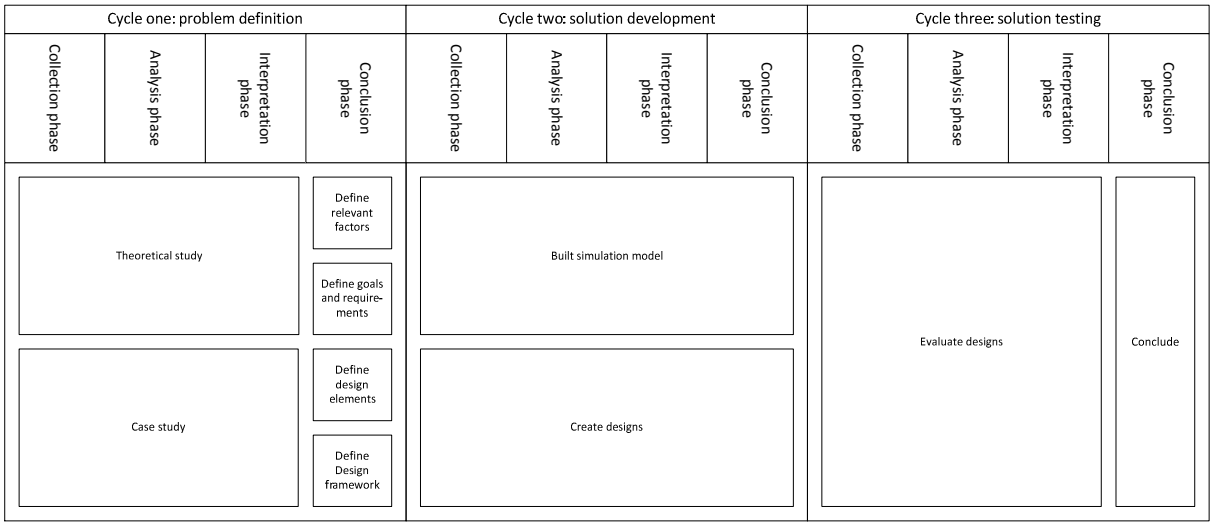


Figure 3: Chronological overview of research and design activities

2.5. Research scope

The scope of the research is summarized as follows:

Focus: The research considers only institutional agreements which are parts of contractual arrangements which steers the behaviour of parties in the supply chain network by creating incentives. The research also considers only the operational coordination system of the supply network.

Depth: The aggregation level of the research is on Supply Chain level. This means companies are considered as a collection of logistical locations which are nodes in the supply network. The individual locations have storage and production functions for product units. Companies that are a collection of nodes in the network have purchasing, selling, ordering, forecasting and coordination functions.

Width: The research only focuses on the 1733 stock products of Draka, Legrand, Remeha and Itho Daalderop for exploring the Bullwhip Effect and the seven Van Geel products listed in Annex XIII in the Supply Chain of the Technische Unie and Legrand Nederland for simulating the effectiveness of the design.

Length: The research focusses only on Research, Development, Test & Evaluation (RDT&E) Systems Engineering Life cycle as described by Sage and Armstrong (2000). The research starts with the definition of the design problem, continues with the development of the solutions and ends with the testing of these solutions. The deployment of the solutions will not be part of this research.

3. Problem exploration

In this chapter the research problem is explored. This starts with reviewing the current state of scientific research on the Bullwhip Effect and continues stating a clear definition and metric for the Bullwhip Effect that is used to explore the current state of Bullwhip Effect for four suppliers of the Technische Unie. This measure is also used in the simulation study. The problem exploration concludes by defining the goals that should be achieved by the design of agreements and which requirements are applicable to the designs.

3.1. Literature review

As mentioned in the introduction the Bullwhip Effect was not explicitly researched by scholars until Forrester (1961) described the phenomenon in his study towards system dynamics in industrial systems. It was however not an intensively researched topic until the nineties after the famous Beer Game of Sterman (1989). Literature from the eighties mainly focuses on empirically demonstrating the existence and significance of the Bullwhip Effect. In the nineties a steady flow of articles emerged towards the causes of the Bullwhip Effect and the effects of various Supply Chain aspects on the Bullwhip Effect, such as lead times, information sharing, demand patterns, forecasting and ordering policies. The article of Lee, Padmanabhan et al. (1997) is one of the most highly cited on the causes of the Bullwhip Effect. As research progresses studies become more detailed and focus more on quantification of the phenomenon and the effectiveness of specific solutions.

Definition of the Bullwhip Effect

Scientific literature has great consensus on the definition of the Bullwhip Effect, however scholars are divided on an appropriate measure for the phenomenon. This will be covered in paragraph 3.2. A number of quotations from scientific literature reveal that the Bullwhip Effect always refers to the variation or oscillation of orders at every echelon in Supply Chains and the amplification or propagation of these variations upstream Supply Chains:

"…the tendency of orders to increase in variation as one moves up in a supply chain" (Croson and Donohue 2006)

"Oscillations of orders at each level of the supply chain and the amplification of these oscillations as one moved farther up the chain." (Croson and Donohue 2003)

"The bullwhip effect refers to a phenomenon that occurs in the supply chains when orders to the supplier have a larger variance than the ones from the customers, i.e. demand distortion. This distortion propagates upstream in an amplified form, i.e. variance amplification" Caloiero, Strozzi et al. (2008) quoting (Geary, Disney et al. 2006)

"…the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (I.e., demand distortion), and the distortion propagates upstream in an amplified form (i.e, variance amplification)" (Lee, Padmanabhan et al. 1997)

The variations in inventories and production are considered by several scholars (Agrawal, Sengupta et al. 2009; Springer and Kim 2010; Ciancimino, Cannella et al. 2012), but authors always use it as an extension of the definition of the Bullwhip Effect as the oscillation and amplification of orders. Therefore we will define the Bullwhip Effect as the amplification of order variances as one moves upstream a supply chain.

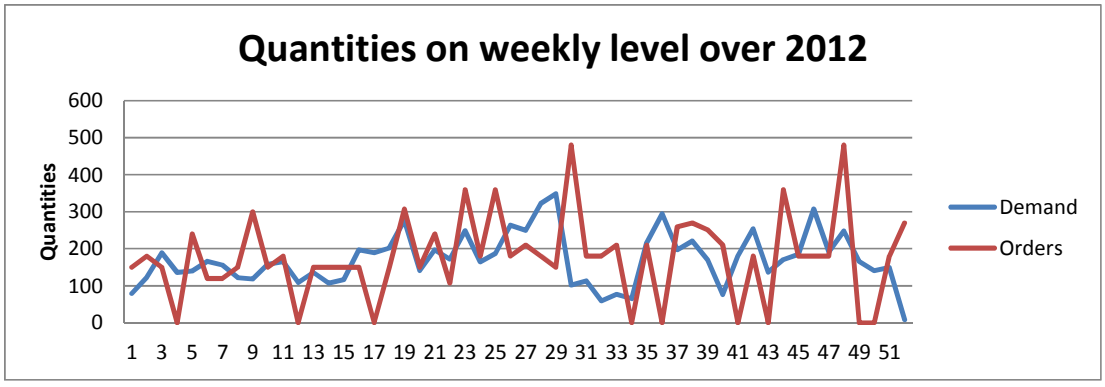


Figure 4: Visualisation of the amplification of variance of orders towards the demand within the Technische Unie

Models and methods for researching the Bullwhip Effect

The Bullwhip Effect has been studied with a wide variety of models and assumptions. The differences between outcomes can be contributed to these differences, however most scholars arrive at similar conclusions. Geary, Disney et al. (2006) identify five research paradigms which are commonly used for Bullwhip Effect research:

- Operations Research Theory: Analytical approach in which the problem is stated in equations and optimal solutions are calculated.
- Filter Theory: stating the BW Effect as the noise or disturbances of placed orders according to the market demand as original input signal.
- Control Theory: Stating the BW Effect as the response of a continuous and controlled system.
- What-if-simulation: Continuous and discrete simulation of causal diagrams in which the effects of system changes to the Bullwhip Effect are observed.
- Ad-hocracy: Detailed understanding of specific cases and finding the specific causes of problems by trial and error.

The many models and assumptions are summarized by Ciancimino, Cannella et al. (2012) for a large number of scientific articles. In general the following models and assumptions are used by scholars:

Research models and methods: As stated above most Operation Research scholars use analytical models to calculate static optima's. Optimization models and statistic models are also used to derive static solutions. Research towards the dynamic behaviour of Supply Chain systems are done by spread sheet models or more complex continuous or discrete simulation models with usually a combination of deterministic and stochastic aspects. For behavioural research scholars use serious gaming experiments.

Performance metrics: Most commonly the ratio between the variance or standard deviation of demand and orders of individual companies is used to measure the Bullwhip Effect as amplification of demand patterns. Some researchers also use the differences in fluctuations in inventory and production quantities between companies in Supply Chains to measure the destabilization of Supply Chains. Besides the direct metrics for demand amplification also costs and fill rates are commonly used as metrics for the effectiveness of Supply Chains in relation to the Bullwhip Effect.

Supply Chain structure: In the most simple settings Supply Chains are modelled as a linear chain with a single party at every echelons trading a single homogeneous product which doesn't change in form or property. The number of echelons usually range from two to four and scholars often compare the situation of information asymmetry towards information integration. Models which contain more parties per echelon in a networked structure, trading multiple heterogeneous products would be more realistic, but also more complex and are therefore rare.

Demand patterns: The demand of the end market is always assumed to be unknown, although the knowledge of demand distributions can be assumed to be known. Scholars use either empiric historical data or stochastic demand distributions. These distributions are usually stable, autoregressive or dynamic. Disney, Farasyn et al. (2006) have compared the effects of different distributions towards the effectiveness of solutions towards the Bullwhip Effect. Stable distributions are often used by scholars who focus on the behavioural aspects of the Bullwhip Effect for reasons of simplicity (Sterman 1989; Croson and Donohue 2003; Croson and Donohue 2006). Analytical researchers often use autoregressive demand distributions, because they are the most realistic. Common are: First Order Autoregressive (AR(1)) distributions (Lee, Padmanabhan et al. 1997; Chen, Drezner et al. 2000; Chen, Ryan et al. 2000; Luong 2006; Sodhi and Tang 2011), Higher Order Autoregressive (AR(n)) distributions (Luong and Phien 2007), Autoregressive Moving Average ARMA distributions (Duc, Luong et al. 2008) and Autoregressive Integrated Moving Average ARMA distributions (Gilbert 2005). Scholars from the field of Control theory often use a predefined function with a standard error to simulate seasonality. They also use step functions to simulate trend shocks in markets (Warburton 2004). Comparing the research outcomes of different scholars, it becomes apparent that the demand patterns and the assumption upon knowledge about these patterns is of major importance for the Bullwhip Effect, because most of the discrepancies can be explained by these assumptions.

Knowledge and information availability: Supply Chain actors are often assumed to be perfectly rational and able to arrive at optimal choices by Operation Researchers. Scholars using simulation methods often assume commonly used heuristics while experimental researchers let their participant entirely free to decide. As stated before researchers often compare the effect of information availability on the behaviour of actors/systems.

Forecasting methods: Two types of forecasting models are used in research: Time series models and fitting models. Time series models are often simple (weighted) average or (weighted) exponential smoothing methods. More elaborate used time series forecasting methods are adaptations of these two methods. Fitting models are based on the assumption that demand follows a certain function in accordance with a stochastic deviation from it expected value. These functions can contain seasonal trends and long term linear trends. The parameters of these functions are defined by minimizing the mean square error of the actual demand towards the function. Some researchers which use a demand distribution assume the actors to know this and let them use fitting methods to find the parameters (Luong 2006; Luong and Phien 2007; Duc, Luong et al. 2008). The validity of their often remarkable findings may be questioned on the basis that in reality demand patterns following a static distribution and companies having knowledge on this may be very rare.

Ordering policies: Scholars most often assume companies to use an order-up-to ordering policy, based on actual practice in Supply Chains. Most models and methods contain fixed time intervals between decision moments and therefore the (s, S) ordering policy is often used. As alternatives to this, base stock policies with dynamic order-up-to levels and smoothened ordering policies are studied as possible solutions to the Bullwhip Effect.

Despite the variety of research methods and used models, there are some striking similarities in the research approaches of scholars. Most of them have a very systemic focus, ignoring the behavioural factors of Supply chains. Limitations in rationality and competence are very often ignored. Also scholars assume high levels of control and predictability, ignoring the sometimes chaotic reality of supply chains. As a result, the validity of the conclusions are discussable due to its dependence on these assumptions

Research on the existence and effects of the BW Effect

Evidence for the Bullwhip Effect existed long before Forrester (1961) described it (Geary, Disney et al. 2006). (Mitchell 1923) already described the problem of forward buying and overstating needs as strategic behaviour in markets that destabilized production. Empirical evidence of the Bullwhip Effect has been shown by many scholars in the eighties and later on (Blinder 1982; Blanchard 1983; Burbidge 1984; Caplin 1985; Blinder 1986; Kahn 1986; West 1986; McKenney and Clark 1995). Well known cases in which the Bullwhip Effect was demonstrated were Pampers at Proctor&Gamble, printers at Hewlett Packard and pasta at Barilla (Lee, Padmanabhan et al. 1997; Simchi-Levi, Kaminsky et al. 2003). The significance of the Bullwhip Effect also became apparent in some extreme cases in the American machine industry (Anderson, Fine et al. 2000) and in the European grocery industry where the amplification of orders ranged generally from a factor 2 towards a factor 20 (Holmström 1997). There are however reports of empirical absence of the Bullwhip Effect (Cachon, Randall et al. 2005). In this study order data was however very aggregated. Calculations were based on the total monthly orders of product groups nationwide in the United States. High aggregation of data in both time and product groups will reduce the measure of the Bullwhip Effect (Fransoo J. C. and Wouters 2000). This research also confirms this in paragraph 3.2 and annex III. There is a consensus in the world of both science as practise that the Bullwhip Effect is a common phenomenon.

The negative effects of the Bullwhip Effect are commonly known as lower service levels due to stock outs and higher costs to handle the fluctuations in demands (Croson and Donohue 2006).These excess costs are both caused by needed improvisations and extra investments in capacity. Lee, Padmanabhan et al. (1997) describe the effects on costs as: excess raw material costs due to premium pricing, excess manufacturing and warehousing costs due to extra needed capacity, underutilization and flexible labour costs and excess transportation costs due to inefficient scheduling and premium shipping rates. The total of these excess costs are estimated at 12,5 to 25% of the total costs (Lee, Padmanabhan et al. 1997), however scholars find it difficult to arrive at exact figures since the contribution of the Bullwhip Effect to total operations costs are difficult to distinguish. Metters (1997) calculates that total elimination of the Bullwhip Effect increases profitability by an average of 15-30%. These saving can be differentiated by smoothing out of long term seasonal patterns and short term demand variance. Eliminating the seasonal patterns can increase profits by 10-20%. Eliminating the short term variance increases profit by 5-10%. In his calculations he only considers the holding costs and penalty costs for unsatisfied demand.

Research on causes of the BW Effect

Research towards the causes of the Bullwhip Effect has converged towards two theories: The idea of four mutually exclusive causes proposed by Lee, Padmanabhan et al. (1997) and the idea of a Core Bullwhip Effect appended by Incremental Effect and multiplied by the presence of information asymmetry. Alongside these two theories which assume full rationality of actors, there are theories towards bounded rationality which further enhance the Bullwhip Effect. Finally strategic behaviour is implicitly stated by many actors as indirect causes for the Bullwhip Effect.

Four causes related to information distortion

Lee, Padmanabhan et al. (1997) identify four causes of the Bullwhip Effect which all find their roots in strategic interactions of fully rational actors in a situation of information asymmetry: Demand signal processing, order batching, rationing gaming and price variations. The first two of these causes are contributed to rational actors which optimize their local internal operations, while the last two are the results of actors strategically interacting with their market environment. Ouyang and Daganzo (2008) and Disney and Lambrecht (2008) explicitly state the decentralized nature of Supply Chains to be the root cause and prerequisite for these four sources of Bullwhip Effect. They emphasize on distorted demand information, disintegrated material flow and lack of replenishment rule alignment as the major causes of the Bullwhip Effect due to disintegration of Supply Chains.

Demand signal processing refers to the dynamic ordering behaviour of companies as a response to the incoming orders of customers. The delay in information flows and material flows creates an overreaction which is the source of upward and downward fluctuations in orders. This cause is also known as the Forrester Effect since it was first described as a cause by Forrester (1961). Lead times have been identified as the major contributor of material delays and amplifier of the Bullwhip Effect (Lee, Padmanabhan et al. 1997). Lee, Padmanabhan et al. (1997) and Dejonckheere, Disney et al. (2003) proved that order-up-to inventory policies are mechanism of negative feedback that always causes the demand signal processing effect. Berry and Towill (1995) identify two types of Bullwhip Effect due to demand signal processing: Demand amplification as the simple increase of short term variability of average demand and rogue seasonality as the emergence of long term seasonal patterns which as a result of forecasting models falsely anticipating on non-existent seasonal trends which are reinforced by positive feedback.

Order batching refers to the tendency of companies to consolidate their demand in larger orders which are ordered in lower frequencies. This cause is also known as the Burbidge Effect due to the extensive research of Burbidge (1981) on this specific aspects. Order batching is related to the application of the Economic Order Quantity method which optimizes local operational costs, but it is also caused by external agreements about minimum order quantities, quantum discounts and order quotas (Lee, Padmanabhan et al. 1997; Simchi-Levi, Kaminsky et al. 2003).

Rationing gaming arises when customers experience frequent stock outs and perceive supply to be unreliable. As a result they structurally overstate their needs to assure product availability. In case of an actual shortage most suppliers ration they available products according to the order size of a customer in relation to total order quantities and backlogs the missing quantities. This further reinforces the incentive to overstate needs. The instability of demand created further upstream the Supply Chain causes product flows to become fluctuating and the perception of unreliable supply is confirmed. It is also described as the Houlihan Effect, named after the scholar that first described this phenomenon in international trade (Houlihan 1987) and it is similar to the Newsboy problem (Fransoo J. C. and Wouters 2000).

Price variations are a source of strategic forwards buying which causes concentration of order quantities in periods of low pricing. The fluctuations in orders in return create price fluctuations. Price promotions are common in both business-to-consumer markets as business-to-business market and further amplify this effect, especially when customers anticipate on these promotions and suppliers are trapped in a situation where competitive forces coerces them to continue these promotions to maintain market shares (Simchi-Levi, Kaminsky et al. 2003).

Core causes and extended causes

Sodhi and Tang (2011) research the causes for the Bullwhip Effect in the case of full information transparency and full rationality of actors in order to distinguish the core causes of the Bullwhip Effect. They find a Core Bullwhip Effect that is only present when demand is uncertain and lead times are larger than zero. The extent of this Core Bullwhip Effect is linear dependent on the total sum of lead times in the chain and independent of the number of echelons. Chen (1998) and Chen, Drezner et al. (2000) also prove that the Bullwhip Effect is only present when demand can never be precisely forecasted. Anderson and Fine (1998) and Chen, Ryan et al. (2000) demonstrate that demand patterns should have a dynamic distribution for the Bullwhip Effect to be present. In the case the demand is a fixed mean with a standard deviation, most time series forecasting methods converge to stable forecasts where the Bullwhip Effect disappears.

Besides this Core Bullwhip Effect Sodhi and Tang (2011) describe an incremental Bullwhip Effect that is caused by operational deviations from theoretical ideal order sizes in the situation of perfect information symmetry and full rationality of actors. These operational deviations are lags in information sharing, necessary batch sizes and operational inaccuracies. They also demonstrate that arborescent Supply Chain structures worsen the batching problem and add to the incremental

Bullwhip Effect. They prove that this incremental Bullwhip Effect is additive to the Core Bullwhip Effect and can even arise when the Core Bullwhip Effect is zero. The addition of incremental Bullwhip Effect happens at every echelon.

Agrawal, Sengupta et al. (2009) show that in addition to this Core and Incremental Bullwhip Effect the situation of information asymmetry amplifies the Bullwhip Effect even further. Chen, Drezner et al. (2000) and Chen, Ryan et al. (2000) demonstrate that information asymmetry creates a multiplicative factor on the Bullwhip Effect in every echelon and causes the extent of the phenomenon to increase exponentially upstream Supply Chains.

Behavioural causes

All of the research towards causes of the Bullwhip Effect above assumes full rationality of actors. Sterman (1989) demonstrates in his experiment that participants of the Beer Game misperceive given information. Croson and Donohue (2003), Croson and Donohue (2006), Nienhaus, Ziegenbein et al. (2003) and (Andraski 1994) also show that the bounded rationality of actors is a source of behavioural errors and a cause of the Bullwhip Effect.

From an operational perspective the ordering behaviour of companies is sub optimal according to their local environment. Croson and Donohue (2006) find that actors in an experimental environment focus too much on their demand line of customers and neglect their supply line. They identify two causes for this biased behaviour. First there is a reduced saliency of feedback, meaning that the complexity of Supply Chain systems makes the effect of individual decisions opaque and blurs causal relations, tampering the learning process. Secondly there is the effect of reduced recency. The time lags between an action and its results also makes causal relations unclear.

From a tactical and strategic perspective the lack of knowledge about the functioning of Supply Chains creates a barrier to invest in the right information sharing and collaboration programs to improve Supply Chain performance (Holweg and Disney 2005). In practice, companies do not understand well how to benefit from external collaboration and demand visibility (Lapide 2001; Holweg, Disney et al. 2005)

Strategic behaviour

Besides rationing gaming and price variation gaming (Lee, Padmanabhan et al. 1997), strategic behaviour is considered rarely as cause for the Bullwhip Effect and the reason companies have not yet collectively solved this problem. Implicitly, some authors do mention important barriers in Supply Chain cooperation. Supply Chains behave as decentralized networks with individual independent agents which optimize their local environment based on their own interests (Fiala 2005). Their behaviour is based on self-optimization and can be opportunistic (Lee, Padmanabhan et al. 1997). The local interests and incentives companies provide to their managers and employees create sub optimal global outcomes in Supply Chains (Tsay and Lovejoy 1999). For example the KPI's that steer the behaviour of sales divisions incentivizes them to push inventories unnecessarily downstream Supply Chains (Simatupang and Sridharan 2002). The nature of the Bullwhip Effect exacerbating upstream supply chains offers little incentives for downstream actors to aid in the reduction of the Bullwhip Effect (Lee, Padmanabhan et al. 1997).

Even when Supply Chain parties acknowledge to potential benefits of cooperation in reducing the Bullwhip Effect, there are many barriers to do so. Short term conflicting interests mitigate the commitment to supply chain collaboration and demand information sharing (Cachon and Lariviere 2001; Holweg, Disney et al. 2005). Shared information is perceived of strategic importance and there companies are reluctant to share it (Fransoo J. C. and Wouters 2000). Upstream actors are most likely to benefit the most of Supply Chain cooperation, while downstream members will bear the cost. Redistribution on these benefits will need to be negotiated in order to incentivize the cooperation of downstream players (Fransoo J. C. and Wouters 2000). When cooperation is achieved on a strategic level companies still need to adapt their organizational structure of responsibilities and performance metrics to incentivize their managers and employees to adopt system wide productive behaviour (Fu and Zhu 2010). Very often companies who engage in information sharing programs do not integrate the received information into their internal operations, but store it in data warehouses for process development and performance measurement studies (Holweg, Disney et al. 2005). Finally the complexity of today's business environment offers a challenge to implement and use information sharing mechanisms with all distribution channels (Stank, Keller et al. 2001; Holweg, Disney et al. 2005). The risks of these investment are often too high in relation to the uncertainty about rewards and time horizon of cooperation (Fransoo J. C. and Wouters 2000).

Research on the effects of Supply Chain aspects

In addition to the research towards the causes of the Bullwhip Effect and their coherency, scholars have focused their research on the impact of specific Supply Chain factors:

Effects of lead times: Lead times are considered one of the root elements of Supply Chains that cause the Bullwhip Effect. When lead times are uncertain and can be considered to have a stochastic nature they induce more Bullwhip Effect than deterministic lead times with the same value as the mean of the stochastic lead time (So and Zheng 2003; Chatfield, Kim et al. 2004). The reduction of lead times is proposed by many scholars as one of the most effective ways to reduce the Bullwhip Effect (Disney and Towill 2003; Luong 2006; Duc, Luong et al. 2008; Agrawal, Sengupta et al. 2009; Sodhi and Tang 2011). Lead time reduction always reduces the Bullwhip Effect regardless of the used forecasting methods (Chen, Drezner et al. 2000; Chen, Ryan et al. 2000; Zhang 2004). Lead time reduction is considered to be more effective than removing information asymmetry by information sharing (Fisher 2000; Raghunathan 2001; Agrawal, Sengupta et al. 2009).

Effect of demand patterns: The Bullwhip Effect is mainly caused by correlations in demand patterns. Uncorrelated demand patterns with stable demands would eliminate the Bullwhip Effect when Supply Chain parties use optimal forecasting and ordering policies (Luong and Phien 2007; Sodhi and Tang 2011).

Effects of forecasting methods: The effectiveness of forecasting methods in reducing the Bullwhip Effect is very dependent on the type of demand pattern. Essentially forecasting methods induce less Bullwhip Effect when they are more accurate (Metters 1997) and when they have smoother predictions based on longer time horizons (Chen, Ryan et al. 2000; Disney and Towill 2003). Luong (2006) claims that minimum square error forecasting methods are always better than time series methods and Agrawal, Sengupta et al. (2009) prove this analytically for first order autoregressive demand patterns. However Liu and Wang (2007) demonstrate that the optimal forecast methods are dependent on lead times. Minimum square error forecasts create less Bullwhip Effect when lead times are long. In case of shorter lead times moving average and exponential smoothing forecast are better. Wright and Yuan (2008) propose the use of the more elaborate Holt's and Brown's time series forecasting techniques.

Effect of order policies: Order-up-to policies are proven to always create Bullwhip Effect (Dejonckheere, Disney et al. 2004). Using a policy that only replenishes a fraction of the difference between the current and desired stock level dampens the Bullwhip Effect (Dejonckheere, Disney et al. 2003). Using order policies that allow inventory levels to fluctuate and function as buffers to reduce fluctuations in production and orders will reduce the Bullwhip Effect and stabilize Supply Chains (Baganha and Cohen 1998).

Effects of order quantities and batch sizes: The Bullwhip Effect caused by batch sizes is linear dependent on the square of the batch size (Sodhi and Tang 2011). Removing minimum order quantities and batch sizes can minimize the BW Effect (Lee, Padmanabhan et al. 1997; Simatupang and Sridharan 2002). Batch size reduction is considered more effective than sharing information (Fisher 2000; Raghunathan 2001; Agrawal, Sengupta et al. 2009).

Effects of product properties: Fransoo J. C. and Wouters (2000) find in a case study towards food products that perishable products suffer less from forward buying, because of the risk of spoiling. Therefore the have less Bullwhip Effect than less perishable products.

Effect of networked structures: Sucky (2009) proposes that the possibility of multiple Supply Chain parties at each echelons able to provide substitute product creates a risk polling effect and may reduce the Bullwhip Effect. He doesn't manage to prove this plausible idea. Sodhi and Tang (2011) criticise this idea by demonstrating that arborescent Supply Chain structures may worsen the Bullwhip Effect due to batch sizes, however they don't falsify the theory of Sucky (2009).

Effects of knowledge: The competence and knowledge of actors in Supply Chain has a significant impact on the biases in ordering. Trained professionals induce less Bullwhip Effect than student in experimental settings (Croson and Donohue 2006).

Research on the effects of solutions for the Bullwhip Effect

Literature is very rich in proposing solutions for the Bullwhip Effect. Most scholars either propose to adapt one or more of the mentioned Supply Chain aspects that are contributing to the Bullwhip Effect or they propose Supply Chain collaboration methods such as Vendor Managed Inventories, Collaborative, Planning, Forecasting and Replenishment or Efficient Consumer Response. Most of these methods have in common that they contain forms of information sharing and centralization of decision making. Holweg, Disney et al. (2005) use these two properties to create four categories of Supply Chain collaboration methods and elaborate on them. In this thesis, we will just focus on the general effects of the common aspects of proposed solutions.

Effect of information sharing: Information asymmetry and distortion of demand patterns upstream supply chains is one of the major causes of the Bullwhip Effect (Lee, Padmanabhan et al. 1997; Lee, So et al. 2000; Lee and Whang 2000). Sharing operational information improves global Supply Chain performance (Yu, Yan et al. 2001). The Bullwhip Effects amplifies upstream in a geometrical manner when end user information is not shared and an order-up-to policy is used regardless of the forecasting method. Information transparency changes the amplification to a linear function (Fiala 2003; Dejonckheere, Disney et al. 2004). Especially when the quality of the shared operational information increases the Bullwhip Effect is significantly reduced (Chatfield, Kim et al. 2004; Dejonckheere, Disney et al. 2004). For example intra echelon information about end market demand, known as Point of Sale information, is more effective than inter echelon information from direct suppliers and customers (Agrawal, Sengupta et al. 2009) and when information is provided in real time with a high level of detail higher Bullwhip Effect reductions can be achieved (Croson and Donohue 2006).Sharing Point of Sale and inventory position information can reduce but never eliminate the bullwhip Effect (Chen, Drezner et al. 2000; Chen, Ryan et al. 2000; Croson and Donohue 2003; Croson and Donohue 2006). Upstream players benefit most from sharing Point of Sale information (Croson and Donohue 2006), however experiments have shown that costs for upstream players can increase when Point of Sale information is shared (Croson and Donohue 2003). In case of non-stationary and unknown demand patterns, sharing POS information might bias the estimation of future demand and increase cost for upstream players. (Gupta, Steckel et al. 2002; Steckel, Gupta et al. 2002).

Effects of centralized decision making: Synchronization of operations in Supply Chains reduces the Bullwhip Effect and dampens fluctuations in inventories (Ciancimino, Cannella et al. 2012). When decision making is synchronized or centralized the effects of forecasting methods and ordering policies are not relevant anymore, however lead times still influence the Bullwhip Effect (Ciancimino, Cannella et al. 2012).

Effects of dampening feedback in order policies: From a Control Theoretic perspective a large number of authors have concluded that the variations in orders can be reduced by using a proportional controller in ordering policies (Disney and Towill 2003; Disney, Naim et al. 2004; Boute, Disney et al. 2007; Chen and Disney 2007; Disney, Lambrecht et al. 2007; Warburton and Disney 2007; Bayraktar, Lenny Koh et al. 2008; Cannella and Ciancimino 2010). Dampening the feedback of forecast errors into ordering policies by ordering only a fraction of the difference between the current inventory and desired order-up-to level reduced the Bullwhip Effect and cost related to order variance (Chen and Disney 2003), however this smoothening increases fluctuations in inventories and related costs (Caloiero, Strozzi et al. 2008). Dejonckheere, Disney et al. (2004) show that these order policies are only effective when Point of Sale information is shared in higher upstream echelons.

3.2. Measuring the Bullwhip Effect

Many scholars have quantified the Bullwhip Effect both theoretically and empirically. For the case study research an appropriate metric is defined and the case study is explored by defining the Bullwhip Effect values for all products in the scope of this research. These values are statistically analysed to explore the specific causes of the Bullwhip Effect in this case.

Defining the appropriate measure

The most commonly used measure for the Bullwhip Effect is a quantitative expression of the oscillations in incoming orders and demand at each echelon and the amplifications of these oscillation between echelons. The oscillations and amplifications of inventory has also been proposed as an additional measure (Agrawal, Sengupta et al. 2009; Springer and Kim 2010; Ciancimino, Cannella et al. 2012). However this research does consider fluctuations in inventories and also fluctuations in production, the Bullwhip Effect will only considered as the variations in orders and demand

Considerations for defining a measure

Scholars use two measures for the oscillations in demand: the variance and standard deviation of the average of the sums of demand over N periods with each period having a fixed time interval T. The basic principle for measuring amplification of variations is creating a ratio of both variations by dividing them (Sodhi and Tang 2011). Since the variance is the square of the standard deviation, oscillation measurements in variances will always lead to a higher figure in amplification ratios than the use of standard deviations.

Several measurements for the amplification of oscillations have been proposed which are all based on the principles of creating ratio values by dividing the oscillations. The most commonly used measure is the amplification over each echelon. This is done by dividing the oscillation value of placed orders by the value of incoming orders (Croson and Donohue 2003; Croson and Donohue 2006). This value gives insight in the amplification of variations at every echelon level. Another measure is the total upstream amplification by creating a quotient between placed orders at every echelon and the end market demand (Chen, Drezner et al. 2000; Caloiero, Strozzi et al. 2008). This value will give more insight in the amplification of variations in market demand of all downstream echelons at the echelon of measuring. When Supply Chains are closed systems the multiplication of amplification over each echelon until a given echelon will be equal to the measure of total upstream amplification (Fransoo J. C. and Wouters 2000). When the Supply Chain under consideration is open, meaning that there is also other side flows of the specific product under consideration this rule doesn't apply, but the equation will be approximately true. Finally, Ciancimino, Cannella et al. (2012) and Cannella, Ciancimino et al. (2008) propose the measurement of amplification in a single value by defining the linear regression of the total upstream amplification at each echelon level. This value has however little meaning and the validity of the value can be questioned since scholars have demonstrated both theoretically as empirically that upstream amplification can be an exponential function.

The measure of oscillations in either the variance of standard deviation towards average orders or demand is appropriate when demand patterns have stable distributions, however, empirically, demands often have a seasonal trend which have a repetitive pattern every year and a long term trend, which makes demand auto correlated to the average demand in that year and previous demands in the same period of previous years. Exploratory research towards the case study of the Technische Unie revealed that this was the case for most of the products, in particular fast moving products. Therefore it seems logical to define the deviations, which are input for the variance and standard deviation, towards a seasonal and linear long term corrected average very period. Attempts to do so have however resulted in inconsistent Bullwhip Effect figures. Basically products that have a clear seasonal demand patterns had higher Bullwhip Effect measures, because the deviations towards the corrected average was smaller. This made the values of seasonal and non-seasonal products difficult to compare. Calculating the simple deviation towards a fixed average always resulted in the lowest possible Bullwhip Effect value compared to a correction for either or both a seasonal trend or long term linear trend and is therefore representative for the lower bound of both the oscillation as amplification.

In theoretical studies the measures as discussed before suffice, however empirical cases provide some additional issues which should be considered when measuring the Bullwhip Effect. First of all the total order quantities a company receives in the time span over which the Bullwhip Effect is calculated does not need to equal the total placed orders. This can be caused by a difference in inventory quantities in a company, but also by breach and disposal of products. It is also possible that Supply Chains under consideration are not closed systems and a company also sells a particular product to other parties than just the customer under consideration. Isolating the purchase order quantities which contribute to the specific customer is practically impossible. Fransoo J. C. and Wouters (2000) identify this last problem in their case study and use a Bullwhip Effect measure that deals with large differences between input and output quantities which was first proposed by Chen, Drezner et al. (2000). This measure first standardizes the variation or standard deviation towards the average incoming and placed order quantities and these are used to calculate the amplification ratios. The standardization of variations allows a measure for unequal input and output quantities, but it makes the compassion of variations throughout the Supply Chain more difficult, because they are based on different totals.

Another practical issue that needs to be addressed in defining a measure for the Bullwhip Effect in empirical cases is the aggregation levels of order quantities towards outlets, product groups and time intervals (Fransoo J. C. and Wouters 2000). Ideally one would like to calculate the Bullwhip Effect as detailed as possible, for every distribution point and every product. However, information availability and the transmutation of products can make it necessary to aggregate information towards groups of outlets and products. The choice of grouping has significant impact on the Bullwhip Effect values. The aggregation in time intervals defines the length of time intervals in which demand is accumulated and used to define the average and deviations over the total number to time intervals. Shorter time intervals always lead to higher Bullwhip Effect

values (Fransoo J. C. and Wouters 2000). This is also confirmed in the case study, see Annex III. The ideal time interval would be according to the planning intervals of companies (Dejonckheere, Disney et al. 2003), however differences in these intervals between companies creates the question which interval is most appropriate. It may also be possible to use multiple time intervals for the calculation at different echelons, but this makes the values less comparable. This issue is present between the Technische Unie and Draka. The Technische Unie aggregates yearly data in time intervals of 13 periods of 4 weeks, while Draka uses 12 months. The differences in aggregation made Draka perceive high variations in incoming orders, where the Technische Unie considered their placed orders to be very stable.

Definition of Bullwhip Effect measure

In this thesis a conservative approach is used on defining a Bullwhip Effect measure, which is able to cope with the practical issues of the case study. Oscillations of orders and end consumer demand are defined by the standardized standard deviation of the average demand, which is not corrected towards any seasonal or long term linear trends. This assures minimum bound values for the amplification and it makes these values comparable among different products while maintaining meaningful metrics for the oscillations and amplifications. Equation (1-4) show the method in which the standardized oscillation *O* at echelon level I is calculated, based on mean μ and standard deviation σ, containing the total demand *D* within each time interval *n* with a length of *T* over a total of *N* time intervals. The values of D_n are the sum of the individual demands *d* at times *t* within the specified time intervals of D_n.

(1) $O_i = \frac{\sigma_i}{\mu_i}$

(2) $\mu_i = \frac{1}{N} \sum_{n=1}^{N} (D_n)$

(3) $\sigma_i = \sqrt{\frac{1}{N} \sum_{n=1}^{N} (D_n - \mu_i)^2}$

(4) $D_n = \sum_{t=(n-1)T}^{nT} (d_t)$

The amplification *A* at echelon *i* is defined by dividing the standardized oscillations of placed orders by those of the incoming orders, as shown in equation (5)

(5) $A_i = \frac{O_{i+1}}{O_i}$

The choice for simple, meaningful metrics which allows comparability of the values among different products is based on the presumption that the actual values are less relevant than the relative change when implementing solutions. Croson and Donohue (2003) argue that the change in percentages of the variation in orders at a specific level is an appropriate measure for the change in Bullwhip Effect. For this one could simply use the σ in equation (3). Croson and Donohue (2003) and Croson and Donohue (2006) also propose a statistical Mann-Whitney U test to determine whether changes in values are significant or just the result of coincidences in stochastic models or experiments.

BW Effect in the case study

The Bullwhip Effect has been calculated for all the product the Technische Unie held on stock in 2012 for four suppliers: Draka, Legrand, Remeha and Itho Daalderop using the amplification measure presented above. Data was aggregated as the total sales of individual products over all outlets on time intervals of one week and four weeks, resulting in two values for amplification of the standard deviation in demand. Annex II presents the aggregated results of this analysis together with aggregated general information over these 1733 products. Annex I presents the structure of the analysis file, together with the information sources. The full analysis file is available in digital format.

Annex II displays the two Bullwhip Effect values. Here 'monthly level' refers to the time interval of four weeks. In addition to the calculation of these values also an analysis towards the Bullwhip applicability was performed. Applicability is assessed either as 'Yes', 'No' or limited. In some cases there was either or no demand or placed orders in 2012. These products were always considered as a 'No' in applicability. Products with the assessment 'Limited' applicability do have both orders and demand in 2012, however the number of periods in which demand was larger than 0 is lower than 4, measuring in 13 periods of four weeks.

In addition to the applicability, Annex II also contains a table that states the linear slope of the demand trend over the period 2009 to 2012. The value expresses the percentage of the linear coefficient of the average monthly demand in this period. A very steep slope would require a correction of the Bullwhip Effect towards this linear trend, however the table reveals most linear trends to be within a 2,5% bounds. A correction towards a linear trend would always result in a higher

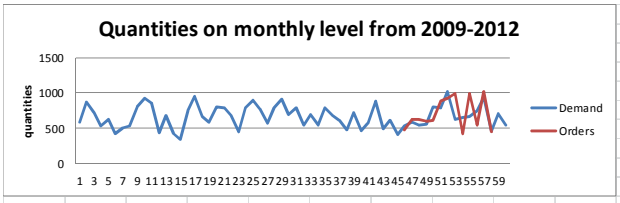
Bullwhip Effect measure. Therefore the current measure is a minimal measure which aligns with the conservative approach taken in defining the Bullwhip Effect measure.

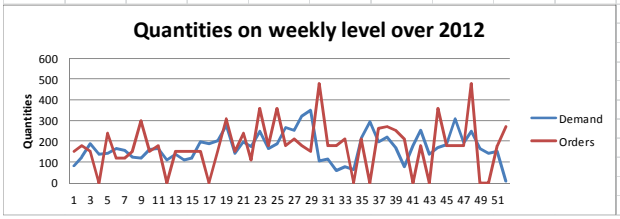
Another addition in the table is the percentage in which total order quantities in 2012 deviate from total demand. Very often orders deviate and are smaller than demand. This could be due to inventory mutations in 2012 caused by changed product policies such as changes in product classifications and according safety stocks. The high amount of products with lower orders can be explained by phase out products which have ceased to be inventory products. Products that have become inventory products are not taken into account.

Analysis of measurement results

For the 1574 products that have been assessed as applicable, a statistical analysis is performed to identify correlations between the Bullwhip Effect values and product properties in order to find specific causes for the differences in Bullwhip Effect values. The areas of statistical analysis and found correlations are visualized in Annex III. Here all statistical values towards coherence and significance are reported. The main conclusions of this statistical analysis are discussed here.

The two Bullwhip Effect measures with different time intervals are homogeneous and strongly correlated. Therefore conclusions on statistical coherences with other variables are similar for both values and therefore the one measure is representative for the other. The measure on weekly level is significantly larger than the measure on the basis of four weeks, further to be called 'monthly level'. Figure 5 illustrates this with an example. This supports the presumption that the exact value of a measure is of less importance than the differences in values among cases and the changes of values under implementation of solutions.





	Demand	Orders		Name	GEEL WANDGOOT GW05 130 W
Total of 2012	8911	9174		artnr TU	4536553
Monthly average	685,4615	705,6923		artnr Legrand	8555023
Monthly variance	27257,77	50116,4			
Monthly stdev	165,0993	223,8669		ABC code	B
stdev/av	0,240859	0,31723		Volume	5569,2
				Weight	1050
BW Effect on monthly level		1,317081		Price	44,35
				Increment	30
				Th EOQ	4,732606126
	Demand	Orders		EOQ	130,4247888
Total of 2012	8911	9174		Order size	210
Weekly average	171,3654	176,4231		% incr. Of orders	0,327%
Weekly variance	4959,452	12928,92			
Weekly stdev	70,42338	113,7054		MDBO	7
stdev/av	0,410955	0,644504		Lead time	13
				Dagen voorraad	7,620079706
BW Effect on weekly level		1,56831		Delivery days	wo_do_vr
				% LT of MBDO	185,714%

Figure 5: Visualization example of Empirical demand, order and Bullwhip Effect values for the Technische Unie

Increments refer to the minimum order quantity in which the Technische Unie is allowed to order multitudes. These quantities are based on the outcomes of strategic negotiations with suppliers. Increments are strongly correlated towards order sizes, which means that they significantly constrain the ordering behaviour and might be a cause of Bullwhip Effect within the Technische Unie. In order to make the increments comparable among products they have been normalized by calculating the percentage of increments towards total placed order quantities of the Technische Unie over 2012. There is a medium correlation between this normalized figure and the Bullwhip Effect both on weekly and monthly level, respective correlations of 0,136 and 0,269. The order batching problem is thus present in the Technische Unie. A quick glance at the products with the highest Bullwhip Effect revealed that they often have very high increments. Sometimes increments were higher than total yearly demand, resulting in a single order within 2012.

Theory suggest that there should be a correlation between lead times and the Bullwhip Effect. In order to make lead times of different product comparable, the lead times should be normalized towards the Minimum Days Between Orders (MBDO): A time interval that the Technische Unie uses as planning intervals for deciding on order quantities, which vary among products. The percentage of lead times towards the MBDO is used as a normalized measure. Pearson correlation coefficient values of 0,321 and 0,289 were found for this measure and respectively the Bullwhip Effect on weekly and monthly level, however this was only valid for situations where lead times were larger than the MBDO. Cases where lead times were smaller than the MBDO consistently have small Bullwhip Effect values. When considering lead times to be the time delay in the control theoretic mechanism that causes the Bullwhip Effect, this makes sense. When lead times are

shorter than the average order intervals, the decision on order quantities only has to take the expected future demand into account, uncoupling the influences of individual orders.

The analysis also revealed a significant difference in Bullwhip Effect among product categories labelled from A-F, stating whether a product is a fast or slow mover. More information on these categories can be found in Annex V. Fast movers with labels A-D have significantly more Bullwhip Effect than slow movers, labelled E-F. This can partially be explained by their lead times in relation to the MBDO. Fast movers are ordered more frequently while having the same lead times as slow movers. Slow movers, which are sporadically ordered, also have different ordering policies which translates the demand one-to-one to orders, often resulting in Bullwhip Effect measures of one.

Finally there are differences in the Bullwhip Effect between the four companies under consideration. Although these differences are significant, the differences in values are very limited. There are also no strong correlations between other factors that can explain these minor differences.

Implications of the results for the Technische Unie

The case study results reveal that both constraints on order sizes and control theoretic mechanisms contribute to the Bullwhip Effect for the Technische Unie. The constraints on order sizes are due to order increments. When these increments are larger than the physically required batch sizes, they unnecessarily constrain order sizes. The control theoretic causes arise when the lead times are larger than the order intervals, which are dictated by the Minimum Days Between Orders. The products of the Technische Unie can be categorized by their increments in relation to the physical necessary batch sizes for suppliers and lead times in relation to the MDBO's. This results in four possible categories which are visualized in Figure 6.

When lead times are shorter than the MDBO's and the order increments are equal to the physically required batch sizes due to the operational systems of suppliers, orders are not more constrained than physically necessary and the systemic feedback of forecast errors will not amplify the fluctuations in orders. This situation is therefore the most desirable concerning the Bullwhip Effect. When lead times are however larger than the MDBO's systemic feedback of forecast errors will amplify the fluctuations in orders and reduction of lead times towards the MBDO is required to reduce the Bullwhip Effect. For these products the Technische Unie can negotiate with suppliers to which extent the lead times can be reduced.

When the increments exceed the strictly physical necessary batch sizes, reduction of these increments can be negotiated with suppliers to alleviate the constraints on order sizes. A reduction in increments will also result in a reduction of order interval and the MBDO for products. This can however result in product moving from a situation where lead times where smaller than the MBDO towards a situation where they have become larger. Additional lead time reduction might be negotiated then too.

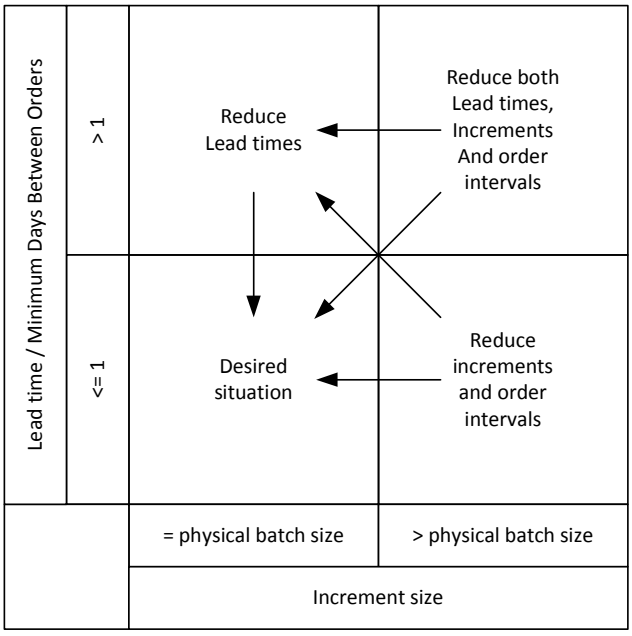


Figure 6: Categorization of products of the Technische Unie towards Bullwhip Effect relevant properties

3.3. Definition of goals and requirements for the Bullwhip Effect

Reducing the Bullwhip Effect is not a goal on its own. It contributes to the reduction of total Supply Chain costs and improving the service levels towards customers. These goals contribute to the overall goal to increase Supply Chain competitiveness. The specific choice for decentralized arrangements that incentivize behaviour bound the possible solution space to which Bullwhip Effect reduction can be achieved and this scope implies a number of general design requirements.

Positioning within general Supply Chain goals

Because Supply Networks consist of self-interested, independent actors, goals always relate to the interest of individual actors. One could distinguish local, actor specific goals and global Supply Chain goals (Ciancimino, Cannella et al. 2012). Global Supply Chain goals should always be aligned with the local goals of all of its members in order to be acceptable to them (Simatupang and Sridharan 2002; Lee 2004). Since Supply Chains compete among other Supply Chains with similar or substitute products, one can state the improvement of Supply Chain competitiveness as the global, overall Supply Chain goal.

Reducing the Bullwhip Effect is one of the means towards reaching this overall goal. In essence the aim in Bullwhip Effect reduction is to reduce both the oscillations and amplification of these oscillations at every echelon in the Supply Chain as much as possible. Because the fluctuations in orders, inventories and production quantities are closely interdependent and influence the effectiveness and costs of supply chains we do not state to which extent each of these oscillations and amplifications should be reduced. Ideally one would desire to reduce all of them as much of possible.

The approach in this research is to define decentralized agreements to incentivize the behaviour of actors to influence the fluctuations in orders, inventory and production quantities in such a manner that the overall Supply Chain competitiveness is increased. This excludes other means to reduce the Bullwhip Effect.

Figure 7 illustrates the global Supply Chain goal, Bullwhip Effect related goal and research scope goal in an abstract representation of a goal tree. Two diamond shaped areas are relevant in this research. First there are means to improve Supply Chain competitiveness, which are be influenced by the reduction of oscillations and their amplification. These are relevant ends to the Bullwhip Effect. Other ends are not relevant, however some means and ends might also influence the same ends to the Bullwhip Effect. Secondly, there are means to reduce the oscillations and their amplifications. When decentralized agreements are able to influence these aspects they are within the relevant means to influence the Bullwhip Effect and define the solution space of this research. Chapter 5 elaborates on the definition of this solution space.

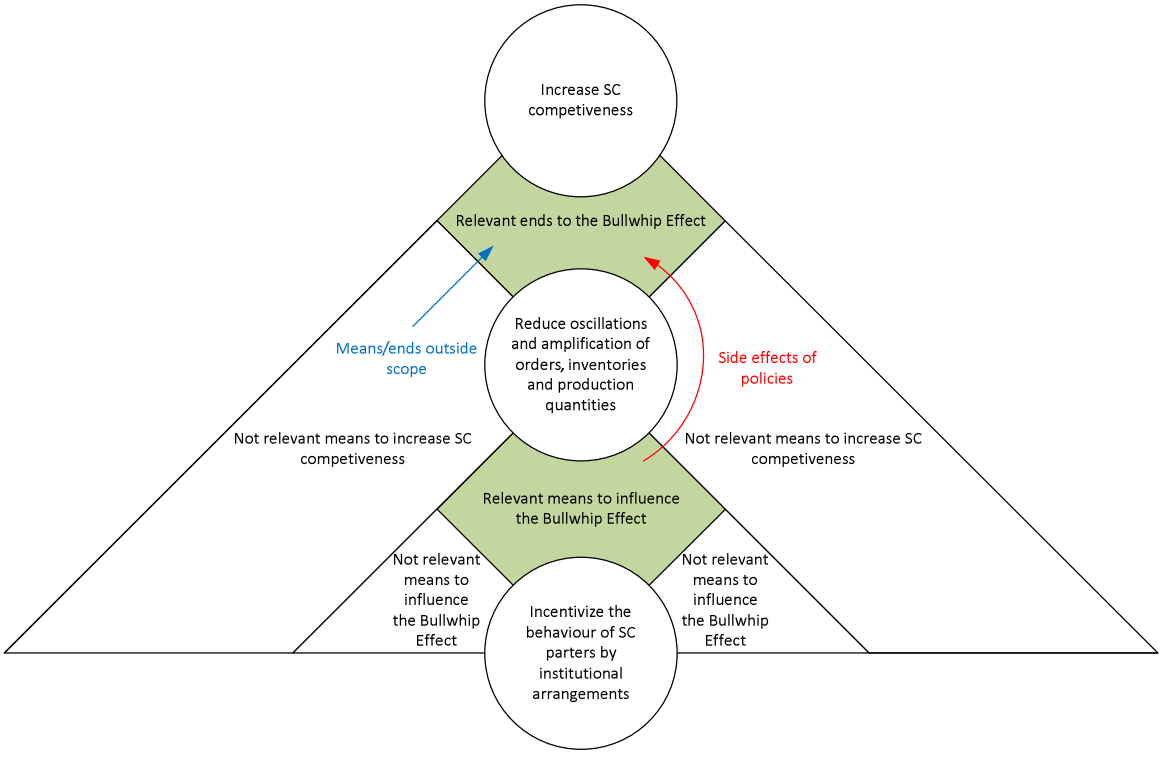


Figure 7: Ends and means definition for the Bullwhip Effect

In Bullwhip Effect and Supply Chain literature a number of important Supply Chain aspects are mentioned to be goals or means to the Bullwhip Effect. Lee (2004) urges the importance of agility of Supply Chains. Simatupang and Sridharan (2002) describe the almost similar concept of responsiveness. They state this as important goals, however they are more likely in the periphery of the solution space to the Bullwhip Effect, since improvement of these aspects does reduce the Bullwhip Effect, but also improves Supply Chain performance alongside by influencing unrelated factors. Also increasing robustness and speed of processes are in the periphery of the solution space of the Bullwhip Effect.

Goal definition

Morash, Droge et al. (1996) describe the capabilities of competitive Supply Chains as reliability in deliveries, pre- and post-sale customer service, responsiveness to the target market, delivery speed, distribution coverage and total cost efficiency. From the perspective of Bullwhip Effect two of those aspects are important: total cost efficiency and reliable deliveries which contribute to the service and satisfaction of customers. Lee (2000) posits revenue growth, costs, customer service and utilization of resources as the major Supply Chain goals. Again customer service and costs are the relevant factors to the Bullwhip Effect, treating resource utilization as a mean towards costs. Most Bullwhip Effect researchers also use customer service and costs as the major objectives (Ciancimino, Cannella et al. 2012).

In this research we take the following approach on defining the goals of the Bullwhip Effect: On the one side solving the Bullwhip Effect should improve operational effectiveness: Having the right products in the right quantities and conditions at the right location at the right time in order to create satisfied customers. On the other side solving the Bullwhip Effect should improve operational efficiency: Reducing total costs. Figure 8 displays the goal tree for the Bullwhip Effect in the context of this research. Here these two major effectiveness and efficiency goals are displayed as increasing customer satisfaction and reducing total costs.

Specifically for the Bullwhip Effect, increasing customer satisfaction means improving the end market and the inter echelon customer service levels. Since Supply Chains are serially linked and improvement of customer service at one point in the Supply Chain has positive external effects on customer service levels downstream no necessary trade-offs are expected. An improvement at customer service anywhere in the Supply Chain is expected to result in global Pareto Improvements. For total costs this doesn't always has to be the case. Improvement in cost for one party can result in higher costs for others. The approach here is to create either Pareto Improvements in costs or Virtual Pareto Improvements by reducing the total sum of all cost of actors. The Virtual Pareto improvement is only acceptable when arrangements create a redistribution of costs and incomes among the Supply Chain, turning the Virtual Pareto Improvement in an actual Pareto Improvement. The Coase Theorem states that in the absence of transaction costs, actors will always find such a redistribution in monetary costs (Coase 1960). When global cost improvements are significant enough to exceed the perceived transaction cost the Coase Theorem is feasible here and it's the objective of the to be designed arrangement to create acceptable redistributions of costs if necessary.

Both on global as on individual echelon level, service levels and total costs often require a trade-off. Theoretically, one could assess the optimal service levels based on the minimization of cost, however in reality this proves to be practically unfeasible and unacceptable from the strategic perspective of competition and marketing. Therefore in reality, service levels are set as a constraint and total costs minimization is the goal function of operations management (Duc, Luong et al. 2008). This approach is also applied within the Technische Unie and the basis of this research too.

Service levels are measured by fill rate. There are multiple measure to calculate the fill rate. The most strict and customer oriented metric is the percentage of orders which were delivered correctly: the right products in the right quantities and conditions at the right location at the right time. A single deviation from the desired conditions renders an entire order incorrect. A less strict metric is to consider the percentage of correct order lines. This allows the definition of service levels per product type and the differentiation in desired service levels. The Technische Unie applies this method and differentiates in desired service levels among product codes A-F. Fast movers with code A have a percentage of 99% and slow movers with code E have a desired percentage of 96%. The most loose metric for fill rates is the simple percentage of total quantities delivered correctly towards the total ordered quantities. This measure is commonly used by Bullwhip Effect scholars (Ciancimino, Cannella et al. 2012), however this measure is less representative for the service towards customers. In accordance with the Technische Unie this research follows the metric based on percentage of order lines.

Initially, the metric for total costs seems obvious: The total sum of all individual cost elements. However, one has to acknowledge the objective to minimize costs to be part of the profit maximization objective in Supply Chains and the effects on incomes also need to be taken into account in the metric. Deviations from the normal market price in sales and purchase discounts are relevant factors which can be influenced by Supply Chain operations and therefore they should be part of the metric.

Most scholars researching the Bullwhip Effect use the sum of inventory holding and delivery shortage costs as the total cost metric (Disney, Naim et al. 2000; Sudhir and Chandrasekharan 2005; Strozzi, Bosch et al. 2007; Caloiero, Strozzi et al. 2008; Duc, Luong et al. 2008). Other authors have added the additional flexibility costs of fluctuations in production to this metric (Dejonckheere, Disney et al. 2003; Disney and Towill 2003; Dejonckheere, Disney et al. 2004). Figure 8 displays three mutually exclusive categories of costs used in this research. First there is capital investments in assets and inventory, which lead to costs in interests and lower returns on investments. These can be reduced by lowering the capital investment need in assets and inventory. The second category consists of operational costs. These are the fixed costs per operational task and reduction of tasks performed by efficient planning can reduce these costs. Finally, contingency cost are the last category. These are the additional cost to normal operations due to unforeseen and undesired contingencies. They consist of discounting, markdowns, foregone discounts and disposal due to obsolescence of products, flexibility costs of improvised operations and inefficiencies in asset utilization. Annex IV contains a full specifications of all relevant costs according to these three categories.

This research focuses on reducing the oscillations in orders, inventories and production quantities and amplification of these in order to reduce the total costs for all Supply Chain parties while maintaining or improving the service levels of all Supply Chain parties. First, the reduction of these oscillations reduces the need of capacity in transport, inventory and production to cope with high peaks in demand, resulting in a reduced capital investment need. Secondly, the reduction in oscillations will cause less product quantities to be stuck in the system to buffer these fluctuations. This will also reduce the needed capital investments, but then for inventories. Also, less product units in the system will allow the elimination of unnecessary activities and more efficient planning, reducing operational costs. This principle is known as one of the basics of eliminating 'Muda' in Lean Manufacturing (Holweg 2007). Thirdly, the reduction in oscillations reduces stock outs, resulting in backlogging, expediting and lost sales. This reduces the number of contingencies and related cost as well as the reduction of operational costs due to efficient planning. Also, the reduction of these elements increases service levels. Figure 8 visualizes these relations.

Finally the question remains to which extent oscillations in orders, inventories and production quantities should be reduced. Disney and Towill (2003) state that fluctuations in production are the most expensive, so they should be minimized. They use a relative weight to determine the importance of inventory fluctuations against order fluctuations. Caloiero, Strozzi et al. (2008) argue that the fluctuations in inventories should be minimized towards zero and the value of order amplification should be one, so the variation in orders upstream Supply Chains should remain stable. Baganha and Cohen (1998), however, describe the role of inventory to buffer fluctuations between demand and production as much as possible, preferably leading to stable production and allowing transport to use optimal utilization. Lee, Padmanabhan et al. (1997) agree with the role of inventory as buffer to fluctuations in transport and production. They state that this buffering allows cost optima's in production and transport by exploiting scales of economies. In this research we consider the fluctuations to be optimally reduced when it reaches a total cost optimum while maintaining or improving the desired service levels. The relative costs of fluctuations in orders, inventory and production in the specific case at hand determine this optimum. One should always be aware that a change in scope might lead to different optimal reductions in fluctuation, so defining a single system wide optimum will be nearly impossible. Therefore the aim of this research is not to find an absolute optimum, but to define satisficing solutions which provide Pareto Improvements to the scope of the research.

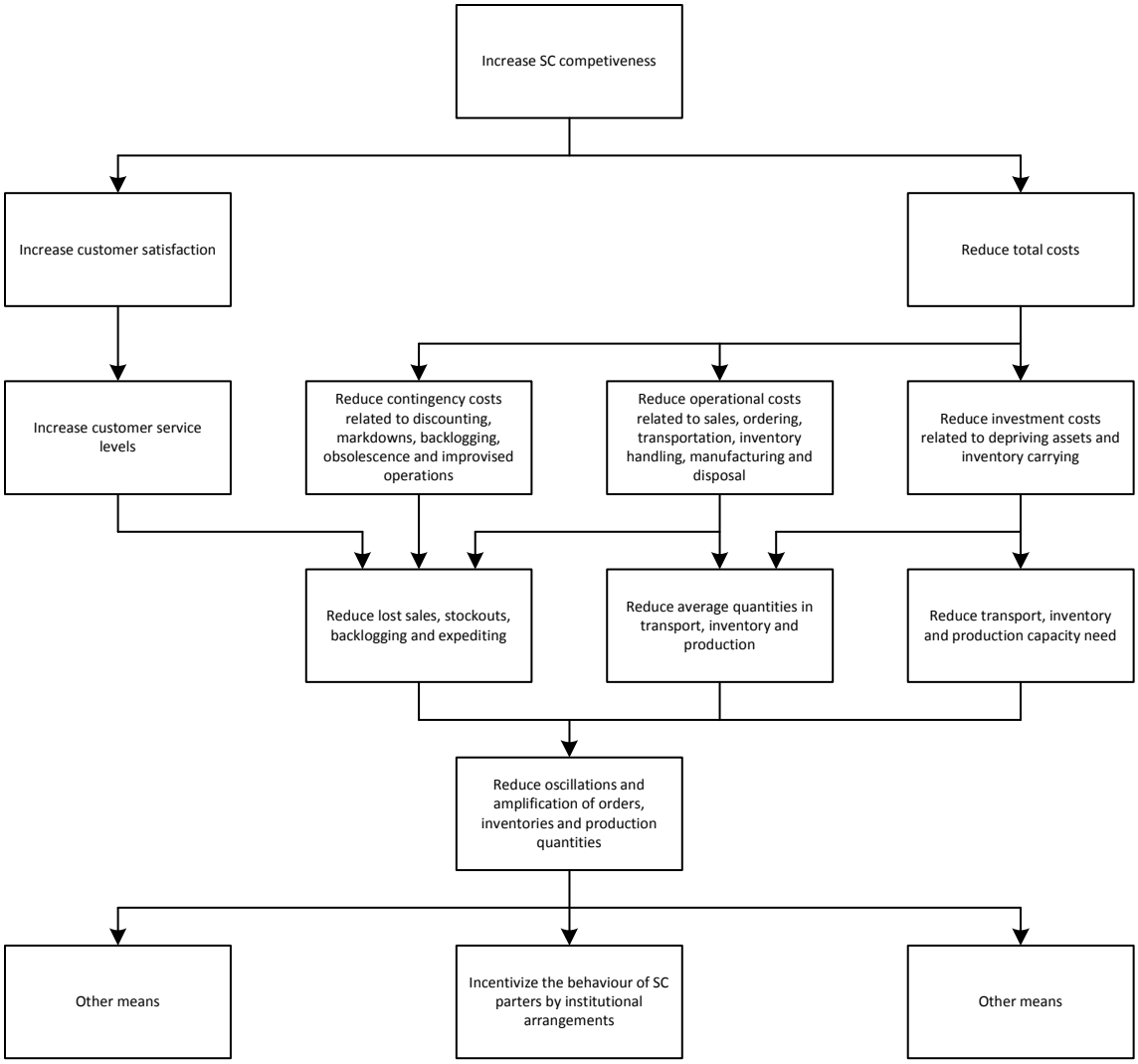


Figure 8: Goal tree, linking the overall Supply Chain goal to the Bullwhip Effect and research scope

Definition of design requirements

The design of the arrangements should be acceptable to all involved Supply Chain parties and related actors, feasible within the specific case study and general Supply Chain situation and finally it should be generally applicable within the most common Supply Chain situations. These three principles are at the basis of the requirements for the to be designed arrangement.

Acceptability requirements

It will be in the interest of all participating actors to engage and continue the arrangements
The arrangement should provide enough direct advantages to both the supplier as customer to adopt it. When the arrangement is in use it should provide strong incentives to continue the arrangement. Therefore it should have long term advantages and disable benefit s of short term opportunistic behaviour.

Actors outside the arrangement should not block the arrangement or frustrate the effectiveness of the outcome
The arrangement should not have negative effects towards the interests of powerful parties outside the arrangement. This can either be other Supply Chain parties or external actors.

The arrangement is in accordance with formal institutions
Applicable formal institutions in general are laws which regulate markets and trade. Mainly these laws ensure the conditions of free markets and regulate markets.

The arrangement is in accordance with informal institutions of participating actors, supply chain parties and general society
The arrangement should be considered fair by the participants. Fehr and Schmidt (1999) have identified inequality aversion as the major fairness norm in economic relations. Applicable informal institutions are norms within markets which define appropriate behaviour for everyone. They define which behaviour is regarded as opportunistic and what is perceived as acceptable bargaining. They also define to which extent defining long term agreements is considered normal. The Supply Chains of the Technische Unie has a short term bargaining nature in which long term agreements are not normal. However trade relations are long-lasting based on trust, informally enforced by tit-for-tat principles, prices and conditions are often renegotiated on short terms by purchasers and sales representatives.

Feasibility requirements

The arrangement is effective within the constraints of the operational Supply Chain structure of the Technische Unie
The structure of Supply Chain is considered a given constraint in this research and the arrangement should operate within this situation. For example, the distribution centre in Alphen a/d Rijn of the Technische Unie has a limited storage and handling capacity. The arrangement should not cause excessive inventories which cannot be handled.

The arrangement will lead to a stable and static behavioural logic in operational planning
Optimal operational strategies and decisions after the implementation should be stable, also in the case of sudden Supply Chain disruptions. When short term deviations are necessary to cope with the temporary contingencies, the arrangement should eventually lead behaviour of participating parties to converge back to these Bullwhip Effect optimal strategies. These principles are described by Prehofer and Bettstetter (2005) as self-stabilizing, self-maintaining and self-healing properties of self-organizing systems.

The arrangement has an acceptable amount of flexibility to be engaged, adapted, abandoned or changed
Since market become more volatile and dynamic in structure (Wilding 1998; Fiala 2005), the arrangements should allow for short term engagement, adaptation abandonment and adaptation in order to prevent ex ante path dependency barriers which are able to prevent the arrangement to be engaged in the first place.

The arrangement has an acceptable amount of need for management of organization and procedures
Engaging the arrangement will require changes in organizational procedures. These will have installation and maintenance costs. The barrier, these changes and related costs create in a networked environment, should not prevent the arrangement to be engaged or continued.

The arrangement has an immediate and clearly understandable effect
Quick effectiveness is important for the success of the design. In the first place, the constant changing environment makes it important for the designs to converge quickly to the optimal situations (Prehofer and Bettstetter 2005). Secondly quick results will reduce the barrier of adopting the arrangement (Simatupang and Sridharan 2002). Thirdly, immediate effect is necessary for the comprehension of actors to adopt optimal behaviour (Croson and Donohue 2006).

General applicability requirements

The arrangement is acceptable to the majority of company identities: cultures, values, strategies and policies
Acceptability towards most company identities is especially important, because arrangements always connect with two independent corporate identities (Simatupang and Sridharan 2002). This limits the possibilities to tailored designs.

The arrangement is applicable within the majority of supply chain network structures
Most common structures in which the arrangement should be functional are very linear, networked, convergent or divergent structures containing either a small or very large number of echelons and companies per echelon.

The arrangements are effective in any configuration in applicable supply chains
Given a Supply Network with companies as nodes and supplier-buyer relationships as links, one could theoretically make a huge number of combinations of configurations in which every link has the option to either have the arrangement in place or not. The arrangement should be effective in any of such configuration.

The arrangement is applicable to the majority of products to which the Bullwhip Effect is relevant
As stated before the Bullwhip Effect is applicable to tangible and storable products with long life cycles and stable demand patterns which are traded in large volumes of its discrete units.

3.4. Concluding remarks

Exploratory research towards the literature on the Bullwhip Effect has revealed that most scholars approach the problem from a systemic perspective, using analytical methods, simulation models and controlled experiments in which they focus on the effects of variations in Supply Chain structures, systemic demand patterns, information availability, knowledge, forecasting methods, ordering policies, lead times, batch sizes and product properties. Serious research towards the existence of the Bullwhip Effect and its negative effects on service levels and operational costs initiated in the eighties. By the end of the nineties demand signal processing, order batching, rationing gaming and price variations are the four most commonly accepted causes of the Bullwhip Effect (Lee, Padmanabhan et al. 1997), however in the 21th century additional ideas on the causes have been proposed. Sodhi and Tang (2011) distinguish among a core and incremental Bullwhip Effect and bounded rationality of actors (Croson and Donohue 2006) and strategic behaviour has been proposed as a cause of the Bullwhip Effect. Most solutions have focused on the integration of operational coordination and transparency of operational information. Also ordering policies and forecasting methods have been proposed by authors.

In accordance with most scholars we have defined the Bullwhip Effect as the variation or oscillation of orders at every echelon in Supply Chains and the amplification or propagation of these variations upstream Supply Chains. We have defined a measure of the Bullwhip Effect based on the ratio between the variations in orders and demand. These variations are based on the standard deviation of the orders and demand as a percentage of their average total values and for the case study the standard deviations are calculated over periods of one and four weeks for the Technische Unie. This exploratory research has found a correlation between the strength of the Bullwhip Effect and the constraining effects of order increments and lead times relative to the average order intervals, given by the Mean Days Between Orders. This implies that reduction of lead times and order increments will reduce the Bullwhip Effect that the Technische Unie creates.

Furthermore we have defined the competitiveness of Supply Chains as the major end for solving the Bullwhip Effect with customer satisfaction and total costs as the two major goals to be achieved within the scope of the Bullwhip Effect, which are measured respectively by service levels and investment, operational and contingency costs of operations. The approach of this research is to reduce the fluctuations in orders, inventories and production in order to achieve a reduction of total costs, while maintaining or improving service levels for all involved Supply Chain parties. For the design of the arrangement we have defined requirements for the acceptability of the design for all involved and related parties, the feasibility of the design within current Supply Networks and general applicability for most products and within most common Supply Networks and companies.

4. Systemic and behavioural analysis of the Bullwhip Effect

In this chapter a conceptual systems model is defined which captures the relevant systemic and behavioural aspects that are relevant for the Bullwhip Effect. This model is the basis for analysis of the case study and definition of the simulation model to test the effectiveness of Forecast Accuracy Discount agreements .The simulation model has a more limited scope than this conceptual model. The goal of the systems model is to create insight in the mechanisms that contribute to the Bullwhip Effect and provide a platform for defining a number of problem perspectives towards the Bullwhip Effect, which are elaborated further in this chapter.

4.1. Systems model

The focus of the systems model lies on the operational level of organizations. Tactical and strategic aspects are therefore considered to be constant. Therefore, the structure of the Supply Chain, organizations and specific processes are considered to be static. The system model exists of two perspectives: The systemic perspective, which describes the Supply Network, organizations, systems and processes as functions and flows and the behavioural perspective, which describes the Supply Network and organizations as structured groups of independent actors with internal behavioural systematics. This morphology of the systems model is illustrated in Figure 9. The internal architecture of the systems model is adapted from the Delft Systems Approach (Veeke, Ottjes et al. 2008), which have based their work on the ground-breaking research of in 't Veld (2002)

The distinction between a systemic perspective and behavioural perspective is also used by Fiala (2005) who uses production nets for the flow of physical elements, petri nets for the systemic coordination and neural nets for the decision making logic and learning of individual actors. The systemic model is based on the logic of organizations as independent agents in networks which exchange goods, information and funds through predetermined flows. This logic is also used by Fiala (2003). Organizations contain a number of executive and coordination processes which steer the flows of goods, information and funds. This definition of organizations in Supply Chains is explicitly described by Simatupang and Sridharan (2002), but is commonly used by most research towards the Bullwhip Effect in the fields of Operations Research, Control Theory, Simulation and Serious Gaming. The Supply Chain Operations Reference (SCOR) model is a commonly accepted standard for descriptive analytics of Supply Chain structures, which also follows this logic (Stephens 2000).

The systemic perspective has a flow oriented principle, consisting of systems with processes and flows of goods, information and funds between these processes. The behavioural model has the principle of causality, consisting of actors and concepts with causal relations between them. The principles of causality and flows are however used in both models. Coordination Theory models (Malone and Crowson 1990; Malone, Crowson et al. 1999) have a different perspective on the behaviour of systems. They distinguish institutions, resources and tasks. Institutions are explicit in the behavioural perspective and tasks are explicit in the processes in the systemic perspective. Resources, as goods, funds, machines, humans and competences , are implicit in the tasks and flows in the systemic perspective.

The Supply Network level of the behavioural perspective is in accordance with common descriptive models for actors and institutions, following the logic of four institutional layers of Williamson (Williamson 1998). The organizational level is in accordance with hierarchical organograms and the situation of a single actor within an organization is in accordance with the Institutional Analysis and Development (IAD) framework (Ostrom 2005), where the systemic perspective are the biophysical conditions, actor with their relations, interests and levels of trust are the attributes of community, the institutions are the rules in use and the externally stated goals are the evaluative criteria. The interactions in the IAD framework are present within the internal decision making structure of an actor. The internal decision making structure is based on the ‘Internal action situation framework’ of Ostrom (2005). The elements of actor types, available actions, available information, outcomes and benefit of outcomes are incorporated in the same structure. The elements of positions and controls from the ‘Internal action situation framework’ are assumed to be given by the market situation.

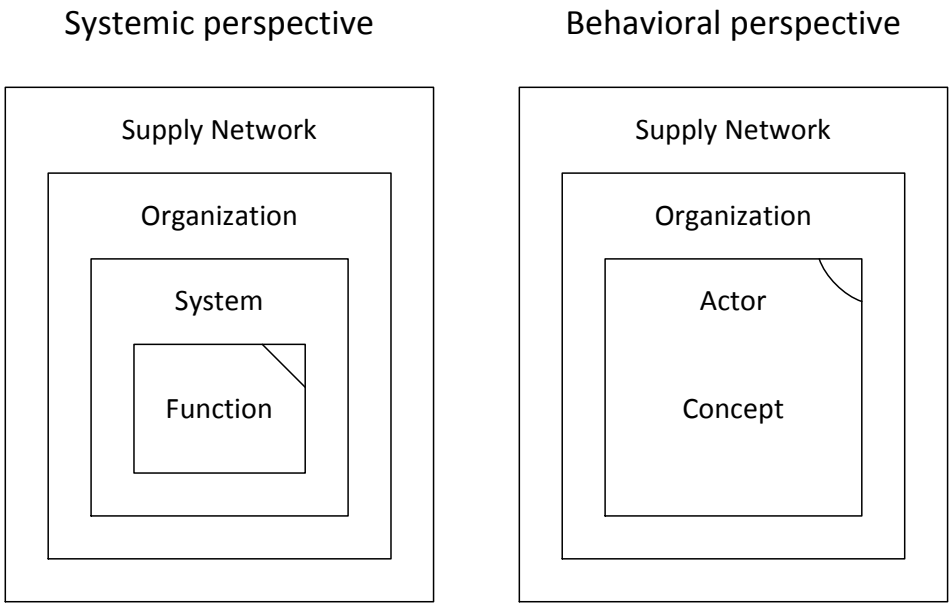


Figure 9: Morphology of the two perspectives in the systems model

Legend of system model elements

The internal architecture of the system model is based on the Delft Systems Approach. Figure 10 is a legend of the elements, which are consistently used in both the systemic and behavioural perspective. In addition this figure contains the generic aspects of system elements that always apply for that specific element.

Processes always contain speed, measured in maximum tasks per time unit, which results in the throughput capacity of a process. They also have storage capacity, measured in maximum amount of units in the specific process. Frequency refers to the number of times a task is performed per time unit. Every process has inherent uncertainty towards their speed and availability, which results in the reliability of a process and the stochastic throughput capacity of a process. Processes which contain units of goods have a disposal rate, due to breach, spoiled goods and obsolescence. Finally they have the three cost factors described in chapter 3.3 and elaborated in Annex IV.

Flows of goods, information and funds always contain the same elements as processed with the addition of modalities, however disposal is only applicable to flows of goods. Flows of goods also contain the properties of products and batch sizes. Product properties that are important are size, which define necessary batch sizes, perishability, which define the risk of spoiling, value density, which define investment costs in inventories and risks of obsolescence, and vulnerability, which define the risk of breach. Information flows also have some additional properties. Aggregation levels determine the detail of information, which is specifically important when operational information is shared. Modern IT capabilities allow more frequent and even real time sharing information (Boyson, Harrington et al. 2004; Lee 2004)

Symbol	Description	General applicable aspects	
	Black box System		
	White box System		
	Process	Uncertainty and reliability Investment and operations costs Disposal Speed Frequency Capacity	
	Process with significant Decision making input		
	Label		
	Collection of processes with highly interconnected information exchange		
	Actor		
	Relation		
	Flow of funds	Uncertainty and reliability Investment and operations costs Modality Speed Frequency capacity	
	Flow of information		Aggregation level
	Flow of goods/services		Product property Batch size Disposal
	Optional aspects		
Text	Concept		

Figure 10: Legend of system model elements

Systemic model: Supply Network level

The Supply network is the first level of the systemic model, consisting of independent organizations as network nodes and links between them. This is visualized in Figure 11. Companies can have vertical, horizontal and lateral relations (Simatupang and Sridharan 2002). From the perspective of Bullwhip Effect research only vertical relations are relevant. These are referred to as commercial links. It is possible to organize the organization nodes in the Supply Network according to echelons, however there is no strict need to do so.

Regarding the Supply Network from the perspective of an individual organization, an arborescent structure emerges of all direct and indirect supplier and customers (Sodhi and Tang 2011). A Supply Chain is defined as a specific route through the Supply Network (Lambert, Cooper et al. 1998), allowing a Supply Network to have large numbers of overlapping Supply Chains.

Uncertainty and disturbances

Although the Supply Network is a static structure from an operational perspective, the are dynamic on a tactical and strategic time horizon. This creates uncertainty towards its structure which is an important aspect for deciding on collaboration in Supply Chain synchronization: Natural disasters, terrorism, wars, epidemics and computer viruses (Lee 2004) are known sources of short term Supply Chain disturbances which create short term uncertainty in the Supply Network structure and functioning of organizations.

End market

The model considers the end market to be a single element. In essence it's the accumulation of the behaviour of all individual consumers that defined the behaviour of the end market, which can either be stable or fluctuating and contain a predictable pattern, such as seasonal and long term economic trends or be very random. Lee, Padmanabhan et al. (1997) identify common habits of consumers to create distinctive demand patterns. Agrawal, Sengupta et al. (2009) statistically prove that most demand patterns of end markets are auto-correlated. Demand patterns are also defined by the specific product life cycles phases (Sodhi and Tang 2011). Products in their early and late life cycles are often slow movers which are more pull driven, while product in mature life cycles are more pushed through Supply Chains.

Goals and performance

Every individual organization is steered by its own goals and has its own performance. From a Supply Chain perspective the overall goals of each organization is defined as: Increase customer loyalty by delivering reliable logistical service against the lowest total costs (Simatupang and Sridharan 2002). One can distinguish two types of organizations though: Manufacturers, which focus mostly on the efficient planning of their production operations and Distributors, which focus more on their customer service.

Commercial link

The vertical supplier-buyer relation between organizations is described as a commercial link, containing the flow of goods, information and funds in both directions. Information flows contain operational information, such as orders, confirmations and shipments, and commercial information such as invoices and bills. Through these flows companies have external effects on each other, known in economic literature as externalities (reference). The Bullwhip Effect is in essence an external effect in flows of goods. In this model, flows can both be performed by suppliers, buyers and third parties, such as Third Party Logistic Providers.

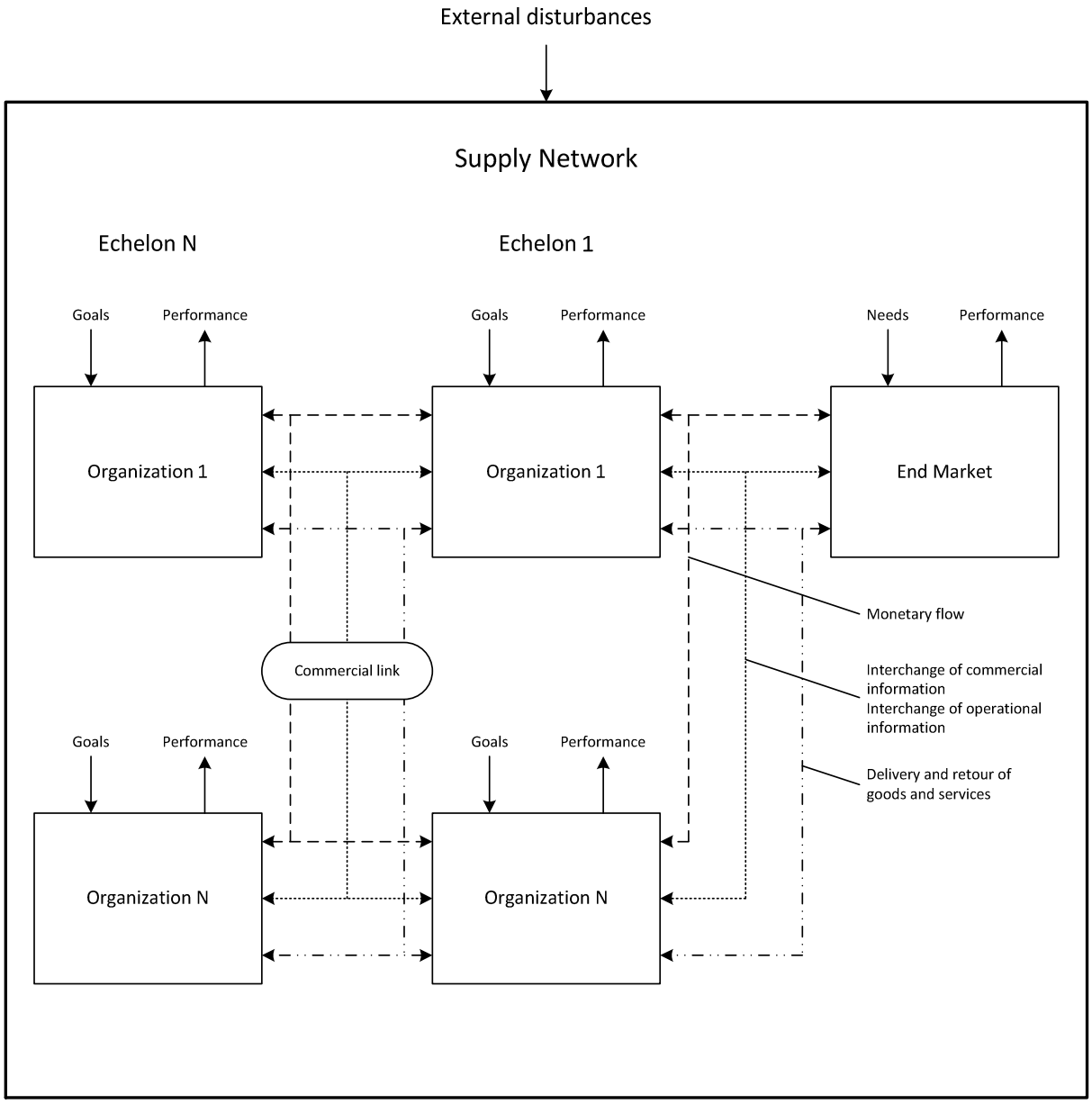


Figure 11: Supply network level of the systemic perspective of the system model

Systemic model: Organization level

From an operational perspective the organization consists of a centralized control system, one or more operational control systems and operational execution systems. This is visualized in Figure 12. Similar to the Supply Network Level there is long term uncertainty on the specific structure of operational organizations as the configuration of these three elements.

Centralized control system

The centralized control system is the top management of operations, which decides on the structure of the logistics and operations systems of the organization and the planning methods and principles used from a strategic perspective and defines the objectives and KPI's to measure performance at operational level.

Operational control system

These systems are offices in which planning functions such as ordering, forecasting and inventory control are performed, based on the objectives of the centralized control systems and available information from suppliers, customers and the operational execution systems. Dependent on their structures, organizations are able to have multiple redundant operational control systems, however an operation execution system can only be coordinated from one operational control system. These multiple systems will synchronise their operations if necessary.

Operational execution systems

These are sites such as factories, distribution centres, warehouses, transhipment points and stores. Flows of goods occur between these systems, both internally as between the sites of different organizations. They are coordinated by a single operational control system and plan their internal operations by receiving external operational information and synchronization among other sites.

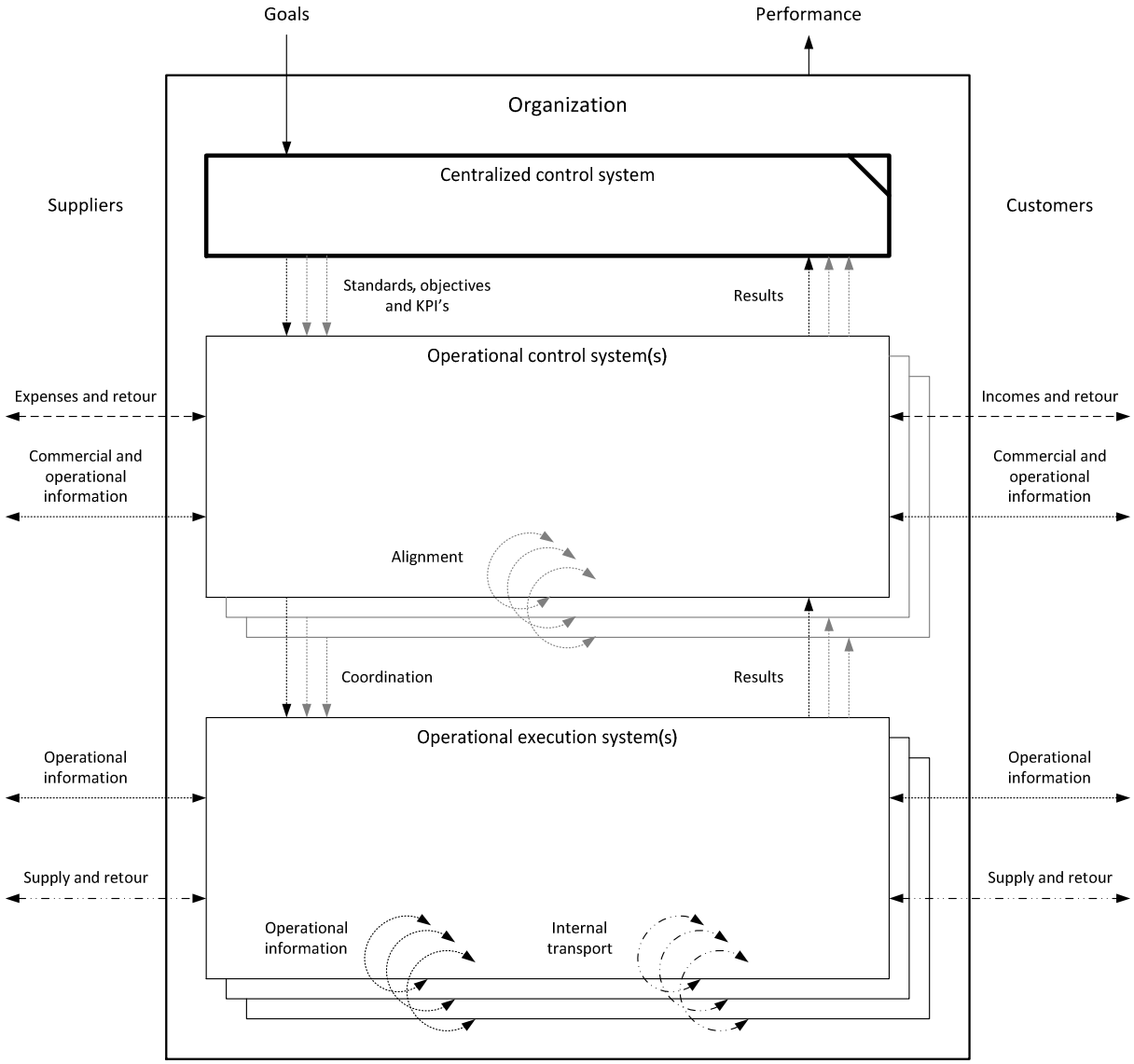


Figure 12: Organizational level of the systemic perspective of the system model

Systemic model: Operational control system

The operational control system has a number of organizational division independent operations functions. Figure 13 shows these functions: Paying and receiving accounts, purchase and sales communications, ordering and order processing, forecasting, inventory management and operations planning. These functions have strongly interconnected information flows, using IT data systems and personal communication. The processes that are important for the Bullwhip Effect are highlighted in the figure by thicker borders of the boxes.

Purchase and sales communications

These functions form the two negotiation processes in a commercial link. Inter-organizational agreements are made here as well as short term agreements upon prices, discount and promotions.

Ordering and order processing

The decision on order quantities is a key feature in the Bullwhip Effect. Order policies use combinations of fixed and variable order quantities and order frequencies, which are commonly based on customer order quantities, expected demand, desired stock levels, inventories and backlogs. The use of Economic Order Quantities (EOQ) is common practise in deciding upon quantities an frequencies.

Inventory management

Desired inventory levels, based on expected sales and safety levels, are common practise in organizations. These levels can either be fixed or dynamic according to demand uncertainty and desired service levels (Duc, Luong et al. 2008). An entirely different approach on inventory management is to allow fluctuations to allow constant production and availability to customer. The inventory level is minimized within these constraints.

Forecasting

Used forecasting models are time series models, such as Simple Moving Average (Chen, Drezner et al. 2000; Zhang 2004), exponential smoothing (Chen, Ryan et al. 2000; Zhang 2004; Caloiero, Strozzi et al. 2008) and more advances methods such as Holt's method and Brown's DES method (Wright and Yuan 2008). Minimum Square Error fitting models are based on assumes demand patterns (Luong 2006; Duc, Luong et al. 2008) or causal models.

Operations planning

This function creates Master Schedules for the operational execution systems based on operational principles, such as Material Requirements Planning, Manufacturing Resources Planning, Lean Manufacturing and Quick Response Manufacturing. These methods together with the definition of the Order Penetration Point is an important given which determines the lead times of products.

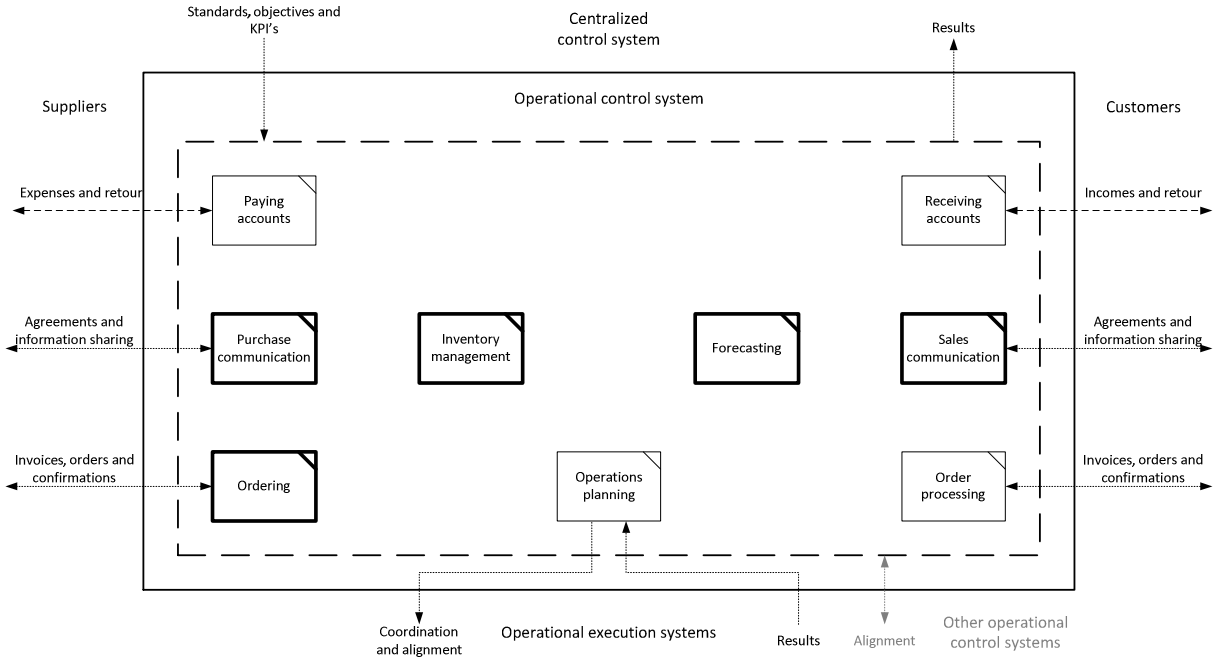


Figure 13: Operational control system of the systemic perspective of the system model

Systemic model: Operational execution system

The functions within the operational execution system are not important for the Bullwhip Effect, since the operational execution systems can be regarded as a single functions. A execution system has a local process control that hierarchically transforms the coordination of Master Schedules to local instructions. Each operational execution system receives and sends goods. Optionally, they can store and manufacture/repackage goods.

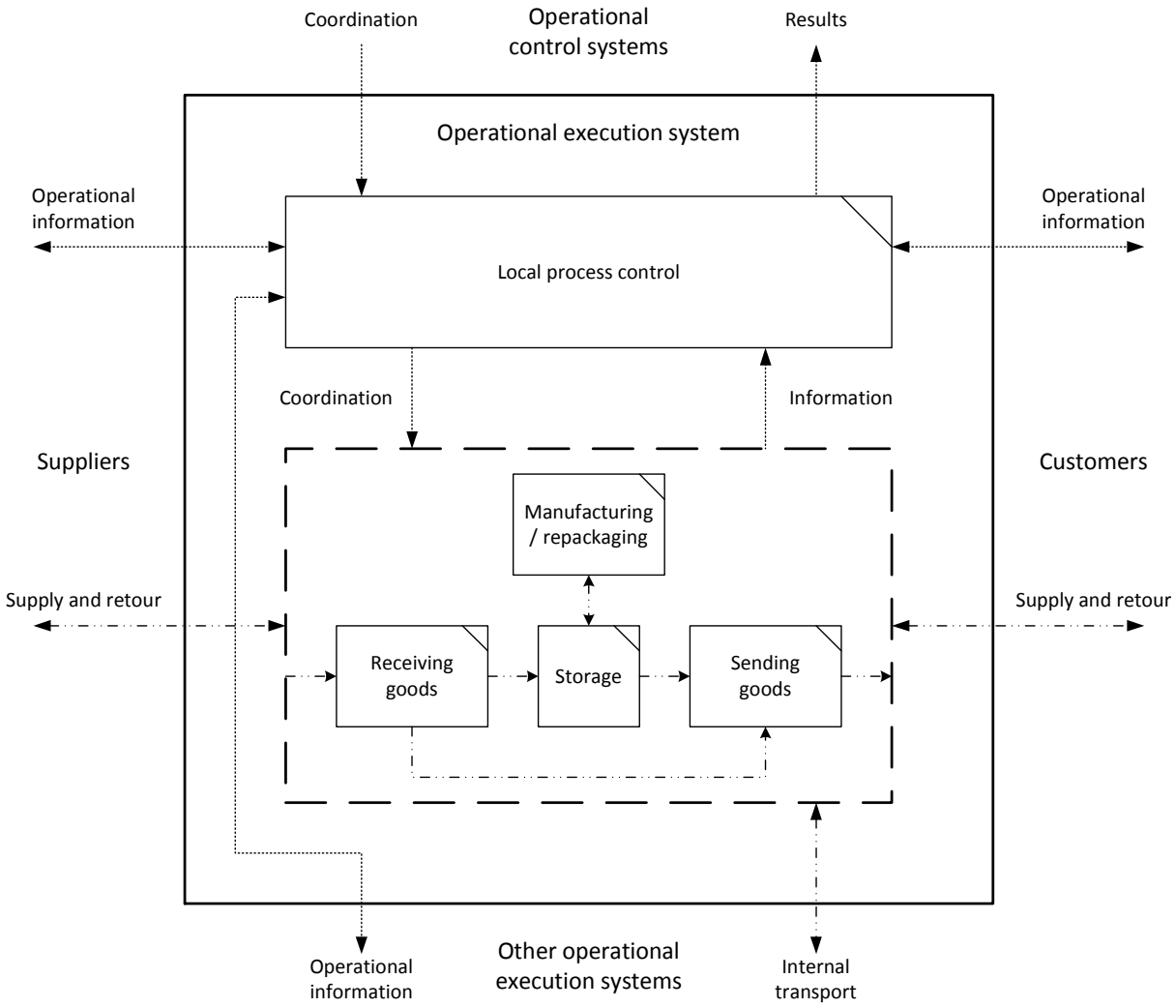


Figure 14: Operational execution system of the systemic perspective of the system model

Behavioural model: Supply Network level

On the Supply Network level the behavioural model is similar to the systemic model as illustrated in Figure 15. Organizations are considered independent groups of actors with common goals. From a market perspective, companies in a Supply Network with commercial links have goals that essentially conflict and the results of negotiations lead to market optima's in prices and quantities delivered to end consumers. From an operational perspective, companies with commercial links in Supply Networks have aligning interests to create system wide optima's in planning to improve performance and reduce everyone's cost. The behaviour of actors in the Supply Network is steered by the interactions through their commercial links and global formal and informal institutions according to the four layer model of Williamson (1998).

Commercial link

From a behavioural perspective, the commercial link consists of three element: The relationship status between two actors, the communication and negotiation on daily operations and agreements and the institutional arrangements in place.

The relationship status consist of two elements: trust and power positions (Ostrom 2010). Trust is defined as the perceived probability that an actor will keep his promises. It's a self-reinforcing mechanism that builds up gradually when actor prove trustworthy (Rosenberg and Stern 1970). Power positions are caused by dependencies and production power. Basically, companies have production power when they are relatively big customers or suppliers and dependencies arise when other companies or consumers have no alternatives for specific goods and services (Simatupang and Sridharan 2002). Global formal in informal institutions aim at distributing power positions by reducing unbalanced power positions caused by monopolies and cartels. Investments in cooperation and Supply Chain integration enhances dependencies.

Institutional arrangements are the agreements which are In place between organizations and the main focus of this research. Communication and negotiation between actors are a dynamic process that leads to the development of the institutional arrangements and the relationship status, especially trust. The specific cost related to this negotiation are defined as transaction cost in the field of New Institutional Economics (reference). These costs arise due to searching and gathering information for negotiations and the efforts needed for holding negotiations and enforcing agreements.

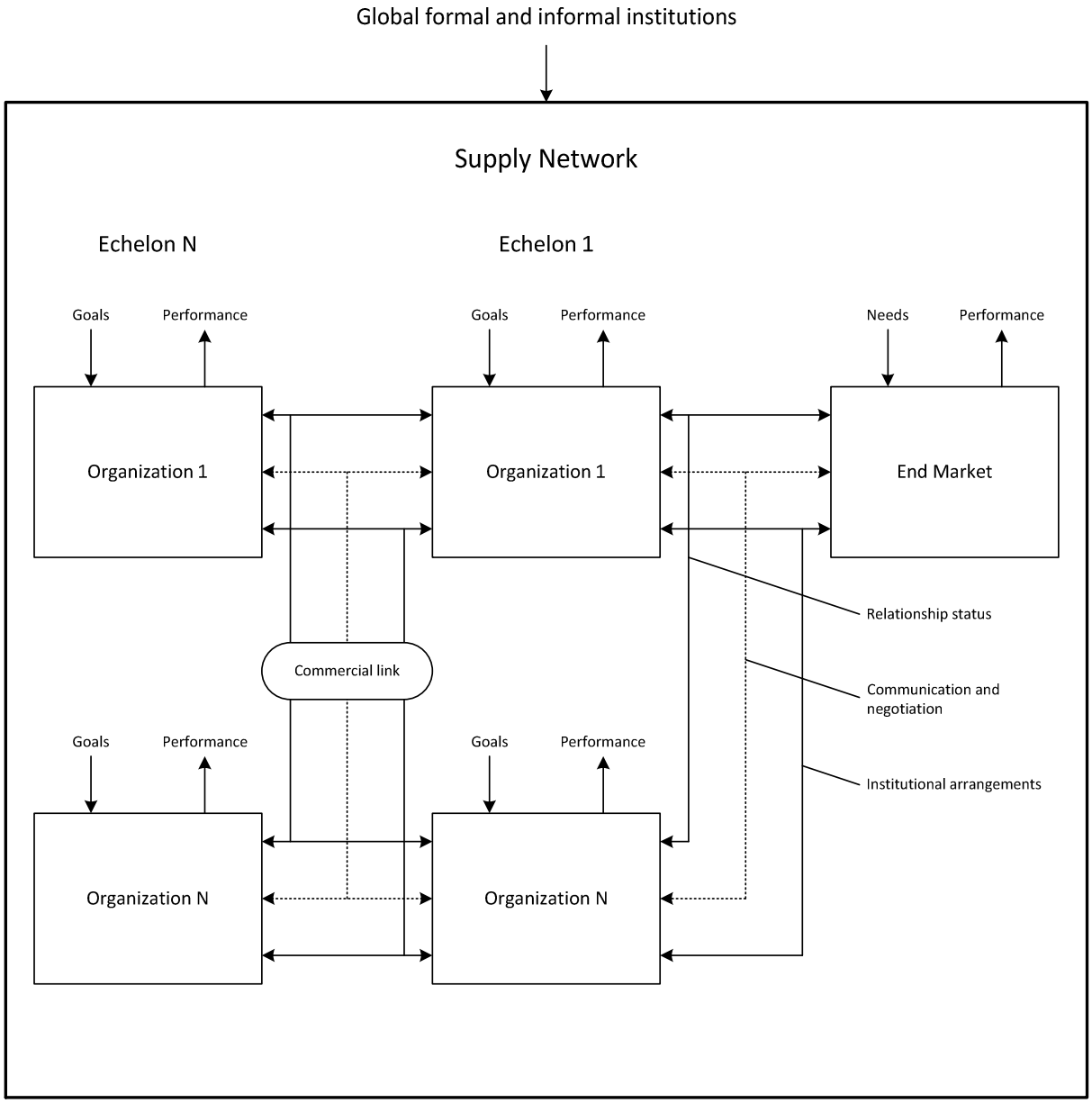


Figure 15: Supply Network level of the behavioural perspective of the system model

Behavioural model: Organizational level

The internal system of the organization from a behavioural level is a hierarchy with divisions as individual actors with their own behaviour. The behaviour of divisions is however steered by global formal and informal institutions, internal informal institutions, such as company identity, culture and values, hierarchical coordination and institutional arrangements with suppliers and buyers in relation to their own interests, rather than hierarchical instructions alone.

Organization structure

The generic design of the hierarchical structure is displayed in Figure 16. The hierarchy has a number of vertical layers and a number of horizontal divisions at every layer with a centralized management on top. Higher hierarchical layers assign positions, authorities, responsibilities, procedures and rules to lower layers. Coordination can happen directly with

instructions or indirectly by assigning objectives. Each division as an actor has authorities and responsibilities over a number of systemic functions in the organization. An actor is only relevant in this research when it controls at least one of the relevant processes in the systemic perspective of the systems model. Because organizations have diverse configurations in organizational structures over operational functions these are decoupled in the systems model. Common configurations according to Supply Chain management are unstructured, functional configuration and integrated configuration, which align with the first three stages of organizational growth in Supply Chain management competency, described by Boyson, Corsi et al. (1999). In unstructured configurations Supply Chain management is not consciously defined in organizational structures which has caused the responsibilities and authorities to be spread out over divisions without any rationality. Functional configurations have autonomous departments like Sales, Purchase, Administration, Finance, Manufacturing, Logistics, Warehousing and Inventory Management, which all optimize their own operations. In integrated configurations, relevant operations functions are often distributed over a commercial department and an operations department.

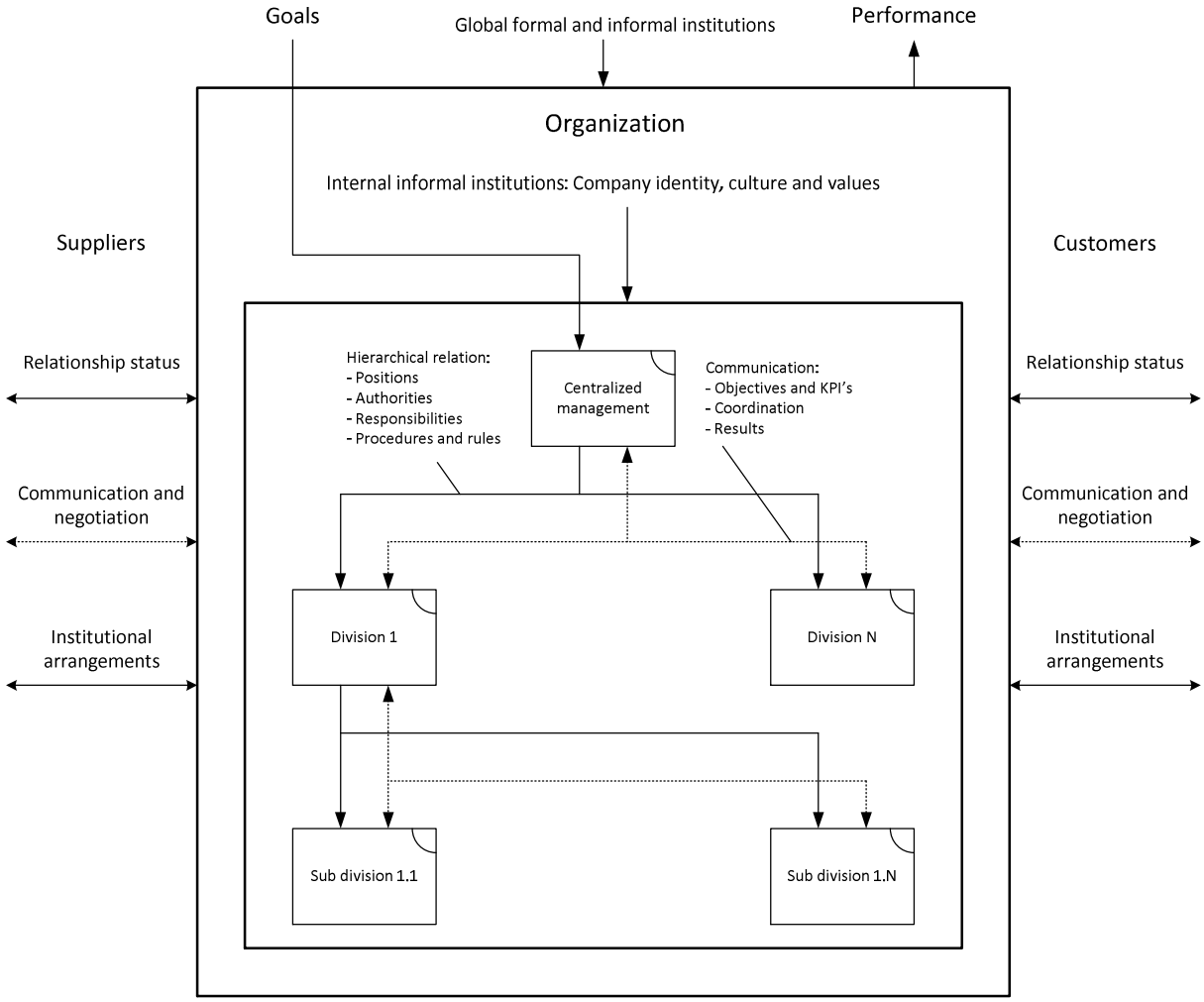


Figure 16: Organizational level of the behavioural perspective of the system model

Behavioural model: Actor level

Organizational divisions are modelled as autonomous, self-interested actors which are bounded rational, which means they only have access to local information, are cognitively limited to understand the full complexity of their decision domains and don't have the required time and resources to arrive at optimal decisions if they would (Simon 1997). Poteete, Janssen et al. (2010) and Ostrom (2010) have proved that bounded rationality is common practise for most economic situations, except the very simplest repetitive situation in static environments where actors are able to learn all available actions, strategies of others and consequences of choices. Croson and Donohue (2006) have proved actors to be bounded rational in very simplified experimental Supply Chain settings.

Behavioural mechanisms

Actors behave in a setting which is constrained by their physical and institutional environment. Figure 17 shows the Institutional arrangements, hierarchical institutions, global informal and formal institutions and internal informal institutions that influence the behaviour of the actor externally. The actor is modelled as self-interested, having both individual related interests, such as gaining incomes, power and positions, as social interest, such as needs for acceptance and positive validation. The hierarchical objectives and coordination in relation to the individual interests creates the basis of normative evaluation of the actor. The external institutions influence the behaviour of the actor both in the logic of consequence, by constraining or allowing the actor to have information or decision making options and influencing outcomes, as the logic of appropriateness, by directly influencing the social interests of actors to behave appropriate according to normative rules (reference).

The actor receives both internal as external information from other organizations, constrained by institutions. These create the information in the memory of the actor. The actor also has a level of general knowledge and competences, which are not perfect due to the assumption of cognitive limitations. They are the paradigms and mental models the actor has about reality. The information, knowledge and competences create the perceived number of decision making options, which are constrained again by institutions. These factor also contribute to the perceived reality of the actor in the specific situations. It's the mental models with assumed mechanisms of reality, which define perceived outcomes of decision making options, which are gain influenced by institutions The relationship status with other organizations and the current communication and negotiation will contribute to the perceived reality on how other actors will behave and react in certain situations.

The perceived outcomes of available decision making options are evaluated on the normative basis of the actor and the decision is made on the most favourable option. Utility is a theoretical concept that is used by Economists and Game Theorist to quantify the perceived value of an option, given the uncertainties of outcomes (reference). The decision will lead to ex post lead to certain outcomes. The evaluation of outcomes influences the knowledge and competences of the actor, possibly changing its paradigms and mental models. The extent in which other organizations behaved as promised will influence the trust and relationship status towards them.

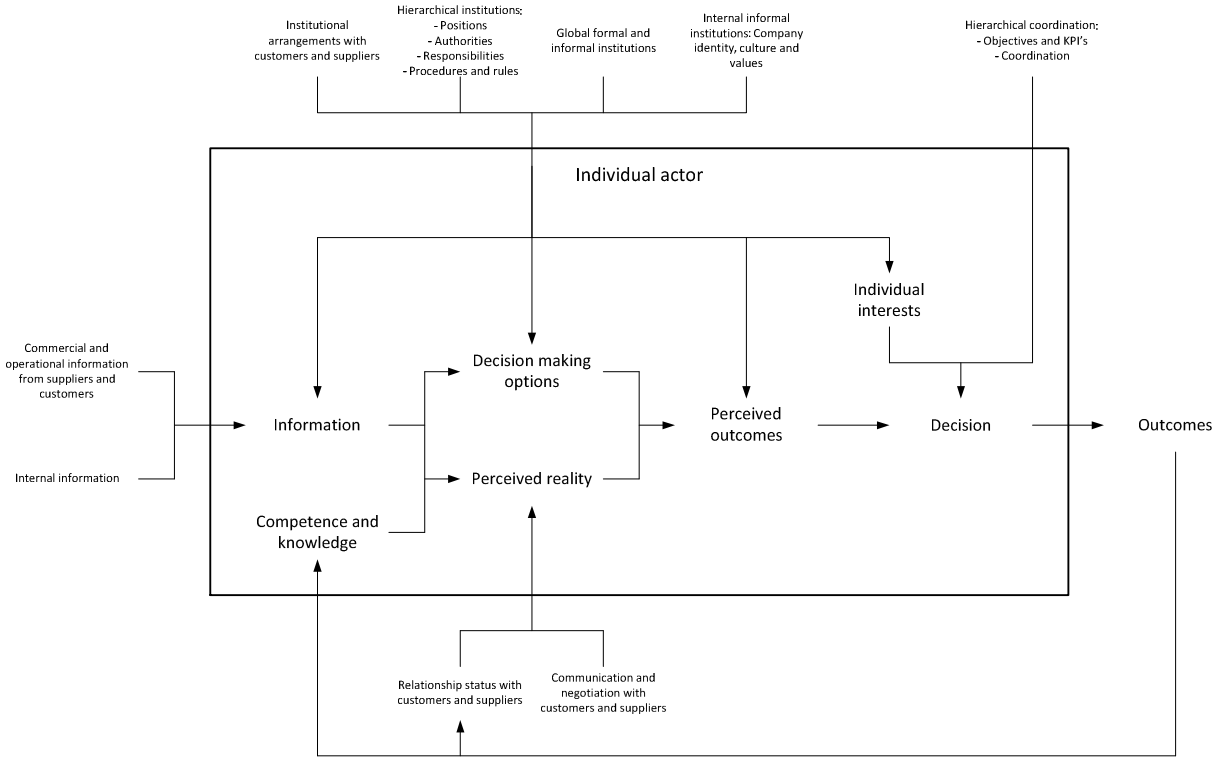


Figure 17: Actor level of the behavioural perspective of the system model

4.2. Systems model in the case study

The case study focuses on the interface between the Technische Unie and Legrand Nederland, specifically for the Van Geel product group. This focus is important, because the supply chain structure for the Legrand product group is different. The structure and processes of Legrand Nederland described here are solely applicable to their Van Geel product group. The described structure and processes of the Technische Unie are generic

Systemic model: Supply Network level

The Supply Chain of the of Van Geel products of Legrand Nederland which are distributed by the Technische Unie within the generic Supply Network of cable ducts sold to the Dutch market is visualized in Figure 18. Here the elements in the periphery of the case study scope are displayed in grey. Also the three elements of the commercial links, flows of goods, information and funds, are simplified in single lines.

The first echelon consists of all wholesalers which sell cable duct elements to the Dutch market. The second echelons consists of all final tier manufacturers which sell these products through these wholesalers. The focus of this case study lies solely on Van Geel products that Legrand Nederland sells through the Technische Unie to the Dutch end market. Legrand Nederland does sell products directly to the end market too, however this also lies outside the scope of this case study. Legrand Nederland is supplied through internal group production facilities of the Legrand Holding which are mainly located in Slovakia, as well as through other external suppliers. Only the interface between these suppliers and Legrand Nederland is important within the scope of this case study.

Uncertainty and disturbances

The structure of both the wholesalers and final tier manufacturers is relatively stable. Most dynamics occur through organizational mergers and acquisitions, however the physical supply structure is stable. Specifically the supply from Legrand Nederland in Boxtel to the distribution centre of the Technische Unie in Alphen a/d Rijn remains and is expected to be stable on the long term. The risks for short term disturbances in the Supply network are relatively low, because the Netherlands has a stable political, legal and economic environment and has a low risk for natural disasters.

End market

The end market consists of professional customers, mainly construction companies which are specialized in the installation of electrical and digital infrastructures in buildings. These companies are known to avoid any stock and rely on the delivery of materials at their construction sites or offices at the moment they need it for their projects. This causes their orders to directly represent their actual needs and justifies regarding the orders of these companies to be regarded as end market demand.

The aggregated demand pattern of this market depends on the product type. Fast moving products are common elements which are present in virtually any electrical and digital infrastructure, like standard cable trays. These products are highly seasonal and their demand is predictable through forecasts based on historical demand. Peak demands occur after the Christmas and summer holidays. The demand pattern also has clear long term trends which follow the economic productivity of the construction market in general. Slow moving products are more specialized elements which greatly outnumber the fast moving products, however only make up a small fraction of the total flow of goods. They have very unpredictable and incidental demand patterns. Large incidental demand also occur for fast moving products and can almost always be traced back to a single order of a large project.

The Van Geel products of Legrand have short life cycles of around five years, caused by the high levels of technological innovation in digital technologies. The Van Geel portfolio of products contains a high number of new products and phase out products. This creates a challenge for the inventory managers of the Technische Unie to predict the demand of new products, assign the appropriate inventory coordination and prevent obsolete inventory.

Goals and performance

The Technische Unie has the goal to create financial profit for the Sonepar Holding by distributing their products to the Dutch market. As a distributing echelon in the Supply Network, the Technische Unie focuses on customer service. The management of their operations aims at achieving their required service levels first and then improve efficiency.

Legrand Nederland has to create financial profit for the Legrand France Holding by manufacturing and finishing their products for the Dutch market. Because most of their customers are distributors rather than end users, their focus lies more on efficient planning of operations.

Commercial links

There are three relevant commercial links in the scope of the case study: 1) the link between the Technische Unie and the end market, 2) the link between Legrand Nederland and the Technische Unie and 3) the link between Legrand Nederland and its suppliers. All of these links are reliable, long term supply links that contain all three aspects.

Link 1 and 2 contain the same products in the same form. These elements are imperishable and insensitive to damage. They also are relatively heavy and have a low value density, which makes them capable for long term storage. Link 3 may contain the same products, possibly requiring some small finishing, such as coating. Also link 3 may contain the materials for production, which are more bulky and have a lower value density.

The flow of these goods are facilitated by the suppliers using trucks in all three links, however there are large differences in batch sizes, delivery frequencies and lead times. Link 1 contains daily delivery on any site within the Netherlands with a lead time of one day for inventory products without any required batch sizes for customers. Products that are not stocked by the Technische Unie have longer lead times up to a month for the slowest movers. The Technische Unie also has a number of retail points where customers can directly buy a very limited assortment of very commonly sold products. Deliveries for link 2 happen several times a week on given days. Lead times range from one day to about a week and order sizes are batched by order increments. Link 3 has even smaller delivery frequencies which in terms of months. Lead times are ranging from one to several weeks and order sizes are often fixed or have large minimal order sizes and increments.

The flows of information has a similar pattern of frequency over the three links. Over link 1 customers continuously place orders using the website interface, telephone calls, e-mail and fax and receive feedback on deliveries and contingencies. Commercial communication happens through the sales offices of the Technische Unie. Operational communication over link 2 happens a few times a week though e-mail or telephone and also contains orders and operational feedback. Commercial communication happens monthly between the sales department of Legrand Nederland and the specific product purchase department of the Technische Unie. At link 3, most operational communication is similar to link 2, however less frequent.

Flows of funds are delayed to the flows of goods. At link 1, customers often pay in advance when ordering at the website or pay directly at delivery. Large orders with customized agreements use bills which are paid within a month. Payments over link 2 and 3 always happen through billing procedures with payments within one to three months.

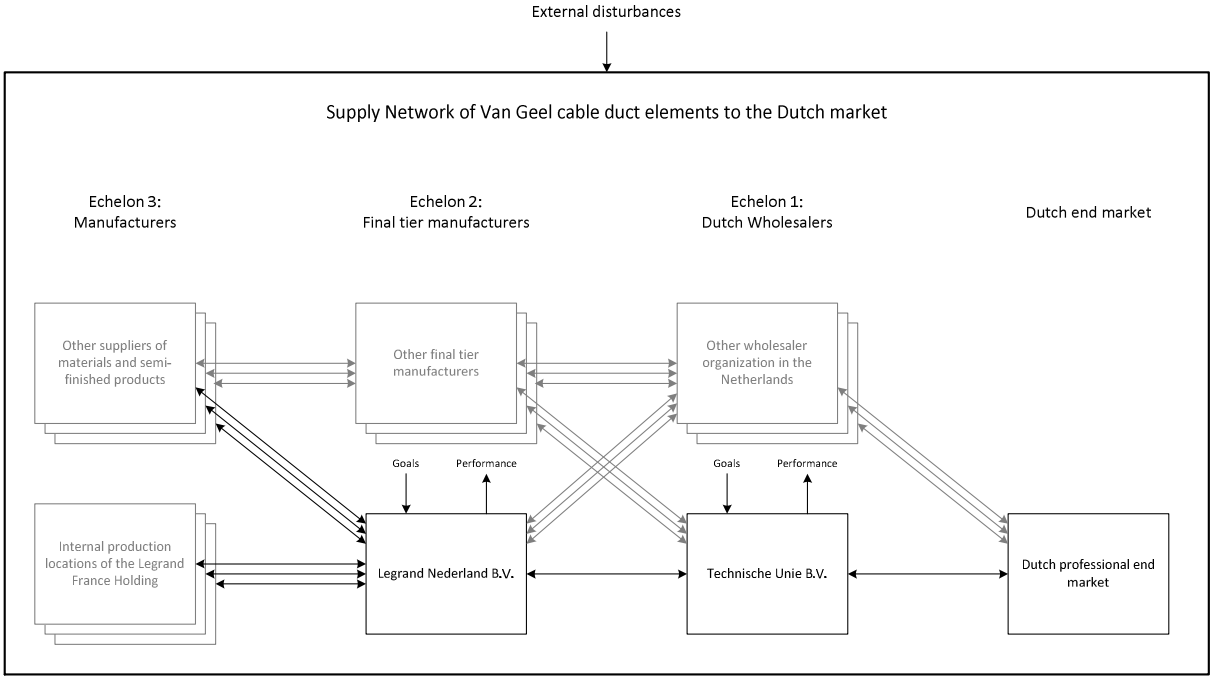


Figure 18: Case study analysis of the Supply Network level of the systemic perspective

Systemic model: Organizational level of the Technische Unie

Figure 20 displays the Technische Unie from the systemic perspective. Here, the content of the operational control system and operational execution system are integrated in this picture. The Technische Unie has a single, centralized operational control system which is coordinated from the main office in Amstelveen, together with the centralized control system. The operational execution systems contains a large number of sites which are all centrally coordinated from Amstelveen

Operational execution systems

The Technische Unie has a hub-and-spoke distribution network containing two distribution centres and 22 transhipment points. Normally, suppliers deliver their goods to the two distribution centres only. The site in Alphen is specialized in small articles within the given dimensions of the standardized plastic crates of the Technische Unie and cables. The site in Streijen is specialized in larger products. Every day products are picked and organized according to customer orders and send from these two distribution centres to the 22 transhipment point throughout the Netherlands. Here the products are reorganized according to customer orders and loaded in other trucks for delivery at the customers the next day. In case customers desire to pick up their orders at one of the sales offices it is also possible to deliver their orders there. Finally the Technische Unie has two sales points in which function as a retail store. These are supplied in the same manner.

The majority of goods flow through this route, however in exceptional cases logistical nodes can be bypassed. Suppliers are able to deliver directly to transhipment points, sales offices, sales points and even customers if necessary. The Technische Unie places such request in case of emergency to prevent late deliveries. Also very large orders can be send directly from suppliers.

The internal structure of the distribution centres and other sites are not relevant for this research. The system is robust and reliable enough to assume that transhipment points can always deliver all orders the day after receiving them and distribution centres are always able to deliver the ordered quantities in the right format to the transhipment points at the requested day when there is enough stock. One can also assume that the distribution centres are always able to accept deliveries from suppliers at the day of delivery and are able to pick those quantities the next day for delivery to transhipment points. In reality, there are some constraints in the capacity of receiving goods and storing them for picking.

Operations planning

The operational execution system is centrally coordinated by an automated planning system. This system automatically translates customer orders into an integrated operational master planning which contains instructions for picking, transportation and delivery. Every individual product is either routed through Alphen or Streijen and the Order Penetration Points of all stock products lies at its distribution centre.

Ordering and order processing

As stated before orders can be placed by customers using the website interface or contacting the sales offices by e-mail, telephone or fax. All orders are stored in a central ordering system, which is the primary input for the operations planning and purchase ordering. Orders place by the Technische Unie to Legrand Nederland occur by e-mail and telephone.

Purchase orders are defined using a system called Mercia. This system defines orders based on actual inventory positions, customer orders, demand forecasts and purchase orders that are already placed. The Technische Unie uses an ordering policy which has both dynamic order quantities and order intervals, however aims at a stable Mean Days Between Orders (MDBO). This is visualized in Figure 19 in the case of constant Safety Stocks and daily order forecasts.

Every day Mercia plans future orders for each product and suggests the inventory managers to place the orders which are close to the lead time of the supplier for that product. The orders are planned on the days that the inventory is expected to reach or go below their Safety Stock value. These dates are called the Need Dates. This date is determined as follows: First Mercia determines the Economic Opening Stock by adding placed purchase order quantities within the supplier lead time to the physical stock and subtracting backlogs to customers. Then Mercia continues to subtract the daily demand forecast quantities until it reaches the Safety Stock and the Need Date is set at the moment that happens. Next Mercia calculates the order Due Date based on the next possible day the supplier is able to deliver and defines the expected stock at that day. Then Mercia calculates the desired order quantity. This is done by summing up the forecasted demand quantities over the a period starting at the due date to the due date plus the MDBO parameter. The planned order quantity is defined by adding the order increments to the minimum lot size until the quantity exceeds the desired order quantity. This will become the actual planned order size. Finally Mercia determines the Re-Order point by subtracting the supplier lead time from the due date. This is the last opportunity to place an purchase order. Mercia repeats this planning until a set planning horizon by defining a new economic stock at the Due Date by adding the planned order quantity to the expected inventory. A new

Need Date, Due Date, order quantity and order receiving date are then defined using the same procedure until the planning horizon is reached

The inventory managers are free to decide when they will actually place an order. They can already place an order at the Due Date this before the Re-Order point is actually reached. Also, unexpected peaks in customer demand may cause the necessity for emergency orders. These orders have a minimal lead time of three days and are only placed when really necessary.

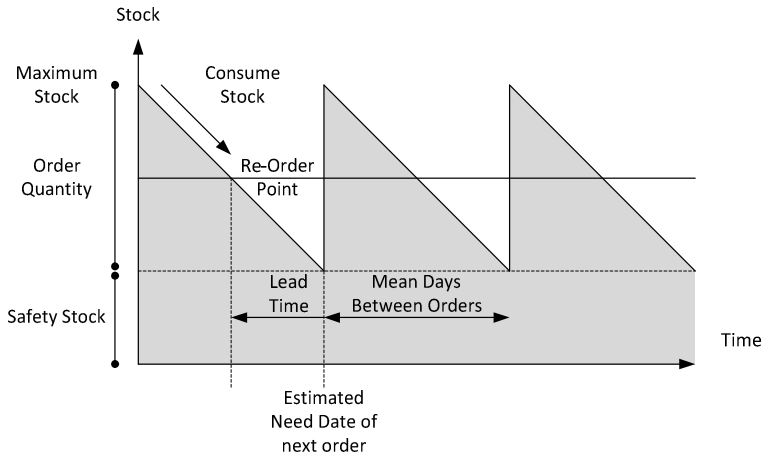


Figure 19: (s, S) Ordering Policy of the Technische Unie

Inventory management

The Technische Unie continuously manages a tailored inventory policy for each product, which can be adapted at all times according to changes in product life cycles and customer demand. In general, there are four exclusive product categories. First regular stock and regular non-stock articles both have a Technische Unie product number and are present in the catalogues. MAN products ("Met Artikel Nummer" meaning "With Article Number" in Dutch) and ZAN products ("Zonder Artikel Nummer" meaning "Without Article Number" in Dutch) are not present in the catalogues but can be ordered on special requests.

Regular stock products are further differentiated according to their inventory turnover speed in classes from A to F. This classification is made according to the amount of order lines that each product has. The exact classification is explained in Annex V. The classification code of the product determines the desired service level. Fast moving products have higher requirement than slow movers. A products require a 99% service level, E products require 96%. The service levels are determined by the percentage of order lines for that product where delivered correctly the next day.

The desired service levels determine the safety stock levels of the products. The Technische Unie determines the average forecast errors and it distributions. Safety stocks values are set to be equal or higher than a certain percentage of the negative forecast errors, corresponding with the desired service level. For example: When a product requires a service level of 98%, the safety stock is set to a value where it would have enough stock to facilitate demand in 98% of the cases. Because forecasts are made for 13 periods of 4 weeks per year, forecast errors are also calculated over these 13 periods. This results in different safety stock values every 4 weeks. Safety stocks are higher in periods where average demand is higher and/or more unpredictable.

Slow moving products have unpredictable incidental demands with only a few order lines every year. Therefore the safety stock is set to a quantity that exceeds a percentage of all order quantities equal to the desired service level. For example: If the desired service level for a product is 96%, the safety stock is set to exceed 96% of the ordered quantities in all order lines.

Forecasting

Forecasts are made over planning periods of 4 weeks for 1,5 years in advance and are revised every period using the forecasting module of the Mercia software. This software uses a linear trend combined with Fourier series with a length of 13 series to fit the historical demand over 5 years using Minimum Square Error optimization. This method captures both the long term economic trends as the yearly seasonal trends in the demand patterns of the Technische Unie. The software

determines whether there is a linear trend or seasonality is the first and then optionally applies them. When both are absent the software defines a flat forecast containing the average demand. Slow moving products often have such a forecast which is often manually set to zero by the inventory managers to prevent high inventories caused by a high number of small inventories of slow moving products. Also the inventory managers are able to adapt the demand data that Mercia uses. Exceptionally large orders are often removed to prevent Mercia from falsely assuming a pattern.

Purchase and sales communications

The Technische Unie has 5 redundant purchase communication functions which are dividing over 5 product groups: Electronics & installations, wires, cables & light, Sanitation, climate control and consumer articles. Sales communications are geographically divided over 36 sales offices.

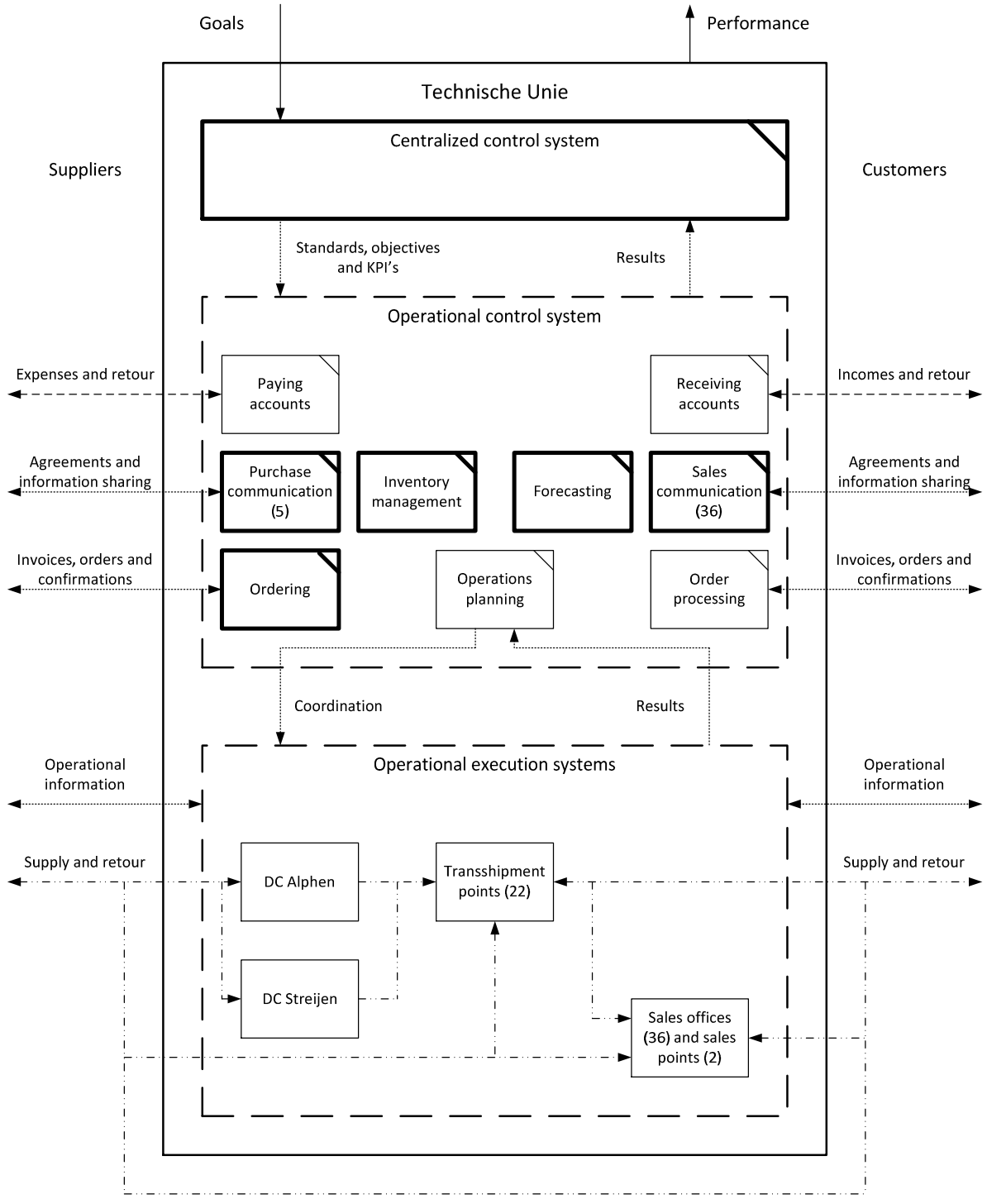


Figure 20: Case study analysis of the organization of the Technische Unie from the systemic perspective

Systemic model: Organizational level of the Legrand Nederland

The organizational level of Legrand Nederland from the systemic perspective is displayed in Figure 21, specifically for the processes of the Van Geel products. For the Legrand products, Boxtel is only a distribution location in the operational execution system of the Legrand Holding, however for the Van Geel products, Legrand Nederland is an autonomous organization, containing a single operational execution system, controlled by a single operational and centralized control system.

Operational execution system

The location in Boxtel is both a production site and a distribution site. The site contains receiving and sending goods functions, storage functions for materials, semi-finished products and finished products and a production function. The storage function also included the repackaging and reorganization of goods from bulky batches to smaller batches. Good from suppliers always flow through Boxtel and have two common routes. Materials and semi-finished products are stored, manufactured into finished products, stored again and then send. Trading products are simply stored and send to customers. The delineation between trade and manufactured products is not exclusive. Some products are traded, but can be optionally finished with for example a coating.

The functions of the operational execution system are also highly reliable, resulting in a robust system. One can assume that goods that arrive from suppliers can be delivered to production the next day. Also goods that arrive from production can always be delivered to customers the next day. Both the inventory, handling and production have no significant capacity constraints. Machine changeover times can also be neglected.

Operations planning

For the Van Geel product portfolio Legrand Nederland coordinates its planning by a pull driven system where inventory points define orders through Material Requirement Planning (MRP I). In the case of manufactured products, the inventory point of finished products defines production orders and the inventory point of materials and semi-finished products defines replenishment orders for suppliers. In the case of trade products the inventory of finished products directly defines replenishment orders for suppliers. The production planning is coordinated through a Master Production Scheduling (MPS) system, which need no further analysis in the scope of this research.

Order Penetration Points (OPP) always lie at an inventory point. For manufactured products this can either be at the materials and semi-finished products or finished products. The position of this point depends on the production throughput times and lead times to customers. When lead times are shorter than production times, the OPP point are positioned at the materials and semi-finished products, since production can be completely pulled by customer orders.

Ordering and order processing

The operations planning system has three types of orders: 1) Production order from the inventory of finished products, 2) replenishment orders from the inventory of finished products for trade products to suppliers and 3) replenishment orders from the inventory of materials in semi-finished products to suppliers. The replenishment orders to suppliers are communicated through e-mail and telephone, similar to the placed orders of the Technische Unie. Production orders are communicated through the internal information system of Legrand Nederland.

All three type of orders follow a similar policy: They are all based on fixed quantities and variable order intervals. The desired fixed order size is called the series size, which is a multitude of the order increments. Orders, deviating from the series size, are always a multitude of the order increments. The increments of replenishment orders are given by the suppliers. The production order increments are based on the properties of the production system for that specific product. Series sizes are revised four times per year and based on the average weekly demand for fast movers. For slow moving products the average order sizes determine the series sizes.

The process of planning and placing orders is executed daily, following a similar pattern for all three types of orders: First orders are planned within a given time horizon. This starts with defining the daily demand within this horizon. This demand is based on the actual customer orders and forecasts. How this is done depends on the position of the inventory point under consideration towards the Order Penetration Point, which in this model can only be at the inventory of finished products or the inventory of materials and semi-finished products which are directly externally supplied. Order decisions of inventory points which are at the OPP point are defined as follows: Within the lead time towards customers only their orders are considered, since the cannot change anymore with the exception of emergency orders. For days after the lead times, the forecasts are used unless already placed order totals exceed this forecast. In such a case the customer demand is taken, however the forecasted quantities of following days are decreased in accordance to the excisions of the forecast.

Order decisions of inventory points before the OPP point only consider customer orders. Inventory points behind the OPP point are decoupled from customer orders and only base their demand on the placed and planned production orders.

After the daily demand is defined, the opening stock of an inventory point is defined by reducing current backlogs from its inventory. Then, the future expected stock is defined on the expected daily demand and placed orders. This is calculated for every day until the expected stock falls below the Safety Stock. At this date an order is planned. The order size is then defined as follows: the sum of the Safety Stock and series size determines the desired stock level. The difference between the expected stock and desired stock determines the desired order size. The actual planned order size will be the first sum of increments that exceeds the desired order size. The planned order is then added to the expected stock and the calculation continues until the next expected ordering date. Planned orders are placed as soon as the ordering time fence is reached. This time fence functions as an ordering deadline, but also has the function to prevent the ordering system from planning orders within the lead times of production or suppliers In the first place. The time fences are often based on the lead times of suppliers and production.

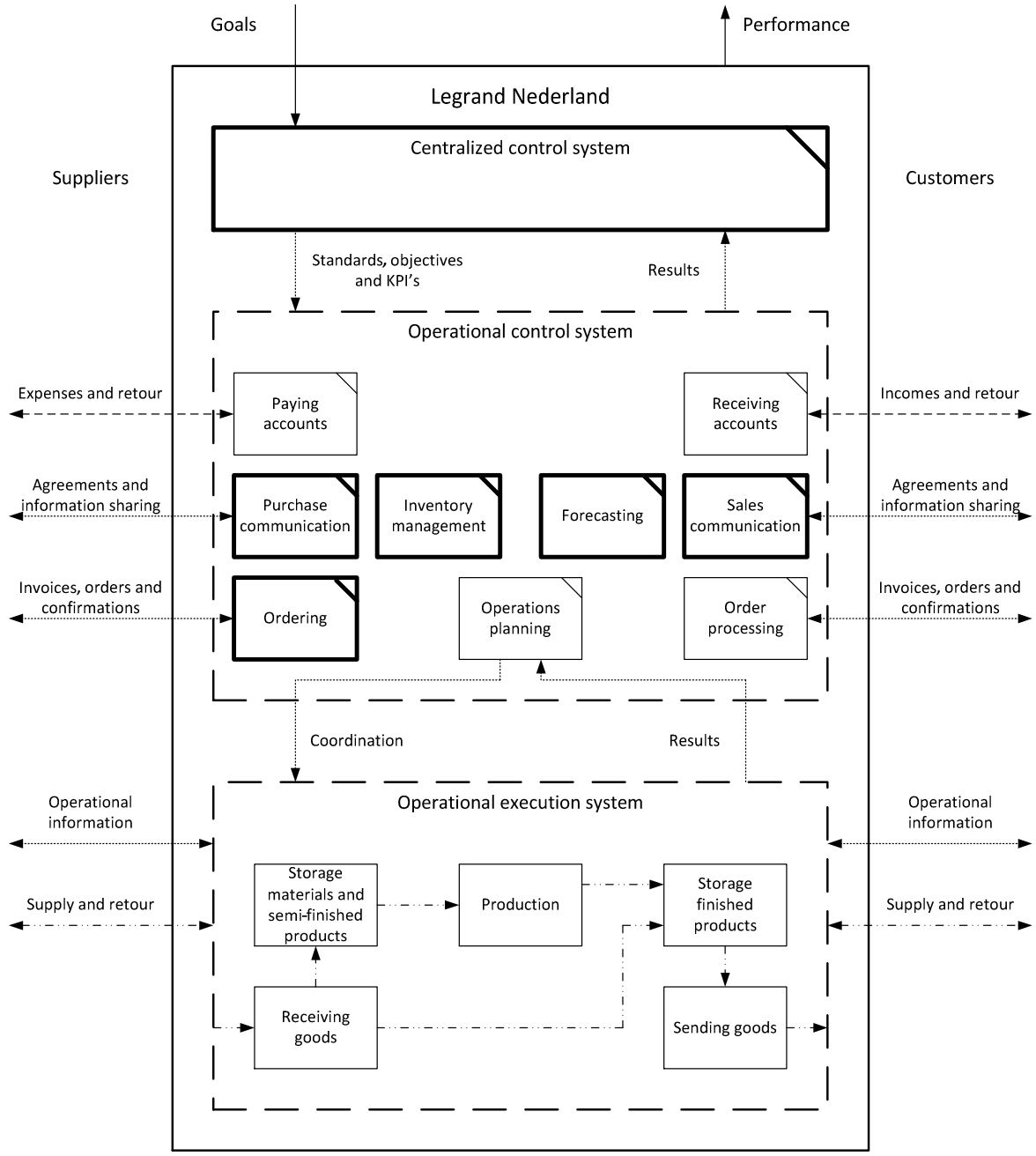


Figure 21: Case study analysis of the organization of Legrand Nederland from the systemic perspective

Inventory management

Legrand Nederland classifies the logistical properties of its products on a A to C scale. A products are considered fast moving products, B and C are considered slow moving products. A products are mainly pushed based on forecasts, heaving OPP points at finished products. B and C products are pull driven with OPP points at the begin of the logistical chain.

Safety Stock is only held at Order penetration Points. On other inventory points, Safety Stock values are zero. Their levels are determined by the desired amount of days Legrand Nederland wants to hold products on stock. Forecasts determine the Safety Stock quantities based on this number of days. Therefore Safety Stocks are dynamic values. There are revised four times per year. The desired amount of days of inventory depends on two product properties: the logistical ABC classification and value density. A and B products have around one to four weeks of stock, dependent on how valuable they are. C products have Safety Stocks based on average order sizes in order to keep service levels acceptable. This does however lead to high inventories measured in days of inventories, while service levels are still low.

Forecasting

For the first months, forecast are made on weekly level and then on monthly level in the long term. Legrand uses a software module called Predicast from Aperia. This module fits time series forecast models on historical demand to determine demand patterns. The focus of these time series models lies more on long term trends and less on seasonality, like the forecasting model of the Technische Unie.

Purchase and sales communications

Legrand has a single purchase communication function, but multiple sales communication functions which are split up by front office and back office activities. The front office functions have been divided over product groups, customer groups and geography.

Behavioural model: Supply Network level

From a behavioural perspective, the Supply Network structure of the case study is similar to the structure from the systemic perspective, as shown in Figure 22. For this analysis we will focus only on the interface between Legrand Nederland and the Technische Unie. The areas outside this scope are drawn in grey in the figure.

Global formal and informal institutions

The interface between Legrand and the Technische Unie lies within the stable institutional environment of the Netherlands and Europe, where its formal institutions are aimed to create and maintain a free market system and equal rights and market access for all its economic operators. In the informal institutional environment of the interface between manufacturers and technical wholesaler it is considered normal and appropriate to bargain on short term discounts and delivery conditions as long as trading partners are stable and trustworthy partners which can maintain a long term relation.

Independence of Legrand Nederland and the Technische Unie

Both Legrand Nederland as the Technische Unie are part of a larger holding and are therefore not fully independent actors. The Technische Unie however, does act autonomously on the Dutch market and Legrand Nederland has independent control of the operational and commercial planning of its Van Geel product group.

Communication and negotiation

Interactions between Legrand and the Technische Unie are weekly on operational level and monthly on commercial level. This high frequency has created a situation in which both parties perceive low transaction costs. Due to the frequent communications both parties have sufficient information for negotiating agreements which is a similar repetitive process. This high frequency eases enforcement of agreements, because it disincentivizes any opportunism.

Relationship status

The Technische Unie has a high market share in the sales of Legrand and the Van Geel brand has a significant market share in the product group for the Technische Unie. Because the Van Geel brand is specifically ordered by customers of the Technische Unie, the Technische Unie is dependent on Legrand Nederland for that specific brand. This creates a situation of mutual dependencies which are about equal. The Technische Unie and Legrand have been trading partners for many years and interactions are very frequent. This all has created strong levels of trust.

Current arrangements

The arrangements that are currently in place are very basic and mostly cover operational aspects. Remarkably none of these agreements are contractually enforced. The Technische Unie has agreed upon ordering between one and four weeks, dependent on the inventory turnover rate of the products. Legrand has agreed upon delivering to the distribution centre in Alphen at Wednesdays, Thursdays and Fridays only. In case of emergencies Legrand has agreed to be able to deliver directly to transhipment points, sales offices and customers when possible. The Technische Unie has agreed upon being able to pick up goods in Boxtel when necessary.

Specifically for individual products Legrand has stated its lead times, required minimum order quantities, required order increments and desired order quantities. The Technische Unie has committed to order the desired order quantities as much as possible. Finally there are agreements on prices and discount conditions. Quantum discounting on single order quantities have mostly been abandoned already.

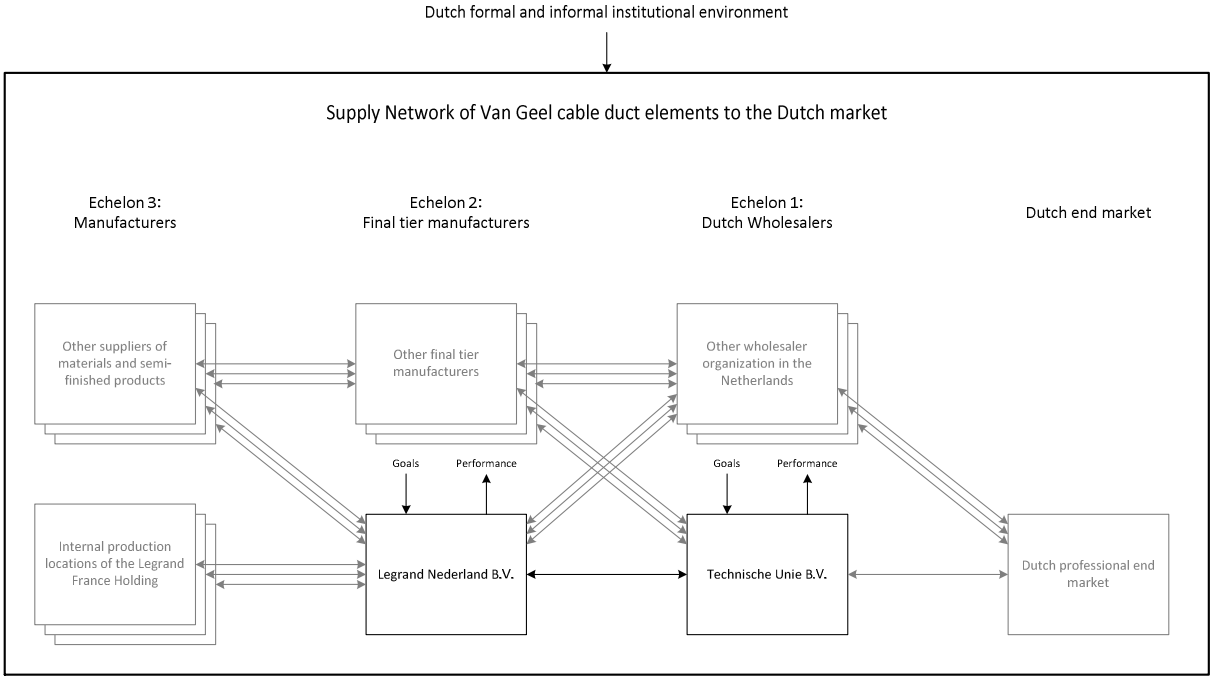


Figure 22: Case study analysis of the Supply Network level of the behavioural perspective

behavioural model: Organizational level of the Technische Unie

From an operations perspective, the organization of the Technische Unie has a functional configuration which is in transition towards an integrated configuration. Figure 23 shows the current relevant organizational divisions. The organization has been divided into commerce and services. In the Commerce division, the Sales and Purchasing department, which are further divided into sub-divisions, cover the relevant functions of respectively Sales communication and Purchase communication. In the Services division, the logistics department is relevant to this research. The division of Supply Chain Management, which is an extension of the former Inventory Management division, covers the relevant functions of ordering, inventory management and forecasting. The other three divisions within logistics are concerned with the local process control of the sites in the execution systems layer.

Internal informal institutions

The Technische Unie describes itself as a logistical service provider that supports customers in their installation processes by advises them in the right choice of materials and delivering their materials at the right time and on the right place. They describe cooperation, involvement, respect, comfort, coherency, leading, total resolution and continuity as their major values.

Purchasing

The Purchasing department is divided into five product groups, which divide authorities and responsibilities over these groups. The department has the authority to define agreements with suppliers on prices, discounting conditions and delivery conditions and is held responsible for these prices and conditions.

Sales

The Sales department is also divided into five geographical groups and then further divided towards sales offices. The sales department has the authority to create customer orders and reserve stock for upcoming orders. They also have the authority to define discounts and special product and delivery conditions. They are held responsible for the sales turnover and resulting margins of those sales, however they have limited responsibility towards the operational effects of reserving stocks and inaccurate ordering.

Supply Chain Management

This division has the authority to place orders at suppliers and ration deliveries of order in case of stock outs. They are held responsible for the service levels, inventory turnover rates and the gained discounts by ordering according to the discounting agreements the purchase divisions have made with suppliers.

Figure 23: Case study analysis of the organization of the Technische Unie from the behavioural perspective

behavioural model: Organizational level of the Legrand Nederland

Similar to the the Technische Unie, the organization of Legrand Nederland partly has an integrated and functional configuration. Their organization distinguishes between the commercial and operational organizational elements and has an integrated planning of Supply Chain Management. Figure 24 displays the relevant organizational divisions in their hierarchical structure. The responsibilities for sales are divided into front office and back office over two divisions. Responsibilities are grouped by the division of Operations which consist of two parts: Supply Chain Management, which is responsible for the aggregated operational planning of operations, and Industrial, which is responsible for the specific production operations. For this research the Supply Chain Management division is most important. Since production is regarded as a single function, internal management of the production operations are not within the scope of this research. The Purchasing division within Industrial is however important, because it contains the purchase negotiation function of Legrand Nederland.

Internal informal institutions

The mission of Legrand Nederland is to increase the convenience of installation and operation of its systems by users, installation contractors, advisors and logistical partners by providing tailored products and services. They want to increase energy efficiency, communication capabilities, safety and design of buildings by continuous product innovation. They describe four core values: Ethics, innovation, customer focus and sustainability.

Sales front office and back office

The front office divisions are further divided according to customer groups: Utility for industry, Utility for housing and large projects. There is also a division for the sales of specialized products. The back office is divided functionally by Customer Service and Calculation & Tendering. These divisions together are responsible for the sales turnovers and margins and have the authority to define agreements on pricing, discounting and delivery conditions. For specific projects these departments act as sales engineers, however this is not the case in the scope of the relation with the Technische Unie.

Purchasing

The purchasing department within the Industrial division is responsible for the strategic and tactical purchasing. They negotiate long term agreements with their suppliers about purchasing prices, discounts and conditions.

Forecasting, Planning & Procurement

This department within the Supply Chain Management division is essentially responsible for the operational planning of quantities. They define forecasts and order quantities for production and replenishment based on the inventory policies, which they also define. They are responsible for service levels and inventory levels.

Warehousing & Distribution

This department within the Supply Chain Management division is responsible for the storing, sending and receiving elements of the operational execution system and is therefore closely related to this research, but not relevant within this analysis.

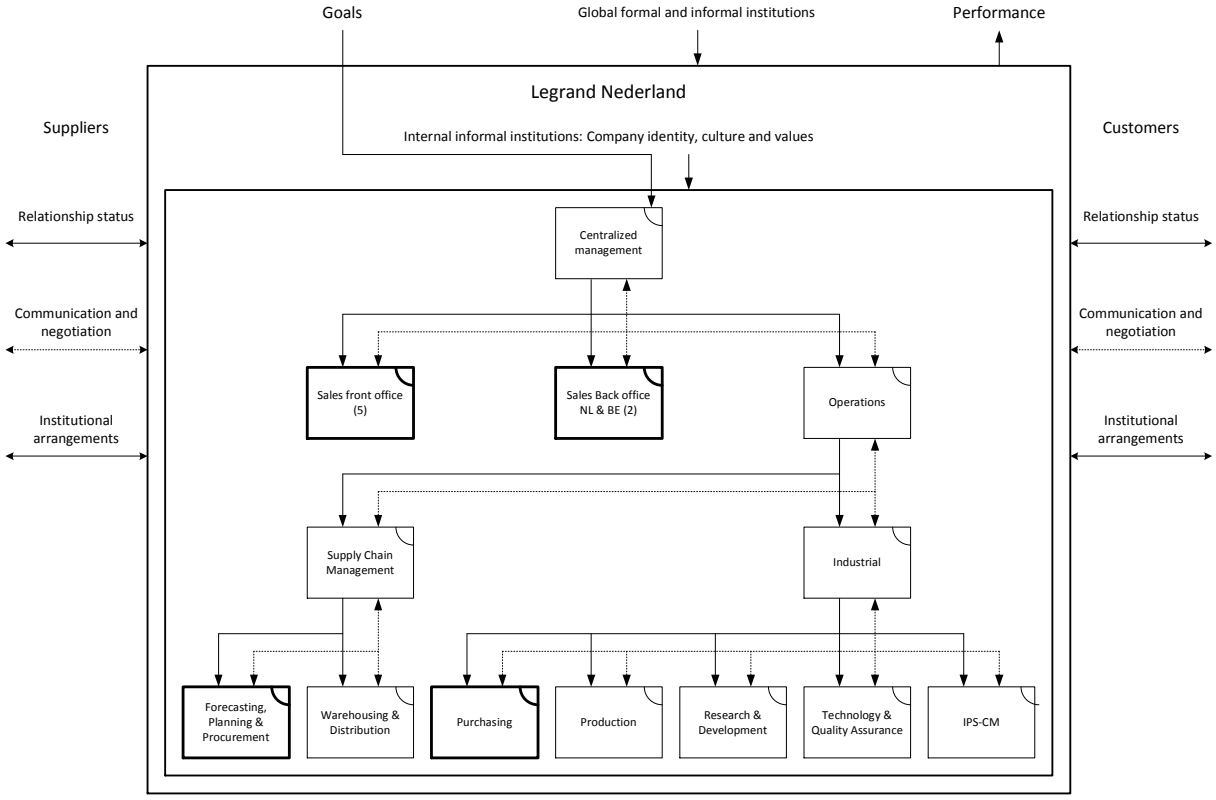


Figure 24: Case study analysis of the organization of the Legrand Nederland from the behavioural perspective

4.3. Problem perspectives on the Bullwhip Effect

In order to solve the Bullwhip Effect by incentivizing the behaviour of Supply Chain parties by institutional arrangement, it is necessary to scope the Bullwhip Effect problem broader than just the immediate causes that have been identified by scholars in the fields of rational and strategic behaviour (Lee, Padmanabhan et al. 1997; Geary, Disney et al. 2006) and bounded rational behaviour (Croson and Donohue 2006). It's necessary to consider the reasons why programs for information sharing and collaboration are not initiated or do not achieve the desired results in Bullwhip Effect reduction. Loughman, Fleck et al. (2000) describe Supply Chain problems to be 20% technology and 80% people. They describe the issues of limited knowledge to solve problems, the lack of incentives due to individual interests and strategic behaviour and the resistance against change in general as a risk averse mechanism. Simatupang and Sridharan (2002) illustrate how information sharing and collaboration can reduce strategic behaviour such as adverse selection and moral hazard, however the same opportunistic behaviour creates a basis of distrust and is a barrier towards cooperation.

In this research we have identified 20 problem perspectives which directly cause the Bullwhip Effect or indirectly contribute the persistence of the problem. These perspectives are not mutually exclusive and are organized in four categories using a framework containing two assumptions about behaviour. Figure 25 shows this organization based on the assumptions about behavioural logic and assumptions on rationality. On one hand, behaviour can assumed to be fully systematic, following a fixed formalized logic which is based on internal information. On the other hand, one can assume behaviour to be an interactive process in which actors try to anticipate on each other's decisions. Rationality can either be assumed to be perfect within their given situation of information asymmetry or to be bounded according to the definition of Simon (1997).

This framework result in four problem areas. Systematic and rational assumptions for behaviour lead to systematic problems which can only be solved by system adaptation. These assumptions are most commonly used in Bullwhip Effect research in the fields of Operations Research. When full rationally is not assumed, there are knowledge problems, where actors biased behaviour is a cause for the Bullwhip Effect or a cause for not being able to solve the Bullwhip Effect. Solutions to these problem lie in the areas of education and formalization of processes. When rational and interactive behaviour is assumed, we find problems in the area of Game Theory, where optimal behaviour leads to the Bullwhip Effect or prevents actors to engage in solving the problem. Especially the lack of incentives to solve the Bullwhip Effect has not been extensively researched. Finally, when one assumes both interactive and bounded rational behaviour, relationships and trust become a problem area for engaging cooperation in solving the Bullwhip Effect.

The individual problem perspectives are elaborated further in this paragraph. It is emphasized here that they are perspectives on the problem and not mutually exclusive causes. Isolating the contribution of individual causes are extremely difficult due to cumulative causality (Fransoo J. C. and Wouters 2000). In these perspectives this even more so the case due to their overlap. The main objective with these perspectives is to create insight in how the Bullwhip Effect problem emerges and persists in Supply Chain systems as modelled in the previous paragraph.

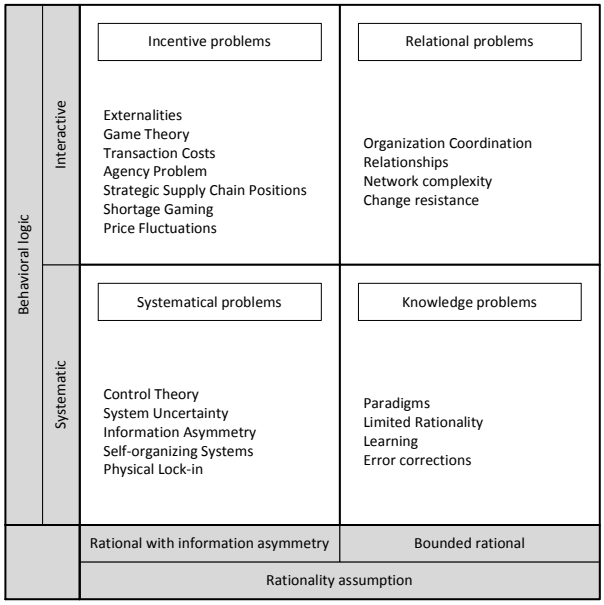


Figure 25: Problem perspectives on the Bullwhip Effect

Control theory perspective

The implications in order oscillations are the result of dynamic behaviour of controlled systems with negative feedbacks which have a time delay and positive feed forward. Orders are the corrective action of companies towards deviations in actual and desired inventory levels (Lee, Padmanabhan et al. 1997; Dejonckheere, Disney et al. 2003). The sum of time delays in processes by lead times and information by their modalities and communicative procedures are cause overshoots in corrective action causing the orders to oscillate (Forrester 1961). Orders are placed on the expectations of future demand by forecasting methods. This created a feed forward control mechanism (Sterman 1986). Forecasts are however positive feedback, since they are positively adjusted according to past deviations in actual demand and past forecasts. This also creates oscillations in the response of orders.

System uncertainty perspective

The demand pattern of the end market is uncertain and it is impossible to define an absolutely correct distribution for this demand (Anderson and Fine 1998; Sodhi and Tang 2011). Forecasting methods are therefore always inaccurate both in their predictions over time as their systemic assumptions (Chen 1998). Processes are also inherently uncertain in their speed and availability. Inaccuracies in expected demand and operational performance is the source of deviations in planned orders and their fluctuations.

Information asymmetry perspective

Supply Chain parties only perceive the direct orders of their customers and have no information about downstream processes and demand of the end market, which explain the causes behind the perceived order patterns. Therefore they misinterpret the meaning of perceived fluctuations in demand when creating forecasts, leading to higher forecast errors and fluctuations in their orders to correct for this (Forrester 1961; Lee, Padmanabhan et al. 1997; Lee, So et al. 2000; Lee and Whang 2000)

Self-organizing systems perspective

Supply Networks and organizations consist of self-interested individual agents which optimize their local environment based on their own interests (Fiala 2005; Disney and Lambrecht 2008; Ouyang and Daganzo 2008) These local self-optimizations lead to suboptimal global outcomes and eventually to sub-optimal local outcomes (Tsay and Lovejoy 1999). Companies theoretically could assess the optimal global cost trade-off between fluctuations in orders, inventory and production in all echelons of the Supply Chains and redistribute the benefits in order to create Pareto Improvements. Instead, Distributing companies at downstream Supply Chain focus on offering the highest customer service, having the lowest possible inventories and ordering costs by the practise of Economic Order Quantities, leading to high amplification of demand. Manufacturing companies upstream Supply Chains suffer high fluctuations in demands, resulting in high fluctuations in inventories and production, resulting in high costs causing higher market prices which the Distributing companies downstream has to pay, making the entire Supply Chain less competitive. The local optimization also happens within companies. Functional departments optimize their own performance based on the local objectives and Key Performance Indicators that have been set to them. Sales departments use minimum order quantities, quantum discounts, order quotas and price promotions in attempts to temporarily boost sales. Purchase departments use forward buying and large order batches to get maximum discounts.

Physical lock-in perspective

Geographic distances, infrastructure, modalities, container sizes and productions systems are given elements which cause the necessity for using certain optimal batch sizes, which cause operational deviations from ideal theoretical order and production quantities and cause fluctuations (Sodhi and Tang 2011). When products are proliferated divergently towards large number of outlets the arborescent nature of the Supply Chain reinforces this effect, because the relative demand quantities per link in relation to the optimal batch sizes becomes smaller (Simchi-Levi, Kaminsky et al. 2003). Changing these systems to allow smaller batch sizes requires large investments, which will not cover the lost investments costs of current assets in cost reduction.

Paradigms perspective

Supply Chain parties have biased mental models and paradigms about the effects of their actions on outcomes which are confined to their local environment or too simplified. They fail to comprehend the complexity of reality and global effects of their actions and how it influences their outcomes. Paradigms about scales of economies, cost efficiency by asset utilization and Economic Order Quantities are examples of such paradigms. This also causes companies to fail to benefit from external collaboration and demand visibility (Lapide 2001; Holweg, Disney et al. 2005)

Limited Rationality perspective

Even with valid paradigms about the mechanics in Supply Networks, parties are incapable of understanding and processing the complexity of reality within the given practical time and resource constraints. Cognitive limitations of actors cause them to make biased decisions (Croson and Donohue 2006). The low saliency and recency of feedback, which are typical for the Bullwhip Effect environment, amplify this problem.

Learning perspective

Assuming valid paradigms and the cognitive competences to fully understand the mechanisms of the Supply Network environment, actors still face the problem of inherent dynamics of their environment and the uncertainty towards this. They will always learn the reality of the decision situation afterwards. The reduced saliency and recency of the Bullwhip Effect environment again contributes to this problem.

Error corrections perspective

Information about system states, such as inventory positions and orders are incorrect due to human errors. Policies based on this faulty data creates deviations from optimal policies. Corrections towards these mistakes, when discovered, results in high and unpredictable order deviations (Geary, Disney et al. 2006).

Externalities perspective

A commercial seller-buyer relation has negative externalities. There is a structural conflict in prices and quantities (Simatupang and Sridharan 2002): Sales representatives want to sell as much as possible at the highest prices, while purchasers want to buy their needed quantity at the lowest prices. According to Classical and Neo-Classical Economics this leads to a stable optimum in prices and quantities, resulting in the highest welfare (reference). However, an operational supplier-receiver relation has positive externalities: There are structural incentives for alignment and integration. When operations managers are able to synchronize their operations both will benefit from reduced costs and their Supply Chain becomes more competitive. In order to achieve this synchronization, information transparency is necessary, although the same information transparency weakens the strategic bargaining position from a commercial seller-buyer relation. This dilemma creates a barrier to share information and cooperate (Fransoo J. C. and Wouters 2000; Cachon and Lariviere 2001; Holweg, Disney et al. 2005).

Game Theory perspective

Companies having a supplier-receiver relation are stuck in a game of chicken. When both parties invest in synchronizing their operations toward each other thy will both benefit from the reduction in costs. However if only one party invests in operational synchronization, the benefits for cooperative party are less and the benefits for the party that abstains from investing are more. This causes both parties to wait for the other to initiate action. In Annex VI, this symmetrical game of chicken is visualized using ordinal pay-off values. When the situation changes by creating information transparency this game of chicken changes to a prisoners dilemma, which is also illustrated in Annex VI. Besides abstaining from and engaging cooperation, every party has the additional choice to defect by taking advantage of the information transparency in commercial negotiations. Doing so will create large benefits for the defector when the other cooperates or abstains, however when both parties defect, the outcome will be less beneficial for both parties than the base situation of both parties abstaining. Gupta, Steckel et al. (2002) have experimentally proved that information transparency leads to strategic behaviour of actors and inferior Supply Chain outcomes due to the interaction of individual behaviour. Because the rational outcome of a game containing information transparency is inferior to the outcome under information asymmetry, actors are unwilling to share information, unless there is enough commitment and trust to promise cooperative behaviour.

Transaction costs perspective

Due to their short term conflicting interests companies have low levels of trust. This causes the perception of high transaction costs in bargaining and maintaining arrangements which enable cooperation and synchronizations and prevent opportunistic behaviour. These high perceived costs outweigh the potential benefits and therefore collaboration does not occur, unless levels of trust increase among companies.

Agency problem perspective

Downstream customers are able to adapt their ordering behaviour and benefit upstream suppliers. These suppliers can be regarded as principals which are prepared to pay for the cooperation and information of direct and indirect customers in the role of agents. Because on a short term it is still not in the interest of agents to cooperate and they will not suffer from uncooperative behaviour there is a risk of moral hazard. The inability of principals to control this problem, prevents cooperation.

Strategic SC positions perspective

Downstream players are often Distributing actors which are primarily concerned with their customer service to maintain a competitive advantage. Upstream players are often Manufacturing actors that are primarily concerned with production efficiencies to maintain price competitive. Downstream Distributors are able to share information and adjust their ordering and inventory management behaviour and benefit the upstream manufacturers, however this will result in higher costs for them. There is a lack in incentives to do this unless they will be compensated

Shortage gaming perspective

As a result of perceived unreliability of supply, customers structurally overstate their needs to assure availability (Cachon and Lariviere 1999). Rationing policies of suppliers in case of shortages further incentivize customers to overstate their needs. This leads to fluctuations in demand and frequent stock outs in Supply Chains which confirm the perception of unreliable supply. In order to reduce the risks of unreliable supply, Supply Chain parties use multi-sourcing strategies for the same product, further overstating their needs through multiple channels. When these multi-sourced products are brand specific, the sum of the overstated demands converged back at the specific manufacturer, who experiences high fluctuations. Multi-sourcing of homogeneous products might reduce the fluctuations due to the effect of risk pooling over multiple chains (Sucky 2009) when markets are not monopolistic. Shortage gaming also happens within companies between decoupled logistical nodes with autonomous responsibilities. Also sales departments are known to artificially inflate orders to assure product availability (Sodhi and Tang 2011).

Price fluctuations perspective

Order quantities and prices of raw material, intermediate and end products fluctuate and mutually influence each other through the principles of Classical and Neo-classical Economics. There are three mechanisms that amplify both the fluctuations in orders and prices. First, suppliers of raw materials can artificially create temporary shortages to raise market prices. These trends are reinforced by market speculations on commodity prices. Secondly intermediate parties in the Supply Network apply strategies of forward buying when market prices are low. Thirdly, end consumers anticipate on price promotions and will only buy products on sale. Cosmetic products of Unilever and Proctor & Gamble are school examples of this consumer behaviour (reference). In order to maintain market shares in competitive markets, retailers and manufacturers are trapped in the situation where continuing price promotions are necessary (Simchi-Levi, Kaminsky et al. 2003).

Organization coordination perspective

In order to coordinate the divisions and individuals of organizations, objectives and performance metrics are defined. The inability of managers to anticipate the outcomes of the behaviour incentivized by these policies is the cause of faulty objectives and performance metrics which create undesirable, counterproductive global outcomes. Wrong coordination is a direct cause of the Bullwhip Effect. For example sales divisions are incentivized to push inventories downstream (Simatupang and Sridharan 2002), overstate their customers' needs to assure availability and artificially boost sales at the end of the financial year to improve performance metrics and bonuses, also known as the 'Hockey Stick Effect' (Geary, Disney et al. 2006). Wrong coordination also creates a lack of incentives to engage inter-organizational cooperation and exploit the possibilities (Holweg, Disney et al. 2005; Fu and Zhu 2010)

Relationships perspective

The conflicting commercial interests and the possibilities of opportunistic behaviour, which are inherent with the nature of markets (Simatupang and Sridharan 2002) are the source of a lack of trust among Supply Chain parties. This lack of trust can result in bad interpersonal relations and attitudes, which are the source of irrational counterproductive behaviour and barriers for cooperation.

Network complexity perspective

Actors in Supply Network often have large numbers of direct and indirect suppliers and customers, resulting in each actor being part of a huge number of specific Supply Chains. The importance of each individual Supply Chain is relatively small. This business environment is too complex to collaborate share information with all distribution channels (Stank, Keller et al. 2001; Holweg, Disney et al. 2005). In the first place companies simply do not have the resources and time to do this. Secondly the potential benefits only outweigh the implementation cost when volumes are large and the uncertainty of the commercial relation on the long term is not too high (Fransoo J. C. and Wouters 2000). Thirdly the networked structure of markets makes it difficult to delineate the boundaries in which centralized planning should be implemented.

Change resistance perspective
Because of the risk averse nature of economic actors (Ostrom 2010) changed in systems and policies are regarded as a threat. The lack of knowledge and wrong paradigms makes people unconfident that they will be able to deal with the new situations and secure their personal interests. Resistance against change (Bowersox 1990) and managerial inertia (Simatupang and Sridharan 2002) are proven to be significant blockades for Supply Chain Collaboration.

4.4. Problem perspectives in the case study

Most of the problem perspectives are applicable to the relation of the Technische Unie and Legrand Nederland, however two major factors which indirectly cause the Bullwhip Effect are not present: Lack of trust and obsolete paradigms. The Technische Unie and Legrand have a stable, long term relationship with high levels of trust and risks for opportunistic behaviour which may harm this relationship are low. Also, both parties are aware of the importance of the Bullwhip Effect and have sufficient knowledge to understand its basic causes and solution areas.

Control theory perspective: Applicable
The principle of negative feedback with a time delay in ordering is present at the Technische Unie for products with smaller Mean Days Between Orders than lead times. The statistical analysis described in chapter 3.2 has demonstrated that such products have higher Bullwhip Effect values. These products are only A-D classified products. For E-F products this perspective is not applicable, because MDBO's are often more than twice as long as lead times and the ordering policies are steered directly by orders rather than forecasts.

The principle of positive feedback by forecasting is also applicable at the Technische Unie, especially the long term linear trend in the forecasts cause this effect. In September 2013 there was an upward change in the downward demand trend, which caused high levels of stock outs and high fluctuations in orders due to corrective action.

System uncertainty perspective: Applicable
The forecast models of the Technische Unie are, like most order models, not fully accurate. Especially incidental high demands can never be predicted in advance and create disturbances. The uncertainty of processes of the Technische Unie and Legrand are however low, so these disturbances are limited.

Information asymmetry perspective: Applicable
The Technische Unie does share its demand forecasts with suppliers, however the actual orders of the Technische Unie are difficult to predict by Legrand and any other supplier, because they have no knowledge of actual inventories and current states of processes within the Technische Unie that will lead to orders.

Self-organizing systems perspective: Applicable
The Technische Unie optimized its own local operational system by minimizing its costs by the application of Economic Order Quantities (EOQ) as much as possible. Through these EOQ values the Technische Unie defines its theoretical optimal Mean Days Between Orders based on average demand. The actual MDBO and order sizes are set preferably according to these theoretical values. This leads to high fluctuations in orders, resulting in higher costs for Legrand Nederland. This part of the problem perspective is the strongest cause of the Bullwhip Effect in this case study. This situation is however only the case for fast moving products. Slow movers, E-F products, don't have this batching problem, because they are ordered by the Technische Unie according to customer orders.

Also the local optimization of sales and purchase divisions is present, however limited. Minimum order quantities of Legrand are based on operational requirements rather than as sales instruments. The use of quantum discounts and price promotions is also limited. The Inventory Management division of Technische Unie does apply forward buying to benefit from price promotions and quantum discount wherever possible.

Physical lock-in perspective: Applicable
The operational system of the Technische Unie is capable of delivering every product in a single unit, however the production system of Legrand requires certain production series sizes and the finished products are packaged in batches of more than one unit. Although Legrand Nederland has already emphasized its organization on the reduction of series sizes and packaging sizes, further reducing these sizes will be a large change and costly investment.

Paradigms perspective: Limited applicable
Both the Technische Unie as Legrand Nederland are aware of the Bullwhip Effect and its effects. Their operations are however completely based on reaching local optima's by the principles of batching according to Economic Order Quantity

thinking, however they begin to change their paradigm, realizing that more frequent ordering can smoothen out operations, reducing inventories and capacity needs.

Limited Rationality perspective: Applicable
Both the Technische Unie as Legrand use heuristics for deciding its replenishment and production orders, rather than actual optimizations. The Supply Chain environment is too complex to define an ordering policy that finds actual optima's in service levels and costs. Instead they set the goals to maximize Inventory turnover rates within the requirements of minimal fill rates. And fine-tune the parameters of ordering policies to achieve these goals.

Learning perspective: Applicable
The market of the Van Geel product group has high levels of technological innovation, resulting in short life cycles. The introduction of new products and phase out of obsolete products is inherently uncertain. Therefore the Technische Unie and Legrand will have to estimate the demands of these products before they have the actual information to make a right assessment.

Error corrections perspective: Applicable
Both at Legrand as the Technische Unie human errors are made concerning the control and input of information for ordering and inventory management. Automation through IT systems reduce the chances on errors, however may amplify the effects of mistakes because of consistent application of wrong information.

Externalities perspective: Applicable
The situation of positive operational externalities and negative commercial externalities is present in the relation between Legrand Nederland and the Technische Unie, as it is in most Supply Chain relations. Both at Legrand and the Technische Unie the commercial interests have priority, causing the purchase and sales departments to be in the lead for defining arrangements. Financial information about costs and margins are not shared for strategic reasons. Operational information about quantities and expectations are only shared when they cannot be used for strategic marketing, such as defining market shares.

Game Theory perspective: Applicable
Both the game of chicken situation and the prisoners dilemma situation under information sharing is present in the relation between Legrand Nederland and the Technische Unie. As stated in the previous perspective, commercially valuable information is treated confidentially in order to prevent any opportunism. The high frequency of commercial interaction among the Technische Unie and Legrand does however offers the possibilities for a tit-for-tat strategy which is described by Ostrom (2010) as a solution for repeated prisoners dilemma games. This strategy implies that both parties behave cooperatively unless another one defects.

Transaction costs perspective: Limited applicable
As stated in the case study analysis, the transaction costs between the Technische Unie and Legrand are perceived as low, because the mutual dependence and frequent interactions prevent opportunism. This has resulted in high levels of trust.

Agency problem perspective: Applicable
Essentially the agency problem is present between Legrand as principal and the Technische Unie as agent, however the frequent interactions between Legrand and the Technische Unie and low levels of information asymmetry reduce the risks for moral hazard. Also the Technische Unie acknowledges their own long term benefits of reducing the Bullwhip Effect and stabilizing Supply Chain flows.

Strategic SC positions perspective: Applicable
The Technische Unie is a Distributing actor with a focus on customer service. Because they do not have production functions, they optimize the costs of transportation and inventory only, resulting in amplification of order variances, mainly because of order batching through the application of Economic Order Quantity thinking. Legrand is a Manufacturing actor for the Van Geel product group. They experience the negative effects of the demand variance amplification and the increased demand uncertainty in their production planning. The Technische Unie has no short term incentives to reduce the Bullwhip Effect, however as stated before, they do recognise the long term potential benefits when Legrand is willing to financially compensate for a different ordering policy which reduces the Bullwhip Effect.

Shortage gaming perspective: Limited applicable
The Inventory Management Department of the Technische Unie does not overstate its needs through ordering. In case of stock outs, Legrand uses a rationing strategy that reduces the incentives for shortage gaming. They contact wholesalers which often place large orders to inquire how much of the order quantity they strictly need and which quantities can be delivered later without causing stock outs for them. Then they try to deliver as much as possible to smaller end user customers. Multi-sourcing is also impossible since the Technische Unie can only order the Van Geel brand at Legrand Nederland. Multi-sourcing by customers of the Technische Unie through multiple wholesalers also does not happen, because the Technische Unie is perceived as a reliable wholesaler. Shortage gaming is therefore not an issue.

The problem of overstating needs by sales departments within the Technische Unie is a known issue. In the past Sales representatives have placed orders in the ordering system which were later removed to assure product availability. This led to amplification of order variances. This problem has however been addressed and a solution is being implemented.

Price fluctuations perspective: Limited applicable
The Technische Unie applies forward buying strategies, but only in case of short term price promotions of suppliers. Long term fluctuations in product prices don't outweigh the extra costs of higher inventories. Large customers of the Technische Unie which place regular orders can anticipate on price promotions of the Technische Unie and apply foreward buying strategies, however most customers order according to the direct need of their projects and don't hold inventories.

Organization coordination perspective: Applicable
Both the coordination of sales departments of the Technische Unie and Legrand Nederland incentivizes its employers to push inventories downstream and create the 'Hockey Stick Effect'. Also the sales departments of Legrand and purchase departments of the Technische Unie have leading authority in defining arrangement without their responsibilities providing incentives to make agreements which improve the operational effectiveness and efficiency.

Relationships perspective: Limited applicable
Essentially the relation between Legrand and the Technische Unie is competitive as any other seller-buyer relationship. However as stated before levels of trust are high due to the long relationship history and disincentives for opportunistic behaviour.

Network complexity perspective: Applicable
The Technische Unie has about 9000 suppliers of which Legrand Nederland belong to the bigger strategic partners. Implementing elaborate systems for integration of operations and information is therefore unfeasible and too expensive, even for bigger suppliers as Legrand. Even though the relation between Legrand anf the Technische Unie is stable and certain on the long term, investments in integrating operational information and planning systems are not realistic.

Change resistance perspective: Limited applicable
Both the Supply Chain managers at Legrand Nederland and the Technische Unie have adopted the new paradigms in which solving the Bullwhip Effect is perceived as a goal to improve the performance of Supply Chains, resulting in improvement of their own effectiveness.

4.5. Concluding remarks

In this chapter we have defined the relevant factor for the Bullwhip Effect by defining a multi-layered generic model from both a systematic and behavioural perspective. The systemic perspective is based on hard systems models and the Supply Chain Operational Reference Model. The behavioural perspective is based on institutional and organization models For both these perspectives we have defined the relevant factors on Supply Network and organizational level. For the systemic perspective we have distinguished execution systems, sites like warehouses, distribution centres and production locations and less important within this research, from operational planning systems which perform important planning functions such as ordering, forecasting, inventory management and commercial communications with customers and suppliers. From a behavioural perspective we have defined organizations as hierarchies in which positions, responsibilities, authorities and procedures are assigned to divisions which are modelled as single actors. Each individual actor is modelled as a group of people with similar interests that is bounded rational and has limited information, which defines its decisions on the perceived outcomes of their perceived available options and learns by evaluating the outcomes of previous decisions. We have applied this model to the case study of the Technische Unie and it will be used for the definition of the simulation model in Chapter 7.

Based on the systems model we have identified a large number of problem perspectives for the existence and persistence of the Bullwhip Effect, which are categorized as either systematic problems, learning problems, incentive problems or relational problems. Most of the problems perspectives that have been addressed by scholars thus far are often systematical problems and related to the existence of the Bullwhip Effect. We have found a number of additional barriers for companies to implement solutions which require integration of coordination and transparency of information which are causes for the persistence of the Bullwhip Effect. These causes can be summarized in four categories: 1) Integrative solutions are unfeasible within complex Supply Networks, because of coordination problems within these networks and unacceptable investment risks, 2) The local, self-optimizing nature of organizations prevents them from adopting system wide optimal behaviour, because it will not directly benefit them, 3) Competitive commercial relationships oppose a barrier to the willingness of companies to share strategic sensitive information and cooperate and 4) The internal coordination of divisions does not incentivize and authorize improvements outside their own domains of responsibilities. Although the relationship between Legrand Nederland and the Technische Unie is good and trustful, these additional causes all apply to the case study as well. These problem perspectives have been used to define and evaluate the design of the Forecast Accuracy Discount Agreements in Chapter 6 and 9.

5. Exploration of the solution space

Since the causes for the existence and persistence of the Bullwhip Effect are categorized in four categories, solutions for the problem are also structured in four according categories: system adaptation for systematical problems, education for knowledge problems, incentivizing for incentive problems and relationship building for relational problems. These solutions can directly solve the Bullwhip Effect by changing behaviour or indirectly mitigate barriers which prevent actors to solve the problem. Figure 26 illustrates the causal relations among the solution areas.

The Bullwhip Effect is the outcome of the behavioural interactions of actors in the Supply Network system. Adapting this system will change behaviour and influences the Bullwhip Effect. Incentivizing is a more indirect approach which can both directly influence the behaviour of actors as drive them to change the structure of the system according to their interests. Solution in the category of education have a similar effect. Gaining knowledge directly changes the paradigms of actors, their perceptions of reality and outcomes of decisions, resulting in different behaviour. It also causes actors to change the structure of their systems according to new insights. Relationship building leads to trust and commitment of actors to change both systems and incentive structures and it creates additional insight in their environment. This indirectly enables the changes in behaviour that potentially reduce the Bullwhip Effect.

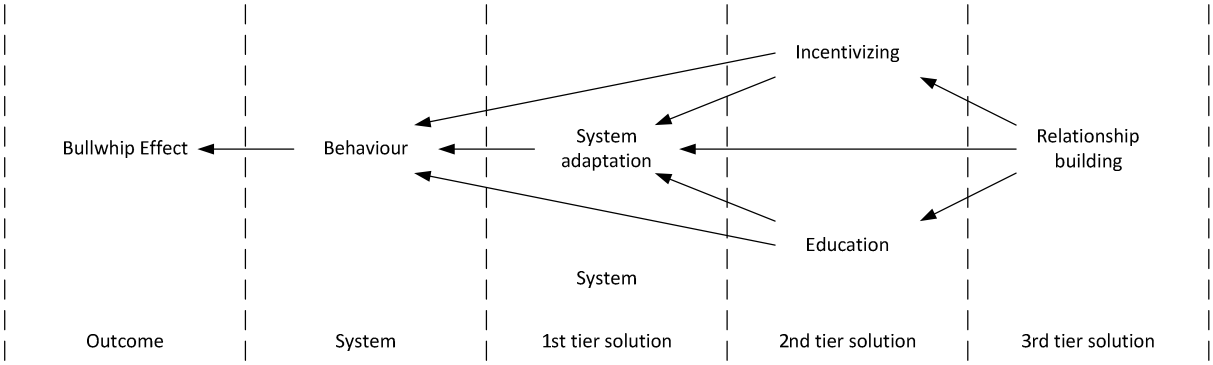


Figure 26: Causal relations among solution categories for the Bullwhip Effect towards the operational Supply Chain system and its outcomes

This research exclusively focuses on institutional arrangements that incentivize actors to change their behaviour and reduce the Bullwhip Effect. In Figure 26 this only includes the solutions which are categorized as incentivizing and are feasible within institutional agreements. Also, this research focus implies only the causal relation between the concepts of incentivizing and behaviour. The indirect effects on system adaption are not considered. Relationship building can be a prerequisite to gain enough trust and commitment to adopt the proposed arrangements. Figure 26 also illustrates this.

In this chapter the solution space within the specific research focus is defined. First this is done by summarizing the found solutions in literature, assess how they influence the problem perspectives and whether they can be included in institutional agreements. This analysis results in a structured collection of substantial options in the general solution space of the Bullwhip Effect. This collection is then structured into the solution space for the specific focus of this research. This is done by the analysis of design frameworks and principles for institutional design, self-organizing systems and contractual agreements.

5.1. Analysis of common solutions for the Bullwhip Effect

A full in depth analysis of the solution space for the Bullwhip Effect is made and elaborated in Annex VII. Here, the solutions found in literature are listed and categorized in the rows of the table. The columns contain the problem perspectives as described in chapter 4.2. The effects of the individual solutions on these perspectives are assessed by colours: a green colour implies the specific solution to solve the specific problem perspective, while red implies the problem perspective to be a barrier for implementing the solution. Blue implies an ambivalent effect of the solution: the solution can both solve or worsen the specific problem perspective. The table contains mainly solutions in the categories system adaptation and incentivizing, in the first case because these are most commonly studied and secondly because these are within the scope of the research. Solutions that can be included in institutional agreements are highlighted green.

System adaptation solutions

Companies are able to restructure their operational systems internally and contribute to solving the Bullwhip Effect without the need of cooperation among Supply Chain parties by changing their planning functions or improve the quality of their operations. On the other hand, cooperative initiatives to solve the Bullwhip Effect involve adaptation of the Supply Network structure, vertical integration of processes, information sharing, communication and agreements about operational procedures. Finally, Supply Chain and Operations Research literature is also rich in diverse predefined solutions for the Bullwhip Effect which often include such cooperation among Supply Chain parties.

Changing planning functions

Without the need for cooperation, companies can adapt their planning functions to counter the Bullwhip Effect. Forecasting methods can contribute to Bullwhip Effect reduction when they are more accurate (Metters 1997; Luong 2006), generate smoother forecasts (Chen, Ryan et al. 2000; Disney and Towill 2003) and when they are based on fuzzy logic instead of discrete logic (Carlsson and Fullér 2001). Redefining the role of inventory as a buffer between production and transport by increasing safety stocks and abandon order-up-to inventory management (Baganha and Cohen 1998) as well as ordering only a fraction of the difference between current and desired safety stock (Chen and Disney 2003; Dejonckheere, Disney et al. 2003; Disney and Towill 2003; Cannella and Ciancimino 2010) are proven methods to reduce the Bullwhip Effect without the need for cooperation. Production systems can contribute to Bullwhip Effect reduction when they are more pull oriented with Order Penetration Points that lie upstream factories, reducing the need for forecasting (Disney and Towill 2003). Fixed quantity production planning dampens oscillations and reduces manufacturing costs (Disney and Towill 2003). Finally consolidating transport allows smaller batch sizes while maintaining a high modality utilization (Lee and Whang 2006). Third party Logistics Providers are capable to consolidate on large scales and allow flexible transport at competitive costs (Lee, Padmanabhan et al. 1997; Fransoo J. C. and Wouters 2000). Although changing planning functions indirectly benefits organizations, the benefits are not always clear on a short time horizon. Reasoning from classical paradigms, most of these solutions are counter intuitive. Additionally, direct benefits often lie at upstream parties and local division oriented performance metrics do not incentivize managers to pursue these changes.

Quality improvement

Improving the performance of processes in its current planning methods is a more understandable approach which does not only solves the Bullwhip Effect, but directly improves overall operational performance. Increasing the speed of processes reduces lead times, which is known to be the most effective solution for the Bullwhip Effect (Van Ackere, Larsen et al. 1993; Lee, Padmanabhan et al. 1997; Fransoo J. C. and Wouters 2000; Croson and Donohue 2006; Sodhi and Tang 2011). Increasing the accuracy of processes and information by means of IT systems, reduces demand distortion, speeds up the learning processes and reduces errors (Sodhi and Tang 2011). Allowing IT systems to use systematical algorithms for decision making reduces errors and counters human cognitive limitations (Disney, Naim et al. 2000; Sudhir and Chandrasekharan 2005; Strozzi, Bosch et al. 2007). Increasing operational flexibility, also referred to as agility (Lee 2004), contributes to Bullwhip Effect reduction. Modular and generic design of products reduces the number of specific components and the relative amount of slow moving items. This reduces lead times and the need for order batching (Lee 2004). Increasing the flexibility of production equipment allows shorter set up times and reduces necessary batch sizes (Burbidge 1981).

Change the Supply Network Structure and vertical integration

The first system adaption solution that requires inter-organizational collaboration is the adaptation of the structure of the Supply Network, although minor improvements can also be made by only redesigning the internal operations structure. Reducing the number of echelons, which autonomously decide upon ordering, positively affects the Bullwhip Effect, because it reduces the number of amplification steps (Lee, Padmanabhan et al. 1997; Geary, Disney et al. 2006; Sodhi and Tang 2011). Creating redundant Supply Chains for the same products makes supply less vulnerable to disturbances (Lee 2004). Similar effects can be achieved by centralizing the planning decisions upon ordering, forecasting, inventory management and transportation schedules, without the need of actual organizational integration (Lee and Billington 1992; Towill 1996; Lee, Padmanabhan et al. 1997; Lee, Padmanabhan et al. 1997; Fransoo J. C. and Wouters 2000). The major drawbacks of network changes is their magnitude on strategic level. Centralizing decision making is less radical, although strategic interests of individual companies create a barrier to cooperate unless there is actual organizational integration.

Information sharing and communication

Most scholars propose reducing the information asymmetry by sharing information and increase communication as a collaborative solution to the Bullwhip Effect. They propose relatively modest levels of information sharing, such as customers indicating their own expectations on orders (Lee, Padmanabhan et al. 1997), but also more elaborate integration of information availability towards Point of Sale data (Lee, Padmanabhan et al. 1997; Chen, Ryan et al. 2000; Fransoo J. C. and Wouters 2000; Croson and Donohue 2003; Croson and Donohue 2006), availability of resources (Simatupang and Sridharan 2002; Croson and Donohue 2006), performances and financial information (Simatupang and Sridharan 2002). Using tracking systems and IT integration this information can be made available in real time (Boyson, Harrington et al. 2004). Besides reducing information asymmetry, sharing information also enabled parties to gain quicker insight in market dynamics, however this requires them to be competent to interpreter information correctly. Information transparency might however also worsen strategic behaviour regarding shortage gaming and forward buying, which worsens the Bullwhip Effect, rather than solving it. As mentioned before, there are also many barriers which prevent parties to share information sharing. First, the strategic importance of information required a high level of trust between parties to engage in information sharing initiatives. Secondly, internal organizational structures do not incentivize sharing information or effectively using it. Finally the complexity of networks opposes a barrier since companies often have a vast number of suppliers and customers. These drawbacks are however not applicable to non-strategic information shared in lower frequencies, such as Indicating expectations on future orders towards suppliers, which is also suitable for institutional arrangements.

Operational agreements

Agreements upon operational procedures concerning the interfaces between suppliers and buyers are per definition within the scope of this research. Parties can reduce the batching problem by reducing minimum order quantities, order increments and batch sizes (Cachon 1999; Fransoo J. C. and Wouters 2000; Simatupang and Sridharan 2002; Sodhi and Tang 2011) and increase order frequencies (Fransoo J. C. and Wouters 2000), however the possibilities on agreeing upon such measures are limited by the physical properties of operational systems. Increasing order frequencies. Another approach is to agree on constraining the possibilities of customers by disabling customers to return purchased quantities in business-to-business relations (Caloiero, Strozzi et al. 2008), bounding the freedom of order quantities (Bassok and Anupindi 1995; Bassok and Anupindi 1997; Lee, Padmanabhan et al. 1997) and minimum purchase agreements (Bassok and Anupindi 1997). From a competitive perspective it is however not always desirable or possible to constrain customers, even though it would eventually benefit them. Here, the lack of internal incentives and understanding system wide interactions again create a barrier for adopting such agreements.

Predefined solutions

Many predefined methods have been proposed as a solution to the Bullwhip Effect. They mostly contain formats for internal operations, integration of operations among other companies and information sharing. Proposed methods are Collaborative Planning, Forecasting and Replenishment (Holmstrom, Framling et al. 2000), Continuous Replenishment (Simatupang and Sridharan 2002), Efficient Consumer Response (Cachon and Fisher 1997), Synchronized Supply Chains (Anderson and Lee 1999; Ciancimino, Cannella et al. 2012), Synchronized Consumer Response, Supply Chain Reengineering/Business Process Redesign (Berry, Naim et al. 1995), Rapid Replenishment and Quick Response Manufacturing (Lee, So et al. 2000). Vendor Managed Inventories is most commonly proposed as a solution for the Bullwhip Effect (Çetinkaya and Lee 2000) and is effective, because it reduces one echelon in the Supply Chain, information is shared and has less delays (Disney and Towill 2003). Because these method involve changes of internal operations, Supply Chain integration and information sharing, they have similar barriers. Capacity allocation schemes were proposed by Cachon and Lariviere (1999) to counter shortage gaming and Quantity Flexibility Contracts were proposed by Tsay and Lovejoy (1999) to constrain the ordering freedom of customers. These methods are capable to be implemented in arrangements.

Incentivizing solutions

Indirectly, organizational integration and agreements can incentivize operational behaviour and reduce the Bullwhip Effect. They alleviate the barriers to cooperation and information sharing as described as incentive problems in paragraph 4.2 and resolve the problems of local optimizing, supply shortage gaming and forwards buying.

Integrative solutions

The first form of integration is inter-organizational alignment of objectives. These objectives steer operational behaviour and alignment can synchronize operations and result in global Supply Chain improvements (Lee 2004). It is necessary to align global objectives with individual interest of actors to prevent potential conflicts (Simatupang and Sridharan 2002). This alignment also implies the definition of coherent global and local performance measures (Fawcett and Clinton 1996).

Secondly roles and responsibilities can be redefined. Extending responsibilities beyond the organization boundaries, creating a situation in which internal divisions have shared responsibilities and authorities on global Supply Chain performance, will incentivize constructive behaviour and synchronize Supply Chain operations (Simatupang and Sridharan 2002; Lee 2004). Besides sharing responsibilities and authorities to create cooperative behaviour, it is also possible to create situations of structural conflicting interests in which the outcomes of interactions and negotiations will result in productive outcomes (Simatupang and Sridharan 2002). Sharing investments and related costs is the third form of integration which incentivizes the synchronization of Supply Chain operations (Simatupang and Sridharan 2002). These integrative solutions can be the result of negotiations and agreements among equally powerful parties, however most successful Supply Chain integration cases are the result of unilateral action of the channel champion (Maloni and Benton 2000). The success of Vendor Managed Inventories in the Supply Chains of Wall-Mart (reference) is such an example, where the most powerful Supply Chain party dictates the standards for Supply Chain operations. Organizational integration is powerful, because it intervenes in the roots of behaviour of actors. However they require large structural changes which are not always feasible in the complex networked structure of today's markets.

Agreements

Unlike organizational integration, incentivizing by agreements don't require large structural changes and are therefore within the scope of this research. Supply Chain parties can agree upon sharing risks cost and rewards without the need of actual organizational integration. This can be done by sharing responsibilities on fill rates towards end consumers (Lee, Padmanabhan et al. 1997; Simatupang and Sridharan 2002) and agree upon sharing financial benefits and burdens (Lambert, Emmelhainz et al. 1999). Simatupang and Sridharan (2002) describe the latter as equitable sharing as a way of incentivizing Supply Chain alignment. A second approach to reduce the Bullwhip Effect by means of agreements are pricing and discounting policies towards customers. Price promotions are an important cause of forward buying. Therefore, abandoning price promotions by Every Day Low Pricing policies is proposed as a solution of this specific cause (Sogomonian and Tang 1993; Lee, Padmanabhan et al. 1997). Quantum discounting is another discounting policy that leads to batching of order quantities. Calculating quantum discount by total order values of all products over a long time horizon will cause less batching of orders than calculating these discounts by quantities of single products per orders (Lee, Padmanabhan et al. 1997). A third area in which agreements can reduce the Bullwhip Effect are cost agreements. Reducing or abandoning fixed order transaction costs and transportation costs towards customers will allow them to order in smaller cost optimal batches according to the logic of Economic Order Quantities (Lee, Padmanabhan et al. 1997). Also, suppliers can charge customers for unexpected deviations of order quantities towards their indicated forecasts (Eppen and Iyer 1997). To counter rationing gaming, parties can agree rationing in cases of shortages to be based on long term average sales rather than current order quantities (Lee, Padmanabhan et al. 1997).

Arrangements can also solve the Bullwhip Effect more indirectly by reducing uncertainties. Third party financial institutions can carry the financial risks of Supply Chain disturbances and resulting inabilities to comply with agreements (Lee 2004). This increases trust and reduces the risk avoiding behaviour that leads to the Bullwhip Effect. Agreements on conflict resolution have been proposed by Ostrom (2010) in an institutional context, Prehofer and Bettstetter (2005) in a self-organization context and Simatupang and Sridharan (2002) in a Supply Chain context as important elements of agreements to reduce uncertainties and increase trust. Agreements upon committing to detaching operational and commercial arrangements will solve the structural dilemma between the operational alignment and commercial conflict of interests (Lee, Padmanabhan et al. 1997).

Agreements are more flexible and feasible in complex network structures, however because they don't intervene at the organizational structures regarding objectives, responsibilities and authorities, they cannot solve the structural misalignment of interests which are at the core of the behaviour of actors. Therefore, the implementation of such agreements needs the commitment of both parties to suit they internal organizational structures towards these arrangement to assure their effectiveness.

Education oriented solutions

Old paradigms, based on local optima's have been identified as an indirect cause of the Bullwhip Effect. They can be solved by specific education of individuals towards the dynamic behaviour of operational Supply Chain systems (Sterman 1989). However, bounded rational actors which reason from more valid paradigms are still prone to biased behaviour due to their cognitive limitations. Therefore, initiatives in which actors quantitatively analyse the causal relations in their specific Supply Chain situations can result in more proper heuristics for operational planning (Croson and Donohue 2006). There are little barriers for education oriented solutions for the Bullwhip Effect. Therefore this solution area is promising for further study. It lies however outside the scope of this research.

Relationship building oriented solutions

Sufficient levels of trust and commitment are prerequisites for most cooperative solutions, including agreements. Relationship building can come in many forms, extending from simple recurrent meeting between suppliers and buyers (Ostrom 2010), to large decision making processes which facilitate structural changes in complex actor networks (De Bruijn and Ten Heuvelhof 2008; De Bruijn, Ten Heuvelhof et al. 2010). Such initiatives create the necessary levels of trust for inter-organizational cooperation and internal commitment to change the current structures. However, the complexity of Supply Networks with their vast amount of actors, opposes an exceptional challenge for any form of centralized process management.

5.2. Definition of solution space for decentralized agreements

Specific frameworks for the design of institutional agreements for governance of operational processes between commercial organizations have not been found. Also, in the specific case study of the Technische Unie, procedures or formats for defining arrangements between suppliers and the Technische Unie were absent. Arrangements with suppliers are collections of informal individual agreements which have emerged by ad hoc reactions on imminent contingencies. This leads to the presumption that institutional arrangements for the governance of operations in a supplier-buyer relationship are not the result of conscious design and therefore design frameworks for these arrangements have not been defined by best practises or researched by scholars.

Scientific literature, however, does provide frameworks and principles for the general design of institutional arrangement, self-organizing systems, contracts and Supply Chain interfaces. These principles and frameworks have been analysed in Annex VIII. Here each design framework/principle is decomposed into a number of concepts. Each concept is analysed by defining how each concept could provide an element in the solution space for institutional arrangements to solve the Bullwhip Effect and how each concept could provide additional design requirements. Concept can also be fixed attributes in the specific context of this research and don't provide any input for the definition of the solution space or design principles for arrangements to solve the Bullwhip Effect. This is stated in the last columns of the analysis.

Solution space definition

The solution space of institutional arrangements to solve the Bullwhip Effect is defined in Figure 27. The solution space consists of a number of mutually exclusive dimensions with a number of relevant options. These dimensions are structured by grouping them. Any solution design may contain a single option per dimension, however not all dimensions need to be present in a single design.

The first type of solution space dimensions concerns information sharing. The information type, aggregation and frequency are design variables for information sharing. Also the designs can contain agreements on frequent meetings between employees from the two involved organizations in order to gain insight in the effect of each other's operations and to increase trust. Commitment on adopting global productive systemic behaviour and objectives is the third area in the solution space, however these agreements require a high initial level of trust between the two parties to implement. This is also the case for agreements on redefining the authorities and responsibilities for ordering decisions and availability of products, which is common in Vendor Managed Inventory programs.

Financial agreements are the fifth solution space area, which has a large potency to directly incentivize behaviour. Effective agreements which directly cause Bullwhip Effect reducing behaviour are: Adopting stable prices, abstaining from price promotions, adopting long term total volume discounts, discounting on accurate forecasting and reimbursing the costs of order fluctuations. Insurances against the costs of lost sales and backlogging indirectly cause less risk averse behaviour which causes the Bullwhip Effect.

Constraining agreements limit the available actions of actors and are effective, because they eliminate decision making options that cause the Bullwhip Effect. The agreements in this solution space all refer to ordering behaviour. First the allowed order quantities can be constrained by a number of rules as visible in Figure 27. Also disabling the ability to return products in business-to-business relations reduces the Bullwhip Effect. Relieving constraints by reducing order increments and order intervals are also effective means in this category.

Agreements on appropriate action in case of contingencies are key to ensure the reduction of risk averse behaviour which causes the Bullwhip Effect, create enough trust to engage the arrangement and ensure the continuation of the agreements in case of unforeseen events. First rationing policies specifically reduce the ration gaming problem. Sanctioning rules are

essential enforce the arrangements itself, while conflict resolution rules give room to negotiate and settle unforeseen situations in which the sanctioning rules are not considered reasonable by both parties.

Finally, agreements on the conditions of the arrangement itself are a prerequisite in any arrangement. Both parties need to agree upon the scope and duration of the arrangement, as well as the conditions in which the agreement will be terminated or actors have the authorities to redefine certain conditions.

Group	Solution space dimension	Relevant options
Information sharing	Information type	Forecasts on expected orders
	Aggregation on product detail	Per product/per product group
	Aggregation on time intervals	Times per day/week/month
	Sharing frequency	Times per day/week/month
Personal meetings	Involved actors	Divisions or persons in purchase/sales/operations
	Agenda topics	List with subjects to be discussed
	Communication frequency	Times per day/week/month
Commitment	Commitment on systemic behaviour	Detaching commercial and operational processes
	Commitment on objectives	Detaching commercial and operational goals
Authorities and responsibilities	Ordering and availability	Seller/buyer authorized to define orders and responsible for buyers availability
Finances	Price arrangements	Long term fixed/dynamic prices
	Price promotions	Use/abstain
	Volume discounting policies	Based on single/grouped products over orders/total volumes
	Forecast accuracy discounting policies	Based on single/grouped products over dayly/weekly/monthly time intervals
	Reimbursing fluctuation costs	Additional ordering costs for fluctuating orders outside set bounds
	Third party insurances	Third party reimburses costs of lost sales and backlogging
Constraints	Minimum order quantities	Use/abstain
	Maximum order quantities	Use/abstain
	Minimum purchase agreements	Minimum quantity per week/month
	Maximum purchase agreements	Maximum quantity per week/month
	Orders bounded by forecasts	Absolute/percentage bounds of allowable orders towards forecasts
	Orders bounded by history	Absolute/percentage bounds of allowable orders towards historical order average
	Returning	Use/abstain
	Order increments	Units
	Order intervals	Times per week/month
	Returning	Use/abstain
Contingencies	Rationing policies	Rationing based on relative order size / long term total purchase quantities
	Sanctioning rules	Costs per specific breach of agreement
	Conflict resolution rules	Procedures for communication and negotiation before sanctioning
Arrangement conditions	Scope of agreement	Applicable products, divisions and geographical areas
	Duration of agreement	Set duration/until cancellation with notice
	Termination conditions	Conditions which allow termination of the agreement
	Adaptation conditions	Conditions which allow adaptation of specific conditions of the agreement

Figure 27: Solution space for institutional arrangements to solve the Bullwhip Effect

Design framework

Since specific design frameworks and principles for institutional arrangement concerning the governance of operations between suppliers and buyers are not found, other frameworks and principles, analysed in Annex VIII, provide guidelines for design.

First, frameworks and principles for institutional design provide a number of requirements: Ostrom (2010) presents the research outcomes of Poteete, Janssen et al. (2010) towards the attributes of micro situational situations in economic dilemmas that affect the level of cooperation among actors. From an institutional perspective Ostrom (2010) also defines 11 principles for successful institutional design. Finally, Ostrom (2010) describes the internal structure of action situations of actors and how rules influence the behaviour of actors. Secondly, the logic of consequence and the logic of appropriateness (reference) are two perspectives on how institutions influence behaviour, which can be a guidance on the design of arrangements.

Prehofer and Bettstetter (2005) define a design process for self-organizing systems, which contains the definition of local behavioural rules and implicit coordination to create design which lack any centralized control and therefore are in reduced state. Then rules for environmental changes are added to make the design flexible and adaptable.

Simatupang and Sridharan (2002) propose three levels of creating incentives in Supply Chains by inter-organizational arrangement: Rewarding behaviour which is considered globally productive, pay for achieved performance and sharing costs and benefits.

In this research no general framework for the design of institutional arrangements was defined, in the first case because of the lack of literature and best practises and in the second case because it was not considered necessary. Instead, a design philosophy was defined by analysis and insight on the systems model and problem perspective as presented in Chapter 4.

5.3. Concluding remarks

Our exploration of the solution space for the Bullwhip Effect has revealed that most of the conceptual solution elements that have been proposed by scholars thus far are mostly within the systemic and incentivizing solution categories. Both conceptual solution elements as predefined solution can either be described as integrative or local, where only the local conceptual solution elements are suitable to be included within agreements. We have selected these elements and defined the alternatives for each of these solution space dimension. Because a framework for the design of agreements has not been found, we have based the design approach on a general philosophy which is described in the next chapter.

6. Design definition

This research has resulted in the design of Forecast Accuracy Discount Agreement, also referred to as FAD agreements as a promising solution for the Bullwhip Effect within the scope of decentralized agreements that solve the Bullwhip Effect by incentivizing productive behaviour. The next paragraph describes the philosophy that has led to this design. Then the design and its expected effect are elaborated in paragraph 0. Finally we will assess qualitatively how the design addresses the defined problem perspectives.

6.1. Design philosophy

As described in the literature research in paragraph 3.1 most scholars propose solutions to the Bullwhip Effect that involve integration of coordination by information transparency and centralization of decision making. As described in paragraph 3.1 and 4.2, there are many barriers to implement such integrative solutions in Supply Networks and ensure their success. There are barriers to share strategic information, negotiate redistribution of benefits, change organizational structures, manage the central coordination and control investment risks within the complexity of Supply Networks.

Decentralized control doesn't have the need for integral analysis based on full information transparency and integral central control, which needs to be decomposed towards instructions for the individual Supply Network nodes and therefore bypasses these barriers. Prehofer and Bettstetter (2005) make the important notion that in self-organizing systems there is no need for full competence and information availability of the indivual network nodes as long as their behaviour leads to an approximation of optimal network situations.

The principle of fractioned ordering includes companies ordering only order a fraction of the required quantities to bring their inventories back to their desired order-up-to level, while taking expected demand during the lead time period into account. From a control theory perspective, this method dampens the negative feedback and prevents overshoots in corrective action, causing the system to stabilize. Fractioning ordering can function as local behavioural rules, resulting in improvement of system performance by self-organization

Therefore the design process focused on incentivizing the application of fractioned ordering. Since Simatupang and Sridharan (2002) propose rewarding productive behaviour as one of the three methods to incentivize Supply Chain behaviour, we focused on financial incentives by discounting agreements. Arrangements in which suppliers directly base their discounts on the actual application of fractioned ordering would require transparency of information and decision making processes for assessment of the discounts and are therefore not feasible within the research scope. Therefore another approach was necessary, which reduces the Bullwhip Effect in the same manner as fractioned ordering.

Fractioned ordering essentially dampens fluctuations in orders, because it dampens the response towards forecast inaccuracies too. An arrangement, which incentivizes customers to order only a fraction of the error quantity between current and forecasted demand, would effectively have the same results. This can be done by basing discount percentages on the deviance between forecasted orders and actual orders. Such arrangements would only require the customer to communicate its expected order quantities to the supplier in advance in order to define the discounts.

Such Forecast Accuracy Discount arrangements directly incentivize strategic cost optimizing behaviour in placing orders and strategic risk averse behaviour towards indicating expected future orders, which both contribute to the reduction of oscillations in order quantities. Indirectly, the arrangements incentivize the customers to change their operational processes regarding ordering policies and inventory management. They will more likely adopt methods that will smoothen their orders, while unexpected demand deviations are buffered by dynamic inventory quantities.

These arrangements can be explained as mechanisms in which suppliers are willing to pay for the Bullwhip Effect reducing behaviour of customers. As long as the cost reductions for the supplier outweigh the extra costs for customers, a discount configuration can be found that redistribute cost and incomes so that both the supplier as the customer experience a reduction of costs, while maintaining or improving their service levels.

6.2. Design description

The Forecast Accuracy Discount agreements contain the solution space elements for institutional arrangements as displayed in Figure 27 in the previous chapter. In Annex IX the specific choices for each solution space dimension are elaborated. Here we will explain the FAD agreements, which essentially has four elements: The actual Forecast Accuracy Discount mechanism, prerequisite conditions, additional agreements on communication and conditions of the arrangement itself.

Forecast Accuracy Discounting mechanism

During the agreement the customer provides the supplier with forecasts of expected order quantities. The customer defines the time interval over which he shares the expected order totals. This can be a period of a week, two weeks or a month, however we will observe later that shorter time intervals, resulting in more frequent forecasts are more appealing to the customer, because it increases the probability on accurate forecasting and high discounts. Then both parties have to agree on the deadline for which a forecast needs to be definite. For example, when a weekly time interval is used for order forecasts, parties can agree upon a four week deadline, so the customer has to deliver weekly forecasts four weeks ahead. For the mechanism to be effective, this deadline should be at least two times the forecast interval. Longer deadlines are useful for the supplier until they exceed the total throughput time to order materials, manufacture and distribute them. Therefore this throughput time is probably the most acceptable value for this deadline.

The customer remains free to order any quantities, however the discount percentage the customer receives over the total ordered quantities in a forecast interval, depends on the deviation between the forecasted quantity and actual ordered quantities in that period. Both parties have to agree on a maximum discount that will be granted when the customer orders exactly the forecasted amounts. They also have to agree upon a deviation bound. When order quantities have larger deviations from the forecasts than these bounds, no discounts will be given anymore. Deviations within these bounds will result in a discount that is a fraction of the maximum discount, equal to the fraction of the deviation towards the set bounds. Figure 28 visualizes this discount structure.

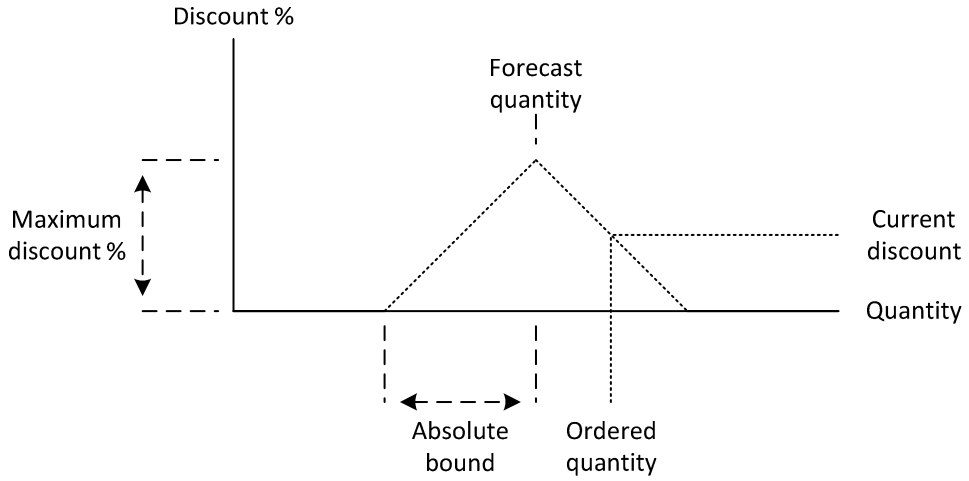


Figure 28: Visualization of the mechanism of Forecast Accuracy Discounting agreements

The absolute bounds and maximum discounts both have to be negotiated. A logical approach to determine the absolute bound is to assess the standard deviation of order total quantities for individual products over the set forecast intervals over a defined previous period. The absolute bound can then be set as a percentage of this standard deviation. As time progresses these absolute bounds can be changed according to changes in the demand pattern of the customer and the customers market. For practical reasons it is however advisable to revise these bounds recurrently after an agreed time interval, for example annually. It is also advisable to set these bounds according to the actual operational benefits of the supplier. This is also advisable for the maximum discount. This value has to be set high enough to create a sufficient incentive for the customer to dampen order fluctuations, however the discounts should result in both a cost reduction for the supplier as the customer. An excessive discount percentage would only benefit the customer and would be unacceptable for the supplier. The theoretical optimal percentage and maximum bounds greatly depends on the properties of the specific situation at hand. Therefore we advise a dynamic situation in which these parameters are periodically renegotiated, based on previous outcomes.

The FAD mechanism is expected to result in the following direct dynamic behaviour: The customer will initially share his actual expected orders according to his forecasts, inventory positions and ordering policies. According to the ordering policy, deviations of actual demand towards the forecast would later result in different order quantities, however deviating from the shared forecast would result in a lower or no discounts. Therefore the customer will try to find a cost optimal order size that lies between its shared forecast and the quantities according to its ordering policy. The created shortages or surpluses towards the desired orders according to the ordering policy of the customer are then spread over orders in later forecast periods, according to the allowable risks of stock outs. The customer keeps the freedom to respond to large demand disturbances, such as an unexpected large order of a large customer, however he will only lose his discount. Because of the financial incentives he will only do this when it is really necessary.

More indirectly the FAD mechanism is expected to have the following dynamic behaviour: The customer will start sharing forecasts that are not exactly the expected orders, but forecast that will assure a maximum expected discount in the probable future deviations. Such forecasts are expected to be more smooth than initially. Because the quantity bounds for discounts are absolute, the customer will also be incentivized to increase the order frequency and spread out order quantities over each forecast interval. This will result in a higher probability to receive higher discounts. Furthermore he will also be incentivized to shorten the forecast intervals to exploit this principle even further.

As time progresses orders are expected to smoothen out. This will result in lower operational cost for the supplier and lower material costs for the customer. It is expected that the discount percentage will converge close to a theoretically optimal value, however this value is dynamic due to market dynamics. Since the standard deviation of orders reduces, the absolute bounds in the FAD agreement are expected to lower as well. This reinforces the incentive for the customer to give accurate forecast and actually order according to them.

Prerequisite conditions

In order for the Forecast Accuracy Discount agreements to be effective a number of conditions in the agreement must assure the correct functioning of its mechanisms. First of all, the increment sizes should be small enough, otherwise they will constrain the customer to order smooth. When the increments are a significant percentage of the average demand per forecast period, it is advisable to assess to which extent they can be reduced according to the physical constraints that the operational systems of the supplier create and to which extents these constraints can be alleviated. The increment size is eventually set by the supplier, which is preferably as small as possible. This is expected to be beneficial for both parties. Secondly, both parties should agree to deliver on due dates rather than treating them as deadlines allowing early deliveries. Uncertainty towards deliveries of suppliers are known to disturb warehousing operations and make them difficult to plan. Finally, in order to make the agreements more effective, agreements upon shortening lead times are optional.

Also, a number of conditions are necessary to disincentivize strategic behaviour which can diminish the effectiveness of the agreements. Quantum discounts on order sizes need to be abandoned to avoid a dilemma in which the FAD agreement incentivizes a customer to smoothen orders while quantum discounts incentivizes him to batch orders. Optionally, the parties can adopt or maintain a quantum discount based on the total turnover quantities per product, which is preferably defined over long time intervals such as years. Another important condition concerns rationing policies in stock-out situations. Suppliers must commit to give equal rationing priorities to orders on the same due date, regardless of the ordering dates. The FAD agreements incentivize customers to place its orders as late as possible. Rationing priorities which prioritize early order dates will incentivize early ordering and another dilemma for the customer which undermines the mechanisms of the FAD agreements.

Agreements on communication

In addition to the forecast sharing, predefined meetings on a monthly or yearly basis can give parties more insight in the operational interactions, increasing the learning process and sped in which parties achieve significant cost reductions. It also increases levels of trust and commitment. Such meetings are optional and only recommended for the most strategic partners, however meetings on renegotiation the conditions and parameters of the agreement are necessary. These parameters are the forecast intervals, forecast deadlines, maximum discounts and absolute bounds for discounts. It is recommended that the forecast intervals and deadlines are changed as little as possible, while the maximum discounts and absolute bounds are revised as the operational behaviour and environment changes.

Conditions of the arrangement

Finally the agreement should contain conditions about the scope, duration, termination and adaptation. The FAD agreements are only recommended for normal or fast moving products, which have a significant impact on the operational processes and costs of at least the supplier. Also the relationship between the supplier and customer has to be of strategic importance for both parties and the costs of changing and executing planning processes should be covered by the benefits. Therefore it is recommended to apply the FAD agreements to commercial links with significant flows of goods in terms of volumes, value and impact on operations. The agreement is recommended to be a continuous arrangement with a yearly revision. Both parties are able to unilaterally terminate the arrangement at the end of each year. Also the parameters are recommended to be renegotiated on a yearly basis. A final important condition are the rules in case of contingencies: The discounts are defined ex post and reimbursed in the bills of the ordered goods, however there might be a significant amount of time between billing and payment. Most companies have a structure of administration costs for late payments by customers. A similar structure is advised for late or no reimbursement of the discounts. Conflicts about the correct application of the FAD agreement might arise. Therefore it is recommended to create conditions and procedures which allow room for intermediate adaptation of the arrangement.

6.3. Qualitative validation towards the problem perspectives

Based on the mechanisms of the Forecast Accuracy Discount agreements within the generic systems model presented in Chapter 4.1, we have made a qualitative assessment of the effects of the FAD agreements on the problem perspectives as presented in Chapter 4.3. The results of this analysis is visualized in Figure 29.

Problem perspective	Impact	Mechanism
Control Theory perspective	Positive	Dampening the negative feedback of deviations between forecasts and actual demand of buyer
System uncertainty perspective	Positive	Reducing the uncertainty towards expected orders by buyer
Information asymmetry	Positive	Reducing information asymmetry towards buyers demand
Self-organizing systems perspective	Positive	Total volume discounting, reduced increments and order intervals reduce order batch sizes
Physical lock-in perspective	None	
Paradigms perspective	Barrier	Classical production paradigms and commercial purchase sales negotiation paradigms
Limited rationality perspective	None	
Learning perspective	Positive	Meetings cause quicker insight for suppliers
Error corrections perspective	None	
Externalities perspective	Barrier evaded	No sensitive information need to be shared
Game Theory perspective	Barrier evaded	No possibilities to apply the defection strategy
Transaction costs perspective	Barrier evaded	Inability for opportunistic behaviour and trust building to reduce perceived transaction costs
Agency problem perspective	Barrier evaded	Benefits for the buyer, eliminates moral hazard
Strategic Supply Chain positions perspective	Barrier	Buyer doesn't accept the arrangement and sources at other suppliers
Shortage gaming perspective	Positive	Overstating needs by buyer reduces discounts
Price fluctuations	Positive	Short term forward buying reduces discounts
Organization coordination perspective	Barrier	Commercial divisions are still not incentivized by performance metrics to adopt the arrangements
Relationship Perspective	Barrier evaded	Low initial levels of trust needed to adopt the arrangements
Networked complexity perspective	Barrier evaded	Decentralized arrangement between supplier and buyer
Change resistance	Barrier	Commercial and operation divisions need to redefine their operations and heuristics

Figure 29: Assessment of FAD agreements on the problem perspectives for the Bullwhip Effect

The Forecast Accuracy Discount agreements positively affect most systematic causes of the Bullwhip Effect: The amplification of negative feedback is dampened, the uncertainty of customer demand is reduced for the suppliers by sharing information about expected orders and the agreement incentivizes local behaviour which has positive system wide emergent behaviour. The only systematic problem related to the Bullwhip Effect that is not addressed is the problem of physical systems can constrain the flexibility in operations. The FAD agreement also reduces the incentives for forward buying caused by perceived shortages and price fluctuation. Barriers to cooperate and share information due to strategic importance are not applicable to the agreements. Therefore high levels of initial trust are not necessary to engage the agreements. It decentralized structure assures it feasibility in the complex structure of Supply Networks.

There are however still barriers to overcome to implement the FAD agreements. First of all, classical production and commercial paradigms have to be overcome to implement the agreements. Operational parties have to understand that their classical heuristics only create local optima's. They have to understand how the counter intuitive measures of the FAD agreement create global optima's which result in improvements for all parties. Commercial parties have to understand that their short term competitive purchase-sales games result in sub optimal operational dynamics. Long term agreements are eventually more beneficial.

Although the FAD agreements will eventually benefit the customers through lower product prices, initially they have no short term incentives to adopt the agreements. They might source their products at other suppliers instead. This is also an obstacle to overcome, possibly by providing strong short term financial incentives by initial high discounts for accurate ordering towards the forecasts.

Finally, the agreement will only be effective when the internal organizational and process structure of both parties will be changed to facilitate the agreements. This needs commitment at strategic level to create a structure of responsibilities and authorities that will incentivize the commercial divisions to contribute productively and enable the operational divisions to smoothen flows of goods and exploit the resulting benefits. Such change processes inevitably have to deal with internal resistance.

6.4. Concluding remarks

We have defined the Forecast Accuracy Discount agreements on the philosophy that financially incentivizing customers to order according to previous shared expectations of their orders will smoothen order quantities and makes demand for suppliers more predictable, which lead to a direct Bullwhip Effect reduction. Furthermore we have identified how the financial incentives through discounts will indirectly incentivize further productive strategic behavior by smoothening forecasts and adapting operational structures. We have then operationalized the FAD agreements, by defining the necessary conditions and prerequisites and finally qualitatively assessed that the agreements positively influence most problem perspectives to the Bullwhip Effect or evade barriers to solving it. This design is the final scope of this research and from now on its mechanisms are implemented in the simulation model in the next chapter and its effects are evaluated to answer the main research question.

7. Simulation model

The effects of the Forecast Accuracy Discount agreements have been tested for a selection of seven Van Geel products using a simulation model of the case study. This chapter describes the design, structure, validation and systemic application of this model to the product selection. The results of the simulations are presented in the next chapter

7.1. Translation of the systems model into the simulation model

The simulation model was built after the case study analysis of the systems model described in chapter 4.1, however it only captures the systemic and short term operational part of the systems model. It applies merely the procedures of the planning functions of Legrand Nederland and the Technische Unie and calculates the physical outcomes. The simulation model does not contain actors with the capabilities to evaluate outcomes, learn and adapt their behaviour accordingly. Therefore the model outcomes need to be evaluated to the interests of the Technische Unie and Legrand to assess whether they are incentivized to apply the specific parameter configurations. This is also done in the next chapter. Also, the following simplifications have been made in the simulation model:

Aggregation of locations

The Operational Execution System of the Technische Unie contains two distribution centres, 22 transhipment points, 36 sales offices and two sales points. Deliveries to customers can flow through many routes. In the simulation model this structure is simplified by only considering the inventories and flows to and from distribution centres. Goods in the simulation model always flow through one of these centres. The delivery system of the Technische Unie is robust enough to assume goods that leave the distribution centres at night, can be delivered the next day.

Simplification of flows of goods and information

All flows of goods are assumed to be available at their destination the next day and all flows of information are assumed to be available for processes that have access to it the next day. The modalities in which goods and information are send is also not considered, because they do not have any significant influence.

Absence of stochastic processes

The simulation model is fully deterministic, because most of the Supply Chain elements are reliable and robust within the time scope of days. Historically, most local disturbances did not have any effect on the operational performance on daily level. Customer demand is the only uncertain factor with actual impact on the Supply Chain performance. The sensitivity towards demand variations is researched though sampling the demand patterns in multiple simulation cases.

Absence of capacity constraints

Most processes have no severe bottlenecks in throughput or storage capacities. Therefore the model does not have any capacity constraints and there are KPI's which indicate the needed capacities, so the acceptability of simulation cases in relation to the actual capacity constraints can be assessed.

Absence of flows of finance and operational costs

Both flows of finance as costs incurred by operations are not simulated. Flows of finance were considered trivial processes with no expected influence on the performance. Operational cost were not considered, because they were not available on the detail level of single activities. Assessing them with sufficient accuracy was not feasible within the scope of this research. Therefore cost indicators were defined, based on the flows and inventories of goods.

Static forecast values

Rather than including the forecasting processes of Legrand Nederland and the Technische Unie, the simulation model uses the historical forecast values over the simulated period. Since forecasts are solely defined by historical demand and the model uses actual historical demand or sampled demand with similar expected values, these historical forecast values are good approximations.

Aggregated demand totals

The model does not distinguish individual customer orders, outside the orders of the Technische Unie to Legrand. Customer demand is accumulated into daily demand totals. In the simulation, the daily demand totals of Legrand are the sum of the ordered quantities of the Technische Unie and demand totals of other customers. This simplification was necessary due to the aggregation level of available data. This aggregation has made it impossible to define service levels according to the

standards of the Technische Unie and Legrand, since they are based on the number of order lines. Therefore, the simulation model also uses indicators for the actual service levels.

Simplified heuristics for decision making under FAD agreements

As described in chapter 6 the Forecast Accuracy Discount agreements incentivize actor behaviour in multiple direct and indirect ways: Ordering, forecast sharing, renegotiating the terms of the FAD agreements and eventually redefining the operational system. Because the simulation model only captures the systemic short term operational behaviour of actors, only the ordering and forecast sharing behaviour is simulated under the influence of the FAD agreements. For these two processes simple, but realistic heuristics are used: The Technische Unie will share the order totals according to its own expectations without any strategic deviations. It will then order according to its given forecasts unless higher orders are necessary to prevent stock outs.

7.2. Conceptual model

For the evaluation of the FAD agreements a discrete, event based simulation model was developed with an incremental time logic of days towards these events. Essentially, the model simulates cases of 364 days, consisting of 52 weeks and 13 periods of 4 weeks, starting from 2-1-2012 to 31-12-2012. Every simulation day a number of events occur which simulate the physical and planning processes of a single product and its corresponding materials and semi-finished products. These processes influence quantities and flows, which are represented by state variables. The dynamics of these variables are also incremental, rather than continuous, meaning that they have a different value for each day. For example: Deliveries of Legrand Nederland to the Technische Unie are represented by the total quantities for each day and stored in an one dimensional array with a length of 364 days. State variables that represent their state at a given moment in time rather than their quantities over time, such as inventories at the distribution centre of the Technische Unie, are represented by two state variables that contain the starting and ending value at each day. The physical and planning processes are repeated each day in a fixed order, depending on the current, past and future values of state variables and the fixed model parameters, until the last day of the simulation scope. Then the state variables are used to calculate overall Key Performance Indicators of the effectiveness and efficiency of the configuration of model parameters in the specific simulation case.

Aggregated conceptual model

Figure 30 displays the conceptual systems model of the inputs, outputs, parameters and processes of a single simulation case which is run by the simulation model. These variables and processes have been conceptually aggregated. A full overview of all variables is given in Annex X and Annex XI displays the interactions between these variables and processes. In Figure 30 the variables are organized according to applicability to either Legrand, the Technische Unie or the Forecast Accuracy Discount agreement.

Model inputs

There are three major inputs to the model: demand, forecasts and initial values. The demand of Legrand distinguishes between the historical demand of the Technische Unie and other customers and the demand of the Technische Unie can either be historical or sampled, dependent on the used simulation mode. Instead of including the forecasting function in the model, historical forecasts are used as model input. The initial values represent the initial inventories and backlogs at the first simulation day.

Model processes and parameters

The processes of a simulation case are steered by the parameters which are also grouped towards applicability to Legrand, the Technische Unie or the FAD agreement. The processes are grouped as general singular processes, which occur either at the initiation or end of the simulation case, or processes of Legrand and the Technische Unie which repeat every simulation day. In Figure 30 these repetitive processes are ordered in the order in which they occur in the model, starting with the Legrand processes. First, information processes update the outcomes of physical and planning processes of the previous day. Then they physical processes simulate the flows of goods according to planning schedules and then the mutation of inventories. Finally the planning processes redefine the planning schedules.

Model outputs

The model outputs are the placed orders of the Technische Unie and Legrand, their deliveries and backlogs, received quantities and backlogs of suppliers, produced quantities and backlogs, inventories and KPI's. For the FAD agreements, the shared forecasts and KPI's concerning ordering accuracy and discounts are model outputs.

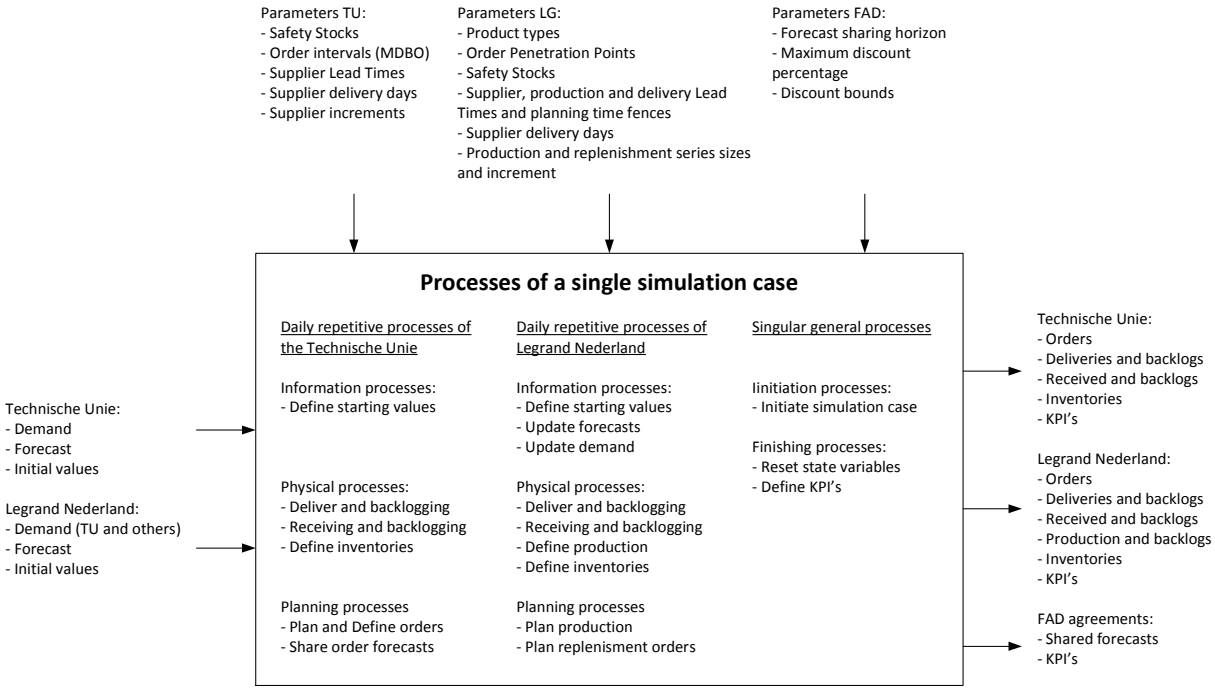


Figure 30: Aggregated conceptual systems model of the simulation model

Processes of the conceptual model

Annex XI contains a full overview of all processes in the simulation model and which variables they use and change. In this part we will shortly describe the most important and non-trivial functions within the simulation processes.

Information and initiation processes

At the start of each day the inventories and backlogs for the start of the day are defined by the process "Define starting values" by copying these values from the end of the previous day. The "Initiate simulation case" does a similar action by copying the initial values of the simulation case. Legrand also has the processes "Update forecasts" and "Update demand", which is the daily revision of respectively the forecast values according to shared forecasts by the Technische Unie under the FAD agreements and the revision of the demand according to placed orders by the Technische Unie the day before. In order to define a new forecast, the "Update forecasts" function first defines the forecast share of the Technische Unie using their market share of the specific product. Then this forecast share is replaced by the order forecast given by the Technische Unie for that day. This process is a model assumption based on the supposition that Legrand assesses the shared order forecasts of the Technische Unie more reliable than their own forecast model and will adjust their forecast accordingly.

Physical processes

Most of these processes are straightforward and generic for Legrand and the Technische Unie. Deliveries are made according to orders and backlogs. Inventory shortages will result in stock outs and the creation of new backlogged quantities. Products are then received at the next inventory point according to the quantities which were sent. Shortages according to orders will add to backlogs and surpluses will reduce the backlogs. The production process of Legrand work essentially the same, however the production throughput time can be longer than a day, causing quantities to reside inside this process for multiple days. After goods are sent and received a new inventory balance is calculated at each inventory point.

Although the physical processes contain no planning functions, the "Deliver and backlogging" process of Legrand does contain a decision making element concerning backlogging which is based on the empirical heuristic used by Legrand. In case of stock outs, Legrand has to ration its available quantities over the Technische Unie and other customers. Because the Technische Unie is a large customer and a wholesaler, the rationing policy of Legrand focuses on reducing their ration first, because, unlike smaller end user customer, their orders are used for replenishment of inventories. Therefore they probably don't need all the quantities right away. In accordance to the empirical heuristic, Legrand will first deliver 50% of their order quantities to the Technische Unie, then deliver the remaining quantities to other customers en finally ration any left quantities to the Technische Unie.

Technische Unie: Plan and define orders

This process follows the ordering heuristic as described in the case study systems model analysis in chapter 4.1. Orders are planned up to a set time horizon based on expected need dates, taking inventories, backlogs, forecast and already placed orders into account. When planned orders are inside the ordering horizon, which is determined by the supplier lead times, an order is placed.

In simulation cases without the FAD agreements the exact empirical policy is followed, however for the cases in which FAD agreements are present the ordering process is adapted using a simple heuristic: The Technische Unie will always order the forecasted quantities, unless they require more to prevent stock outs. In such a case they will increase their order size as little as possible, in order to stay above the safety stock at the end of the week.

Technische Unie: Share order forecasts

For this process another simple, but realistic heuristic is applied: The Technische Unie will share their actual expected weekly order totals. In order to define these quantities, this process will plan the orders according to the empirical ordering policy of the Technische Unie, described in the previous part, again after the ordering process has been finished. It will then update the weekly expected order totals.

Legrand: Plan production and Plan replenishment orders

These processes also follow the empirical heuristic of Legrand as described in chapter 4.1. Since the shared forecasts under the application of FAD agreements only influence the forecasts of Legrand, these processes are similar in the simulation cases with FAD agreements.

Key performance Indicators

For the measurement of the performance of the simulation cases a number of Key Performance Indicators have been defined. These are listed in Table 1. They indicate the case performance related to inventories, production, ordering, the functioning of the FAD agreements and the general overall Supply Chain performance. The KPI's defined in Table 1 are calculated both for Legrand as the Technische Unie whenever possible. Since Legrand has two inventory points, the inventory KPI's are calculated both over the inventory of materials as finished products, although inventory inbound KPI's only apply to materials and inventory outbound KPI's only apply to finished products. The full list of used KPI's in the simulation model is defined in Annex X.

The KPI's are designed to cover the objectives of this researched as described in chapter 3.3: Reducing the oscillations of orders, inventories and production and their amplification along Supply Chains in order to achieve a total cost reduction for all Supply Chain parties, while maintaining or improving their service levels.

First of all, in order to measure whether this goal is reached, KPI's are needed which indicate the oscillations of inventories, production and orders. For each of these aspects three indicators are defined: the average flows of goods, maximum flows of goods and the number of days with flows of goods. For inventories the inbound and outbound flows are used to define the fluctuations in handling operations, for production the daily production quantities are used to define fluctuations in production and orders quantities define the fluctuations in transportation.

The goal is to minimize the average and maximum flows to respectively reduce the related contingency costs for improvised operations and capacity investment costs. Whether the number of days with flows should be maximized or minimized is uncertain. On one side maximizing the number of operations contributes to minimizing the two above mentioned aspects, however it results in extra costs due to additional handling operations, setting up machines and transportation movements. In order to deal with this dilemma we will use the Bullwhip Effect measure as a leading measure to define the reduction in oscillations and related contingency and investment costs.

Secondly, in order to measure an actual total cost reduction, the average inventories should be taken into account in addition to the reduction of fluctuations. KPI's for average and maximum inventories are defined as well. As a leading KPI for the inventory holding costs, the inventory turnover speed is used as a leading KPI. This is a generally accepted, normalized measure to assess the acceptability of inventory levels in relation to its average demand.

Finally the service levels are indicated through two KPI's: The percentage of total quantities delivered on time and the days without any created backlogs. The second measure is more strict than the first one and its service level is always lower than the measures used by the Technische Unie and Legrand, which use the percentages of order lines. Therefore the days without backlogs are a good lower bound for the service levels. The percentage of total quantities delivered is expected to

be more positive than the actual service levels, however this does not have to be the case due to the distribution of quantities over larger and smaller orders.

In addition to the Supply Chain performance measurement, KPI's concerning the performance of the FAD agreements are defined which indicate the average ordering accuracy towards forecasts and the average discounts obtained by the Technische Unie. This figures are normalized towards the average weekly demand and maximum possible discounts to make them comparable among different products.

Group	KPI name	Measure	Goal	Indicated factors
Leading KPI's	Percentage of quantities delivered	Total quantities delivered on time / total demand	Maximize	Service level
	Percentage of days Without backlogs	Total days without added units to backlogs / total days	Maximize	Service level
	Inventory turnover speed	Total demand / average inventory	Maximize	Inventory holding costs
	Bullwhip Effect on weekly level	(stdev of orders / average orders) / (stdev of demand / average demand)	Minimize	Bullwhip Effect
Inventory KPI's	Average inventory	Sum of daily inventory level / total days	Minimize	Inventory holding costs
	Maximum inventory	Maximum of daily inventory value	Minimize	Inventory holding capacity investment costs
	Average inventory inbound	Sum of daily received goods / number of days in which goods were received	Minimize	Inventory handling contingency costs
	Maximum inventory inbound	Maximum of daily received goods	Minimize	Inventory handling capacity investment costs
	Days with inbounds	Number of days in which goods were received	Uncertain	Inventory handling resource utilization costs
	Average inventory outbound	Sum of daily sent goods / number of days in which goods were sent	Minimize	Inventory handling contingency costs
	Maximum inventory outbound	Maximum of daily sent goods	Minimize	Inventory handling capacity investment costs
	Days with outbounds	Number of days in which goods were sent	Uncertain	Inventory handling resource utilization costs
Production KPI's	Average production quantity	Sum of daily production / number of production days	Minimize	Production contingency costs
	Maximum production quantity	Maximum of daily production	Minimize	Production capacity investment costs
	Days of production	Number of production days	Uncertain	Production resource utilization costs
Ordering KPI's	Average order quantity	Sum of daily orders / number of days with ordered quantities	Minimize	Transportation contingency costs
	Maximum order quantity	Maximum of daily orders	Minimize	Transportation capacity costs
	Days with orders	Number of days with ordered quantities	Uncertain	Transportation resource utilization costs
FAD KPI's	Average forecast deviation	Sum of average weekly order forecast deviation / total weeks	Minimize	Order forecasting accuracy
	Normalized forecast deviation	Average forecast deviation / Average weekly demand	Minimize	Order forecasting accuracy
	Average discount percentage	Sum of total discount / Sum of total purchase value	Maximize	Discount costs/gains
	Normalized discount percentage	Average discount percentage / maximum discount percentage	Maximize	Discount costs/gains

Table 1: Key Performance Indicators of the simulation model

7.3. Simulation model functionalities and modes

The physical simulation model has been built using the VBA.net programming language. This model has been designed around the conceptual simulation model which simulates individual cases according to the specific input variables and parameters. Figure 31 illustrates how the conceptual simulation model is the central function in the physical simulation model architecture, which is controlled by the Simulation control function. Through the user interface, one can centrally control the simulation. Input data and initial parameters can be loaded though assigning the path of the input data text files. The structure of the input text files are static and listed in Annex X. Also the output file to which the results need to be written can be defined in the user interface through assigning the path of the output data text file. The data in the text files is structured through semicolon separations, which allows them to be opened and edited with MS Excel. Then the user can manually adapt a number of the model parameters though the interface and set the modes of the simulation, which will determine the processes in the Conceptual simulation model and Simulation control. Finally the user interface is used to initiate the simulation through the Simulation control function, which will initiate the results to be written to the output file when the simulations have been finished.

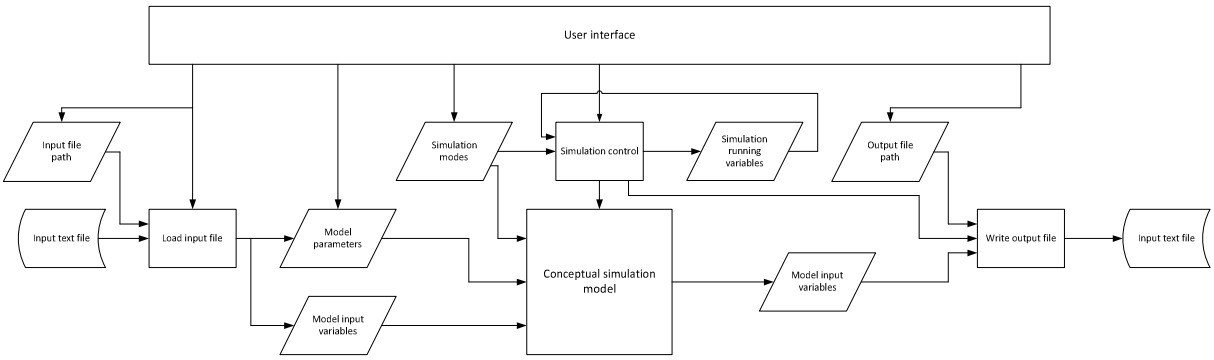


Figure 31: Physical simulation model architecture

The user interface of the model is displayed in Figure 32. The user has to define both the input and output file through the buttons and define the simulation modes through the ComboBoxes. The simulation will only be able to start when these aspects have been defined. Optionally, the user is able to adapt a number of operational parameters concerning the lead times of processes, order frequencies, series sizes and increments for the Technische Unie and Legrand and the FAD parameters.

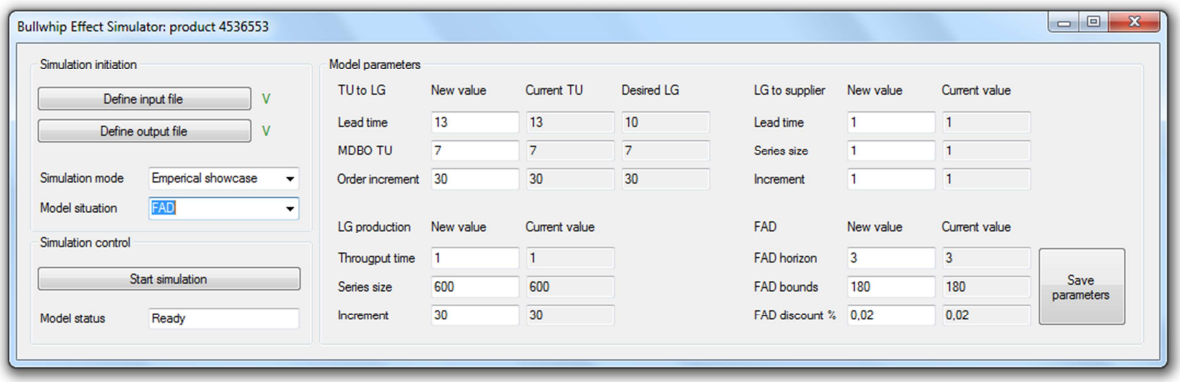


Figure 32: User interface of the simulation model

Simulation modes

The user needs to define two simulation modes: First, the "Model situation" determines whether the simulation uses the FAD agreements or the current null situation in operational planning. Second, there are three "Simulation modes" which are described here.

Emperical validation mode

The function of this mode is to assess whether the simulation model input, structure and parameters are valid by comparing the simulation output to historical results. In this mode the Null case model situation is the only option. The model simulated a single case and decouples the processes of Legrand and the Technische Unie, by using the historical orders of the Technische Unie as input of Legrand and assuming correct deliveries of Legrand to the Technische Unie according to placed orders. In the output file only the operational state variables are displayed in a table where simulated and historical values of the same variable are grouped for comparison. The results of this validation are discussed in paragraph 5 of this chapter.

Empirical showcase

The function of this mode is to explore the effects of the FAD agreements and parameter changes to the operational performance. A single case is simulated where the Technische Unie and Legrand are coupled through orders and deliveries. The model uses the historical demand of the customers of the Technische Unie and the historical demand of other customers than the Technische Unie for Legrand. The results of the simulation case is displayed in a table with operational state variables and an overview of the KPI's. This allows a thorough analysis and understanding of the effects of the case configuration.

Stochastic series

This mode is created to test the sensitivity of the case performance towards contingencies in the historical demand over 2012. Instead of the historical demand of customers of the Technische Unie for the specific product, this mode uses 1000 samples of a demand pattern which is similar to the historical demand distribution. The definition of these distributions and samples is explained in paragraph 4. Besides this adaptation, this mode is the same as the Empirical showcase. In this mode only the KPI's of the 1000 cases are reported by giving their average values and standard deviations.

7.4. Product selection

The exploratory research towards the Bullwhip Effect towards four suppliers of the Technische Unie in chapter 3.2 has revealed that the Bullwhip Effect is related towards the ratio between the lead time and Mean Days Between Orders, the order increment size, relative to yearly order totals and the A-F product categorization according to the Technische Unie. Products with longer lead times than the MDBO value, relatively large increments and A-D coding are found to have larger Bullwhip Effect values. Therefore the product selection is based on defining a set of products which contains all possible combinations of these three properties.

Table 2 contains the distribution of the Van Geel product portfolio of the Technische Unie among four aspects: 1) The product categorization divided into groups of fast movers A-D and slow movers E-F, 2) the relative increment size towards the yearly order total dividing in unconstrained <=1%, constrained 1%<=25% and total constrained >25%, 3) The percentage of lead times toward the MDBO divided in smaller or equal to 100% and larger than 100% and 4) The Bullwhip Effect applicability assessment divided into yes, limited and no. In this distribution a selection was made to products that are fully applicable to the Bullwhip Effect and not totally constrained by increments. They non applicable areas are greyed out in the table. This leaves eight white areas of which only six contain products. Slow moving E-F products with larger lead times than MDBO's actually do not exist, because the Technische Unie purposely uses high MDBO values and forecasts of zero to plan them.

The products of these six categories were listed and presented to Legrand Nederland for selection before the simulation model was built. For the 1%<=25% increment category only the products with a percentage equal or higher than 10% were taken to assure that there would be significant differences in the constraining effect of increments on the ordering process. Legrand was asked to select six product with the following requirements: Operational data over 2012 should be available. The end product has exclusive materials which are replenish and used only for the manufacturing of that specific product. Preferably one units of materials is converted into one unit of finished products or at least the conversion is known and consistent. Finally all products should have a similar operational control which makes the result comparable.

		ABC	A-D			E-F		
		Incr	<=1%	1%<=25%	>25%	<=1%	1%<=25%	>25%
% LT of MBDO	BW Apl							
<=100%	Yes		74	249	9	16	141	79
	Limited		0	0	0	0	4	13
	No		0	0	2	0	0	18
>100%	Yes		6	41	0	0	0	0
	Limited		0	0	0	0	0	0
	No		0	0	0	0	0	0

Table 2: Distribution of Van Geel products in the portfolio of the Technische Unie

It has been challenging to find manufactured products with exclusive materials. Therefore Legrand has made a selection of seven products which are closest to these requirements. Table 3 displays the general information of this product selection. Annex XIII contains the more information of these products. Annex XIV contains visualizations of the customer demand and ordering patterns of the Technische Unie on monthly and weekly level. These graphs demonstrate the constraining effect of order increments are the delayed ordering response when lead times are higher than MDBO's. Product 4536827 and 4536835 are two variations of essentially the same product with a different coating. Therefore by combining the data of these two products they can be simulated as one product. Product 4536553 is constructed from generic sheet of steel which are used for the manufacturing of many other products. Therefore the replenishment of materials for this product will be outside the scope of the simulation of this product. Finally, product 4256632 is the coated variant of another product which is sold directly as a trade product. For the simulation corrections are made to the sales and replenishment of it semi-finished product.

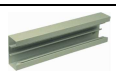
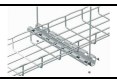
General product information							
Article nr Technische Unie	4536827	4536835	4255030	4536553	4531430	3407384	4256632
Article nr Legrand	8555101	8555103	341443	8555023	8234000	CM013500	344784
Description Technische Unie	GEEL EINDSCHOT GW05 130 CR	GEEL EINDSCHOT GW05 130 W	GEEL DEKSEL STIJGST 60X200	GEEL WAND-GOOT GW05 130 W LG3	GEEL M10 DRAADSTANG LG1	CAB MONTA-GEPR. RCSN L500 ELVZ	GEEL AFTAKSTUK 60X300 9010
Description Legrand	Eindschot 130 x63 r1013	Eindschot 130 x63 r9010	Deksel stijgst P31 60x200 Sdz	Wandgoot 3m 130 x63 r9010	Draadstang m10 l=1m	Ophangrail RCSN B500 elvz	Aftakstuk P31 60x300 9010
Product image							
Product type Legrand	Production	Production	Trade	Production	Trade	Trade	Production
Comments	Similar material as 8555103	Similar material as 8555101		Material is generic steel sheets			Material is also trade product
% Lead Time of MDBO TU	93%	93%	46%	186%	186%	46%	46%
Lead Time vs MDBO problem	No	No	No	Yes	Yes	No	No
% incr. of yearly order total TU	0,41%	0,21%	11%	0,33%	17%	0,39%	20%
Increment problem TU	No	No	Yes	No	Yes	No	Yes
Fast or slow mover TU	Fast	Fast	Fast	Fast	Fast	Slow	Slow
BW Effect TU on monthly level	1,92	1,83	3,27	1,31	4,36	1,51	1,36
BW Effect TU on weekly level	2,50	2,59	3,12	1,57	4,46	1,25	1,64

Table 3: Simulation product selection

Product specific adaptations in the operational input data and parameters

Specific adaptations have been made in the input data and simulation application for the manufactured products of Legrand with divergent conditions.

Product 4536827 and 4536835 (Legrand 8555101 and 8555103)

These two products are considered as one for the Empirical showcases and Stochastic series, however they are separately validated. Therefore there are two input files with these products for the Empirical validation each containing the individual data for each product for the Technische Unie. For Legrand the two products are however treated as one. Therefore historical data is summed up and parameters are adjusted. The parameters of both products are the same for Legrand except for the production series size, which is 300 units for 4536827 and 600 for 4536835. Here the higher value of 600 is taken since the total demand the sum of these products. The safety stocks have also been summed up.

For the Empirical showcases and Stochastic series, the data of the TU and Legrand are summed up. For the Technische Unie the parameters of these products are also identical except for the safety stock values. Since the safety stocks are based on the standard deviations of forecast errors, these two safety stocks are summed up as standard deviations, resulting in a lower value than the simple sum.

Product 4536553 (Legrand 8555023)

For this product there is a single input file for all simulation modes, however because the scope excludes the replenishment of materials of Legrand, the inventory of materials has been set at an almost infinite high number and all parameters have been set to 1.

Product 4256632 (Legrand 344784)

In order to deal with the direct sales of the materials of this product, there is a validation input file and a separate input file for the Empirical showcases and Stochastic series. The validation file has added the total demand of the materials to the demand of other customers than the Technische Unie. This causes the values of production and inventories of finished products to be much higher, however the inventory values of materials and replenishment quantities should be similar than the historical values. The validation will therefore be based on these two values.

For the Empirical showcases and Stochastic series, the sales of materials is deleted. Because the demand of the material is much higher than for this product, the replenishment series sizes and increments are much higher too. Therefore the focus of this product will also exclude the replenishment processes. The inventory values of materials are also set to an almost infinite value and replenishment parameters are all one.

Demand sampling for Stochastic series

In the Stochastic series mode, the sensitivity of the effects of the FAD agreements towards variations in demand of the customers of the Technische Unie is tested by using multiple samples of similar demand. Exploratory statistical research has revealed that the distribution of daily demand totals follow the form of a skewed normal distribution for fast moving products and exponential distributions for slow moving products. This is visualized in the charts in Annex XV. Also, the demand totals per period follow a yearly seasonal pattern, however no difference were found in demand totals for specific days of the week. Therefore the daily demand totals in the cases of the Stochastic series were sampled using a fitted demand distribution. These values were then scaled according to the seasonal demand pattern.

This was done by defining a frequency distributing table of the empirical daily demand for each product, excluding Saturdays and Sundays, and rescale this distribution in percentages of total demand. Then the form of the distributed was assessed. Skewed normal distributions were fitted using Weibull distributions. The a and b value of this distribution has been defined by fitting through minimizing the sum of squared differences though the GRS non-linear optimization method in MS Excel. Exponential distributions were fitted the same way using exponential distribution functions in which the λ value was fitted. Finally, the distributions of slow moving products had very little days with demand above zero. These cases have been fitted according to their empirical distributions using customer demand increments according to the empirical data. Table 4 shows the used distributions and their parameter values.

After the definition of the distributions, the probabilities to days with zero demands were set to the empirical percentage. Then the other values were rescaled to obtain a distribution with a total sum of 100%. Using this final distribution the expected value of the average demand per period was defined and compared with the empirical average demand per period over 2012. These values are also displayed in Table 4. The deviations in percentage are higher for slow moving products, however considered acceptable.

Article nr TU	Distribution type	Parameters	Exp value of average demand per period	Average empirical demand per period	% deviation of exp val towards emp val
4536827	Weibull distribution	a: 1,56 b: 15,82	274,35	277,46	-1,1%
4536835	Weibull distribution	a: 1,84 b: 29,21	499,00	517,38	-3,6%
4255030	Exponential distribution	λ: 0,6614	15,08	13,31	+13,3%
4536553	Weibull distribution	a: 1,60 b: 36,88	642,41	685,46	-6,3%
4531430	Weibull distribution	a: 1,19 b: 55,80	1149,29	1145,00	+0,4%
3407384	Emperical distribution	Increment: 5	27,31	24,77	+10,3%
4256632	Emperical distribution	Increment: 1	3,23	3,54	-8,8%

Table 4: Distribution properties for demand sampling

Besides the distributions, a set of seasonal scaling factors were defined for each of the 13 periods of the Technische Unie, which are listed in Annex XV. These were defined by dividing the empirical demand total per period by the expected value of average demand per period. Multiplying each daily sampled demand value by this factor will lead to the total demand in that period to be equal to the empirical demand in that period. Because the average expected demand totals per period in the Stochastic series are always equal to the empirical demand, the historical forecasts are valid as forecasts for the Stochastic series, because the average forecast deviations per period in the Stochastic series will equal the empirical case.

7.5. Model validation

Validation of the model structure, input data and parameters have been performed by expert validation methods. For the Technische Unie, Henk van Delden, the manager of the Inventory Management Department, has provided the formalized procedures of the relevant functions and the quantitative input data and parameters. For Legrand Nederland, this has been done by Ronald Tjio, manager of the Supply Chain Management department and Misha Boereboom, master planner at the department of Forecasting, Planning & Procurement.

Empirical validation of outcomes

The model outcomes have been validated through the Empirical Validation simulation mode. For the Technische Unie their simulated orders are compared to their historical orders. For Legrand the simulated inventories and orders are compared to their historical values and for production products also the production output is considered. The outcomes of these comparisons are visualized in Annex XVI for all seven products. For product 4536553 the replenishment quantities are not present, because of the scope limitation. The validity assessment has been performed visually by comparing similarity in order quantities and frequencies for replenishment and for inventories similarities in average quantities and shapes were assessed. Most of the comparisons are considered sufficiently similar however there are two areas of deviations.

First the replenishment orders of Legrand in the simulation outcomes are often an increment higher than the series size. In Annex XVI this is visible for products 4536827, 4536835, 4255030, 4531430 and 3407384. This happens, because the simulated ordering policy of Legrand was assumed to set a desired inventory level which equals the safety stock plus the series size, then initially the order size to the series size and increase the order size by each increment until the order exceeds the desired inventory levels. In reality the order sizes are rounded down instead of rounded up. The effect of this deviation is however not expected to affect the validity of the research outcomes as long as the current policy is consistently applied.

The second deviation concern the product 4256632. As stated before the inventory of finished products and production outcomes can be ignored, because they include the sales of the materials as product as well, resulting in much higher production quantities and order sizes. The inventories of materials and replenishment is however applicable for the validation, because both the simulated values as empirical values display the inventories and orders of materials for both production as sales. In the replenishment chart one can observe much higher order totals and frequencies in the simulated case, especially at the end of the year 2012. Because the average inventories of materials in the simulation case are stable, the demand in the simulation case has to be higher than in the empirical case. The source of this deviation has not been found, however is again not expected to affect the validity of the research outcomes as long as simulations are performed consistently. The demand for the Empirical showcases and Stochastic series are different after all, since they exclude the direct sales of the materials

Validation of the sampled demand in the Stochastic series

In order to validate the sampled demand for the Stochastic series, which are based on the fitted demand distribution and seasonal scale factors, we compare the KPI outcomes of the Empirical showcases with the average values of KPI's in the Stochastic series. The assessment of deviations has been done by standardizing these deviations towards the standard deviations of each distribution of KPI values in the Stochastic series. Annex XX displays tables with all these relative differences for all products and simulation cases. The meaning of these cases are explained in the next paragraph. Table 5 displays the maximum absolute differences for each product and KPI over the simulation cases. Explorative research has shown that deviations below 5 times the standard deviation are acceptable, since standard deviations have revealed to be small. There are however some cases in which standard deviations are larger, which need to be addressed.

First, product 4531430 has some large deviations for the Technische Unie at maximum inbounds, outbounds and orders. At Legrand, these values are also relatively high. Closer research has revealed that these maximum values are much higher for the Empirical showcases than the Stochastic series. In the empirical demand of this product over 2012 a unusual high demand is found of almost 800 units in one day, while the yearly demand total is around 15.000 units, resulting in an

incidental high flow of goods. Such demand spikes may occur in the Stochastic series too, but are rare. Therefore the average values of these maximums middle out and a large difference is explained.

For the combined products 4536827 and 4536835, many mean KPI values of the Stochastic series are different than the Empirical showcases. Analysis has shown that this was caused by a difference in total demand. The demand of the Stochastic series were consistently higher, which resulted in frequent stock outs due to forecast inaccuracies, lower service levels, lower inventories, more frequent ordering and less accurate ordering according to the FAD agreements. The exact cause is not found, but it is probably related to the definition of sampled demand for de combined products. The definition of the demand distributions and demand sampling of these two products have been done separately at first and then the sampled demand were added up, similar to the Empirical demand. The result of this error pictures the situation of a product for which both Legrand as the Technische Unie systematically underestimate the demand in their forecasts. Since the different cases are simulated under these faulty but consistent conditions, valid conclusions of the effects of FAD agreements can still be drawn, however one has to keep the given situation into account.

		Technische Unie						Legrand					
		4536827 en 4536835	4255030	4536553	4531430	3407384	4256632	4536827 en 4536835	4255030	4536553	4531430	3407384	4256632
General KPI's													
Service level	By perc of total quant delivered on time	4,63	0,75	0,85	0	0,48	2,03	2,17	0	2,63	2,9	0	0
	By perc of days without any backlogs	4,9	0,97	0,9	0	1,78	3,37	2,6	1,72	2,6	2,04	0	1,8
Inventory turnover	Times per year for finished products	5,61	0,86	0,93	1,19	1,21	2,15	4,86	1,48	1,65	1,38	0,79	2,1
	Times per year for materials							4,09	0	0,27	0	0	2,86
Bullwhip Effect	Amplification on weekly level	3,88	0,87	1,5	2,04	1,2	2,34	3,42	2,34	0	2,56	1,75	0
Inventory KPI's													
Average inventory	Average of finished products	8,08	1,66	1,14	1,54	1,65	1,67	2,66	2,08	1,67	2,33	1,57	2,1
	Average of materials							3,19	0	0,32	0	0	1,83
Max inventory	Maximum of finished products	3,39	2,61	1,54	1,89	1,42	2,18	2,35	2,24	1,54	1,66	1,6	0
	Maximum of materials							1,29	0	0	0	0	0
Average inbound	Average inbound of materials/products	5,12	2,73	1,98	1,84	1,27	1,98	2,4	2,31	0	2,14	1,85	0
Max inbound	Maximum inbound of materials/products	2,44	3,01	2,19	12,4	1,14	1,35	1,72	2,07	0	2,48	1,41	0
Inbound frequency	Number of inbounds of materials/products	7,7	1,61	1,63	1,08	1,43	2,36	4	2,04	0	1,68	1,53	0
Average outbound	Average outbound of finished products	5,49	0,4	0,73	0,36	2,51	2,95	4,21	1,9	1,98	1,62	1,52	1,53
Max outbound	Maximum outbound of finished products	3,28	1,28	1,29	9,92	1,58	1,05	2,45	0	1,37	4,06	0,1	0
Outbound frequency	Number of outbounds of finished products	2,83	1,15	2,77	0,8	1,28	0,77	7,08	1,61	1,63	1,26	1,43	2,36
Production KPI's													
Average production	Average production quantity							3,81	0	2	0	0	1,83
Max production	Maximum production quantity							2,33	0	1,4	0	0	0
Production frequency	Number of production runs							4,93	0	1,26	0	0	2,44
Ordering KPI's													
Average orders	Average order quantity	5,79	2,73	1,21	1,85	1,27	1,98	2,4	2,31	0	2,14	1,85	0
Max orders	Maximum order quantity	1,94	3,01	2,07	12,4	1,14	1,35	1,72	2,07	0	2,48	1,41	0
Order frequency	Number of orders	7,78	1,61	0,95	1,09	1,43	2,36	4	2,04	0	1,68	1,53	0
FAD KPI's													
Forecast deviation	Average forecast deviation	7,88	1,48	1,49	1,81	0,71	2						
	Av forecast deviation as a perc of av dem	5,48	1,67	1,6	1,86	1,2	1,71						
Discount percentage	Average discount percentage	5,35	1,64	1,71	2,18	1,02	2,55						
	Av disc perc as a perc of the max poss disc	5,35	1,64	1,71	2,18	1,02	2,55						

Table 5: Absolute differences in average KPI values of Stochastic series towards the KPI's of Empirical showcases, measured in multiples of the standard deviation of the distribution of KPI values in the Stochastic series

7.6. Simulation approach

The showcases have been used for exploratory research towards the effects of the FAD parameters and other parameters on the Bullwhip Effect and other performance indicators of Legrand and the Technische Unie. Based on this explorative research and the results of the statistical analysis discussed in chapter 3.2, a number of presumptions were defined which have led to a systemic simulation approach.

First of all, high increments are found to have a constraining effect on the effectiveness of the Forecast Accuracy Discount agreements and other parameter changes. In some cases the simulation outcomes were identical. Therefore the alleviation of increments to an acceptable size is presumed as a prerequisite for any other measures. The extent to which increment sizes should be lowered depends on the extent to which they constrain the possibilities of ordering in the current situation. The extent to which they can be lowered depends on the operational possibilities of Legrand.

Secondly, the statistical research has revealed that the Bullwhip Effect is related to situations were lead times, according to the Technische Unie, are longer than the Mean Days between Orders. Also, the Technische Unie has put forward the idea to shorten order intervals to smoothen out the Bullwhip Effect, which is also incentivized by the FAD agreements. Therefore it is desirable to compare the flowing four situations: 1) Long and equal lead times and MDBO's, 2) short and equal lead times and MDBO's, 3) Longer lead times than MDBO's and 4) Longer MDBO's than lead times. Conveniently, the lead times according to the Technische Unie for all products are 13 days and the desired order intervals according to Legrand would be 7 days, which is always equal or lower than the current MDBO of the product selection. Therefore these four cases are based on 13 and 7 days for the long and short values of lead times and MDBO's.

The Forecast Accuracy Discount agreements have three relevant parameters, the forecast sharing horizon, the maximum discount percentage and the discount bounds. The last two parameters don't determine the ordering behaviour of the Technische Unie in the simulation model, but only determine the resulting discounts. This is due to the specific ordering heuristics which are chosen for the FAD situation in this simulation model. Therefore, the effects of varying the maximum discount percentages and discount bounds are not researched. The forecast horizons are however an important parameter within the ordering heuristic of the Technische Unie in the model, since it determines when forecast will be shared and what quantities are expected. In order to have any effect, the forecast sharing horizon should be longer than the lead times. Therefore a minimum value of two weeks is chosen for this parameter. The maximum reasonable length of the sharing horizon is expected to be the total throughput time of Legrand, which is always equal or less than five weeks. Therefore this simulation test the effects of forecast sharing horizons between two and five weeks.

Systemic simulation approach

For every product a total of five simulation cases are simulated. The specific parameters for each product in every case is displayed in Table 6. First, the null case preserves all the empirical parameters. Then the Increment alleviation case, reduces the ordering increment of the Technische Unie and production and replenishment series sizes of Legrand, whenever these constrain the effects of any other parameter changes. This has been assessed by the exploratory research. Constraining order increments of the Technische Unie have been reduced as much as possible to the desired customer order sizes given by Legrand. The constraining series sizes have been reduced as much as possible to their increment size. The further five cases all maintain the Increment Alleviation settings. In the third case the MDBO value is set to 13 days, equal to the lead times and in the fourth case this value is set or maintained at 7 days. The fifth case combines setting or maintaining the MDBO to 7 days and reducing the lead times from 13 to 7 days.

For each of the 30 simulation cases, different configurations of the FAD agreements are simulated. First of all, there is a null configuration with no FAD agreements in place. Then in addition, the FAD agreements are activated with their product specific parameters as displayed in Table 7. Only the forecasting horizons are varied, resulting in four additional simulation runs. Per simulation case there is one null case and four FAD agreement cases.

Case names	**4536827 and 4536835**	**4255030**	**4536553**	**4531430**	**3407384**	**4256632**
Null case	Empirical	Empirical	Empirical	Empirical	Empirical	Empirical
Increment alleviation (IA): TU ordering increment LG production series size LG replenishment series size	 Fr 600 to 15 Fr 1200 to 150	 Fr 20 to 1 Fr 160 to 20	 Fr 600 to 30 N/A	 Fr 2000 to 25 Fr 12000 to 500	 Fr 80 to 20	 Fr 10 to 1 Fr 7 to 1 Fr 10 to 1
IA + MDBO = 13 MDBO	Fr 14 to 13	Fr 28 to 13	Fr 7 to 13	Fr 7 to 13	Fr 28 to 13	Fr 28 to 13
IA + MDBO = 7 MDBO	Fr 14 to 7	Fr 28 to 7			Fr 28 to 7	Fr 28 to 7
IA + MDBO = 7 + LT = 7 MDBO Lead time	 Fr 14 to 7 Fr 13 to 7	 Fr 28 to 7 Fr 13 to 7	 Fr 13 to 7	 Fr 13 to 7	 Fr 28 to 7 Fr 13 to 7	 Fr 28 to 7 Fr 13 to 7

Table 6: Overview of simulation cases and parameter settings

FAD parameters	**4536827 and 4536835**	**4255030**	**4536553**	**4531430**	**3407384**	**4256632**
Forecasting horizon: varied fr	2 to 5 weeks	2 to 5 weeks	2 to 5 weeks	2 to 5 weeks	2 to 5 weeks	2 to 5 weeks
Maximum discounts: fixed to	2%	2%	2%	2%	2%	2%
Discount bounds: fixed to	400 units	20 units	180 units	2000 units	30 units	10 units

Table 7: Overview of FAD parameter variations for each simulation case

8. Simulation results

In this chapter we analyse the simulation results and define a number of propositions which are supported by the simulation result data. Annex XVII contains the complete overview of KPI outcomes of the Stochastic series, which is used for this analysis. The propositions are only applicable within the scope of the case study: The Van Geel product group within the Supply Chain of the Technische Unie and Legrand Nederland. Finally, the overall results are defined, which are supported by the propositions and we will address how the simulation outcomes incentivize the tactical and strategic behaviour of Legrand Nederland and the Technische Unie in this case.

8.1. Propositions

In order to support our overall findings we have defined a number of propositions which are supported through the simulation outcomes. First we define the basic finding that higher inventories lead to higher service levels and vice versa. We use this first proposition to support that the alleviation of constraining increments leads to improvements of all performance indicators when safety stocks are adjusted accordingly to maintain acceptable service levels. Then we extend the Increment Alleviation situations by adjusting the order intervals and support proposition 3, stating that reducing order intervals improves the operational performance, again when safety stocks are adjusted to maintain service levels. Then we support proposition 4 that the additional reduction of Lead Times along with the reduction of order intervals within the Increment Alleviation situation, leads to further improvements in the reduction of fluctuations. Finally we use the optimal situations of these parameters to assess which forecast sharing horizon is optimal when Forecast Accuracy Discount agreements are applied to these situations.

Proposition 1: Average inventories and service levels are either positively correlated or not correlated

Higher average inventories reduce the risks of stock outs and therefore increase the service levels. This proposition has been tested in the cases for the situations without the Forecast Accuracy Discount agreements by comparing the service levels and average inventories of the same products in different simulation cases. Table 8 displays the found correlation between the two types of service level measurement and the average inventory for Legrand and the Technische Unie. All cases confirm proposition 1. All cases with neutral correlations can be explained by either a service level of 100% in all cases, indicated by a single asterisk, or the case being identical to the null case, indicated by double asterisks. A further comparison between the outcomes of different FAD horizons within the simulation cases results in the same findings, however this analysis is considered to support the proposition sufficiently.

		Nullcase		Increment Alleviation		IA + MDBO = 13		IA + MDBO = 7		IA + MDBO = 7 + LT = 7	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
4536827 and 4536835	Service level definition 1			Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
	Service level definition 2			Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
4255030	Service level definition 1			Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*
	Service level definition 2			Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*
4536553	Service level definition 1			Neutral**	Positive	Positive	Positive	Neutral**	Positive	Positive	Positive
	Service level definition 2			Neutral**	Positive	Positive	Positive	Neutral**	Positive	Positive	Positive
4531430	Service level definition 1			Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive
	Service level definition 2			Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive
3407384	Service level definition 1			Neutral**	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*
	Service level definition 2			Neutral**	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*
4256632	Service level definition 1			Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*
	Service level definition 2			Positive	Neutral*	Positive	Neutral*	Positive	Neutral*	Positive	Neutral*

Table 8: Compared correlation between service levels and average inventories

Proposition 2: Alleviating increment constraints reduces the Bullwhip Effect and fluctuations in inventories, production and orders for the Technische Unie and Legrand

Reducing the increments order sizes of the Technische Unie and the production and replenishment series sizes of Legrand, reduces the Bullwhip Effect and fluctuations in inventories, production and orders for both parties. Table 9 contains the percentages in which the KPI's of the Increment Alleviation cases differ from the null cases. These percentages are displayed normatively, which means they display whether they improve or worsen rather than become larger or smaller.

For all of the six products the inventory KPI's related to inbounds and outbounds, the production KPI's and ordering KPI's improve both for Legrand as the Technische Unie. Also the stronger the increment alleviation, the stronger the improvement of these KPI's. Also proposition 1 is confirmed for these cases. According to proposition 1, the deterioration of service levels can be compensated when average inventory levels are increased. By adjusting their safety stock levels, the Technische Unie and Legrand can set their service levels back to their original values, while maintaining improvements in

the Bullwhip Effect and fluctuations of inventories, production and orders. The average inventories are expected to equal or exceed their original values.

		4536827 & 4536835		4255030		4536553		4531430		3407384		4256632	
Increment Alleviation (IA):													
TU ordering increment				20 to 1				2000 to 25				10 to 1	
LG production series sizes		600 to 15				600 to 30						7 to 1	
LG replenishment series sizes		1200 to 150		160 to 20		N/A		12000 to 500		80 to 20		10 to 1	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
General KPI's													
Service level	By perc of total quantities delivered on time	0,01	-0,11	-0,02	0	0	0	0	-0,1	0	0	-0,04	0
	By perc of days without any backlogs	0,01	-0,23	-0,02	0	0	0	0	-0,04	0	0	-0,04	0,02
Inventory turnover	Times per year for finished products	-0,02	2,55	0,21	0,61	0	2	0,49	2,44	0	0,16	0,53	2,63
	Times per year for materials		1,58		N/A		0		N/A		N/A		-0,03
Bullwhip Effect	Amplification on weekly level	0	0,56	0,19	0,43	0	N/A	0,64	0,64	0	0,19	0,28	N/A
Inventory KPI's													
Average inventory	Average of finished products	-0,02	0,72	0,18	0,38	0	0,67	0,33	0,71	0	0,14	0,35	0,73
	Average of materials		0,61		N/A		0		N/A		N/A		0
Max inventory	Maximum of finished products	-0,05	0,46	0,2	0,33	0	0,47	0,19	0,53	0	0,15	0,33	0,15
	Maximum of materials		0,49		N/A		0		N/A		N/A		0
Average inbound	Average inbound of materials/products	0,09	0,74	0,32	0,72	0	N/A	0,81	0,91	0	0,46	0,49	N/A
Max inbound	Maximum inbound of materials/products	0,02	0,51	0,3	0,45	0	N/A	0,62	0,79	0	0,19	0,27	N/A
Inbound frequency	Number of inbounds of materials/products	0,1	2,72	0,43	2,38	0	N/A	3,85	8,4	0	0,79	0,87	N/A
Average outbound	Average outbound of finished products	0,01	0,14	-0,01	0,07	0	0	0	0,38	0	0	0,01	0,27
Max outbound	Maximum outbound of finished products	0,03	0	0	0	0	0	0	0,25	0	0	0,07	0
Outbound frequency	Number of outbounds of finished products	0,01	0,17	-0,01	0,07	0	0	0	0,6	0	0	0,01	0,35
Production KPI's													
Average production	Average production quantity		0,67		N/A		0,74		N/A		N/A		0,62
Max production	Maximum production quantity		0,41		N/A		0,51		N/A		N/A		0
Production frequency	Number of production runs		1,95		N/A		2,76		N/A		N/A		1,43
Ordering KPI's													
Average orders	Average order quantity	0	0,74	0,32	0,72	0	N/A	0,82	0,91	0	0,46	0,49	N/A
Max orders	Maximum order quantity	0	0,51	0,3	0,45	0	N/A	0,62	0,79	0	0,19	0,27	N/A
Order frequency	Number of orders	0	2,72	0,43	2,38	0	N/A	4,29	8,4	0	0,79	0,87	N/A
FAD KPI's													
Forecast deviation	Average forecast deviation												
	Av forecast deviation as a perc of av demand												
Discount percentage	Average discount percentage												
	Av disc perc as a perc of the max poss discount												

Table 9: Normative comparison of the null cases towards the Increment Alleviation cases.

Proposition 3: Reducing order intervals, reduces fluctuations in inventories, production and orders and average inventories for the Technische Unie and Legrand

This proposition has been tested by comparing the KPI's of the Increment Alleviation cases to the cases with Increment Alleviation and the Mean Days Between Orders of the Technische Unie set to 13 days and 7 days. Table 10 shows the results of the comparison of the cases in which the MDBO's were set from their empiric value to 13 days and Table 11 shows these results for MDBO's set at 7 days.

Both these tables confirm overall improvements on the fluctuations in inventory inbounds and outbounds, production and orders for the Technische Unie and Legrand when the MDBO's are reduced. Also in cases where MDBO's are increased the exact opposite effect is visible. The Bullwhip Effect is also reduced for the Technische Unie in cases with reduced MDBO's and increases in cases with increased MDBO's. For Legrand the Bullwhip Effect values increase when they values of the Technische Unie are lowered and vice versa. This can be explained by the fact that order intervals to suppliers of Legrand are unchanged. This causes the reductions in oscillation of orders of the Technische Unie to lead to a relative increase of the amplification of orders of Legrand. Also the reductions of MDBO values reduces the average inventories for the Technische Unie and higher MDBO's have the opposite effect. In concordance with proposition 1 service levels deteriorate when average inventories decrease. Again changes in safety stock levels can correct the negative effects on service levels.

		4536827 & 4536835		4255030		4536553		4531430		3407384		4256632	
IA +MDBO = 13													
MDBO		Fr 14 to 13		Fr 28 to 13		Fr 7 to 13		Fr 7 to 13		Fr 28 to 13		Fr 28 to 13	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
General KPI's													
Service level	By perc of total quantities delivered on time	-0,01	0	-0,03	0	0,01	0	0	0,01	-0,13	0	-0,05	0
	By perc of days without any backlogs	-0,01	0,01	-0,03	0	0,01	0	0	-0,03	-0,13	0	-0,05	0,02
Inventory turnover	Times per year for finished products	0,06	0	0,3	0	-0,19	0,02	-0,08	-0,01	0,35	0	0,3	0
	Times per year for materials		0,02		N/A		0		N/A		N/A		-0,02
Bullwhip Effect	Amplification on weekly level	0,09	-0,04	0,34	-0	-0,61	N/A	-0,41	0,03	0,1	-0,01	0,23	N/A
Inventory KPI's													
Average inventory	Average of finished products	0,05	0	0,23	0,01	-0,23	0,01	-0,08	-0,02	0,26	0	0,23	0,02
	Average of materials		0,02		N/A		0		N/A		N/A		0
Max inventory	Maximum of finished products	0,04	0,02	0,23	0	-0,26	-0,07	-0,01	0	0,06	0	0,2	0
	Maximum of materials		0,01		N/A		0		N/A		N/A		0
Average inbound	Average inbound of materials/products	0,06	0,01	0,47	-0,02	-0,71	N/A	-0,65	-0,01	0,38	0,04	0,42	N/A
Max inbound	Maximum inbound of materials/products	0,05	0,04	0,31	0	-0,43	N/A	-0,51	0,01	0,06	0,01	0,17	N/A
Inbound frequency	Number of inbounds of materials/products	0,06	0,01	0,86	-0,02	-0,41	N/A	-0,39	0	0,59	0,03	0,67	N/A
Average outbound	Average outbound of finished products	-0,01	0,02	-0,01	0,15	0	-0,26	0	-0,18	0,05	0,18	0,02	0,28
Max outbound	Maximum outbound of finished products	0	0,03	0,01	0	0,03	-0,2	0	0,03	-0,04	0	0,06	0
Outbound frequency	Number of outbounds of finished products	-0,01	0,02	-0,01	0,18	0	-0,21	0	-0,15	0,06	0,21	0,02	0,37
Production KPI's													
Average production	Average production quantity		0,02		N/A		-0,28		N/A		N/A		0,29
Max production	Maximum production quantity		0,01		N/A		-0,19		N/A		N/A		0
Production frequency	Number of production runs		0,02		N/A		-0,21		N/A		N/A		0,4
Ordering KPI's													
Average orders	Average order quantity	0,07	0,01	0,47	-0,02	-0,71	N/A	-0,65	-0,01	0,38	0,04	0,42	N/A
Max orders	Maximum order quantity	0,03	0,04	0,31	0	-0,43	N/A	-0,51	0,01	0,06	0,01	0,17	N/A
Order frequency	Number of orders	0,07	0,01	0,86	-0,02	-0,41	N/A	-0,39	0	0,59	0,03	0,67	N/A
FAD KPI's													
Forecast deviation	Average forecast deviation												
	Av forecast deviation as a perc of av demand												
Discount percentage	Average discount percentage												
	Av disc perc as a perc of the max poss discount												

Table 10: Normative comparison of the changes of Mean Days Between Orders from their empiric values to 13 in the Increment Alleviation cases.

		4536827 & 4536835		4255030		4536553		4531430		3407384		4256632	
IA +MDBO = 7													
MDBO		Fr 14 to 7		Fr 28 to 7						Fr 28 to 7		Fr 28 to 7	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
General KPI's													
Service level	By perc of total quantities delivered on time	-0,12	-0,04	-0,05	0	0	0	0	0	-0,19	0	-0,07	0
	By perc of days without any backlogs	-0,14	-0,04	-0,04	0	0	0	0	0	-0,19	0	-0,07	0,03
Inventory turnover	Times per year for finished products	0,53	0,05	0,47	0	0	0	0	0	0,52	-0	0,44	0
	Times per year for materials		0,13		N/A		0		0		N/A		-0,02
Bullwhip Effect	Amplification on weekly level	0,42	-0,33	0,48	-0,01	0	N/A	0	N/A	0,17	-0,03	0,33	N/A
Inventory KPI's													
Average inventory	Average of finished products	0,34	0,05	0,32	0,01	0	0	0	0	0,34	0,01	0,3	0,02
	Average of materials		0,12		N/A		0		0		N/A		0
Max inventory	Maximum of finished products	0,24	0,08	0,32	0	0	0	0	0	0,1	0	0,27	0
	Maximum of materials		0,13		N/A		0		0		N/A		0
Average inbound	Average inbound of materials/products	0,32	0,06	0,63	-0,02	0	N/A	0	N/A	0,58	0,04	0,57	N/A
Max inbound	Maximum inbound of materials/products	0,08	0,21	0,4	0	0	N/A	0	N/A	0,1	0,01	0,22	N/A
Inbound frequency	Number of inbounds of materials/products	0,45	0,05	1,64	-0,02	0	N/A	0	N/A	1,32	0,03	1,23	N/A
Average outbound	Average outbound of finished products	-0,08	0,15	-0,01	0,26	0	0	0	0	0,1	0,33	0,03	0,41
Max outbound	Maximum outbound of finished products	-0,09	0,08	0,01	0	0	0	0	0	-0,06	0	0,09	0
Outbound frequency	Number of outbounds of finished products	-0,07	0,17	-0,01	0,35	0	0	0	0	0,11	0,48	0,03	0,68
Production KPI's													
Average production	Average production quantity		0,15		N/A		0		0		N/A		0,42
Max production	Maximum production quantity		0,08		N/A		0		0		N/A		0
Production frequency	Number of production runs		0,18		N/A		0		0		N/A		0,7
Ordering KPI's													
Average orders	Average order quantity	0,32	0,06	0,63	-0,02	0	N/A	0	N/A	0,58	0,04	0,57	N/A
Max orders	Maximum order quantity	0,07	0,21	0,4	0	0	N/A	0	N/A	0,1	0,01	0,22	N/A
Order frequency	Number of orders	0,46	0,05	1,64	-0,02	0	N/A	0	N/A	1,32	0,03	1,23	N/A
FAD KPI's													
Forecast deviation	Average forecast deviation												
	Av forecast deviation as a perc of av demand												
Discount percentage	Average discount percentage												
	Av disc perc as a perc of the max poss discount												

Table 11: Normative comparison of the changes of Mean Days Between Orders from their empiric values to 7 in the Increment Alleviation cases.

Proposition 4: When order intervals and lead times are equal, reducing both these values, reduces fluctuations in inventories, production and orders and average inventories for the Technische Unie and Legrand

This proposition has been tested by comparing the Increment Alleviation cases with MDBO's and lead times of 13 days towards increment Alleviation cases with MDBO's and lead times of both 7 days. The normative results of this comparison are displayed in Table 12. The results show that in most cases the fluctuations in inventory inbounds and outbounds, production and orders are reduced for both the Technische Unie as Legrand as well as their average inventories, with their according deterioration in service levels. However the combined products 4536827 and 4536835 display different results. Analysis has shown that this is caused by the excessive sampled demand values in the Stochastic series, which has been covered in paragraph XXX. In the Empirical showcase the KPI's resemble the products 4255030, 4536553 and 4531430. Also, for the slow moving products 3407384 and 4256632 the reduction of MDBO's and lead times does not create an overall improvement. This leads to the proposition that the reduction of lead times and MDBO's is less beneficial for slow moving products.

		4536827 & 4536835		4255030		4536553		4531430		3407384		4256632	
IA +MDBO = 7 +LT = 7													
MDBO		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7	
Lead Time		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7		Fr 13 to 7	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
General KPI's													
Service level	By perc of total quantities delivered on time	-0,05	-0,11	-0,01	0	0,01	-0,02	0	-0,02	-0,17	0	-0,06	0
	By perc of days without any backlogs	-0,06	-0,13	-0,01	0	0,01	-0,03	0	0,02	-0,19	0	-0,06	0,01
Inventory turnover	Times per year for finished products	0,31	0,02	0,23	0	0,18	-0,01	0,1	0,01	0,39	-0,01	0,26	0
	Times per year for materials		0,03		N/A		0		N/A		N/A		0
Bullwhip Effect	Amplification on weekly level	0,29	-0,59	0,17	0	0,37	N/A	0,32	-0,04	-0,03	-0,01	0,04	N/A
Inventory KPI's													
Average inventory	Average of finished products	0,24	0,02	0,19	0	0,15	-0,01	0,09	0,01	0,28	0	0,21	0
	Average of materials		0,01		N/A		0		N/A		N/A		0
Max inventory	Maximum of finished products	0,1	-0,25	0,21	0	0,28	0,06	0,01	0	-0,03	0	0,07	0
	Maximum of materials		-0,48		N/A		0		N/A		N/A		0
Average inbound	Average inbound of materials/products	0,33	-0,18	0,28	0	0,45	N/A	0,42	0	0,13	-0,03	0,16	N/A
Max inbound	Maximum inbound of materials/products	-0,04	-0,34	0,05	0	0,36	N/A	0,43	-0,01	-0,03	-0,02	-0,04	N/A
Inbound frequency	Number of inbounds of materials/products	0,48	-0,15	0,36	0	0,79	N/A	0,68	0	0,13	-0,03	0,18	N/A
Average outbound	Average outbound of finished products	-0,02	0,04	0	0,11	0,01	0,23	0	0,17	0,05	0,06	0,01	0,11
Max outbound	Maximum outbound of finished products	0,02	-0,11	0,02	0	0,12	0,16	0	0,02	-0,07	0	0,04	0
Outbound frequency	Number of outbounds of finished products	-0,02	0,04	0	0,12	0,01	0,29	0	0,2	0,05	0,06	0,01	0,12
Production KPI's													
Average production	Average production quantity		-0,02		N/A		0,21		N/A		N/A		0,11
Max production	Maximum production quantity		-0,28		N/A		0,13		N/A		N/A		0
Production frequency	Number of production runs		-0,03		N/A		0,25		N/A		N/A		0,13
Ordering KPI's													
Average orders	Average order quantity	0,25	-0,18	0,28	0	0,41	N/A	0,42	0	0,13	-0,03	0,16	N/A
Max orders	Maximum order quantity	-0,04	-0,34	0,05	0	0,34	N/A	0,43	-0,01	-0,03	-0,02	-0,04	N/A
Order frequency	Number of orders	0,33	-0,15	0,36	0	0,69	N/A	0,69	0	0,13	-0,03	0,18	N/A
FAD KPI's													
Forecast deviation	Average forecast deviation												
	Av forecast deviation as a perc of av demand												
Discount percentage	Average discount percentage												
	Av disc perc as a perc of the max poss discount												

Table 12: Normative comparison of the changes of Mean Days Between Orders and lead times from 13 days to both 7 days in the Increment Alleviation cases.

Proposition 5: Forecast Accuracy Discount agreements are most effective in achieving Pareto Improvements for the Technische Unie and Legrand when forecast horizons are longer

In order to support this proposition an assessment of the effects of forecast sharing horizons are made for each of the 30 simulation cases. The results of this assessment is displayed in Annex XVIII. Here, the differences between the KPI values of forecast horizons from 2 weeks to 5 weeks and the situation without the FAD agreement are normatively displayed in percentages. These values are used to assess whether high or low forecast sharing horizons are desired by the Technische Unie and Legrand in each specific case. In Table 13 the results for each simulation case is displayed for the KPI groups Bullwhip Effect, inventory fluctuations, production fluctuations, ordering fluctuations, forecasting accuracy and received discounts by the Technische Unie. The KPI groups for service levels and average inventories are left out of the analysis, since they can be corrected according to the mechanism in proposition 1. For each KPI group within a simulation case the table displays for the Technische Unie and Legrand, whether they have a preference for higher horizons, lower horizons or no preference. The colour of the cell displays, whether this preferred forecast horizon improves, deteriorates or maintains the performance of that KPI group towards the situation with no FAD agreement. For the forecasting accuracy and received discounts no colours were given since they don't have any value in the situation with FAD agreements. In addition to this analysis an assessment has been made whether the FAD agreements achieve a Pareto Improvement towards the absolute empirical null case on all KPI's, except again service levels and average inventories, for both the Technische Unie as Legrand, regardless of their forecast sharing parameter value. These simulation cases have been highlighted with orange borders in Table 13. The normative comparison of the KPI values of each situation towards the empirical null case is displayed in Annex XIX.

Table 13 reveals high variability in the preference towards forecast sharing horizons among different products and the KPI groups Bullwhip Effect, inventory fluctuations, production fluctuations and ordering fluctuation. However, in the cases which create Pareto Improvements for both the Technische Unie and Legrand, higher horizons are often preferred for both. Also longer forecast sharing horizons provide in all situations more accurate forecasts, which is preferred by Legrand and

higher discount totals, which is preferred by the Technische Unie. Based on these findings we propose that longer forecast sharing horizons are most desired by both parties within the feasible cases in which a Pareto Improvement can be achieved.

		Nullcase		Increment Alleviation		IA + MDBO = 13		IA + MDBO = 7		IA + MDBO = 7 + LT = 7	
		TU	LG	TU	LG	TU	LG	TU	LG	TU	LG
4536827 and 4536835	BW Effect	Low	High	Low	High	Low	High	High	Low	High	Neutral
	Inventory fluctuations	Low	Low	Low	Low	Low	Low	High	High	High	High
	Prodution fluctuations		Neutral		Low		Low		High		High
	Ordering fluctuations	Low	Neutral	Low	Neutral	Low	Neutral	High	High	High	High
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	
4255030	BW Effect	Neutral	Neutral	Low	Neutral	High	Neutral	High	Neutral	High	Neutral
	Inventory fluctuations	Neutral	Neutral	Low	Low	Neutral	Neutral	High	Neutral	High	High
	Prodution fluctuations		N/A		N/A		N/A		N/A		N/A
	Ordering fluctuations	Neutral	Neutral	Low	Neutral	Neutral	Neutral	High	Neutral	High	High
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	
4536553	BW Effect	High	N/A	High	N/A	Low	N/A	High	N/A	High	N/A
	Inventory fluctuations	High	Neutral	High	Neutral	Low	Low	High	Neutral	High	Neutral
	Prodution fluctuations		Neutral		Neutral		Low		Neutral		High
	Ordering fluctuations	High	N/A	High	N/A	Low	N/A	High	N/A	High	N/A
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	
4531430	BW Effect	High	Neutral	High	Low	Low	Low	High	Low	High	Low
	Inventory fluctuations	Neutral	Neutral	Neutral	Low	Low	Low	Neutral	Low	Neutral	Neutral
	Prodution fluctuations		N/A		N/A		N/A		N/A		N/A
	Ordering fluctuations	High	Neutral	Neutral	Low	Low	Low	Neutral	Low	Neutral	Neutral
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	
3407384	BW Effect	High	Neutral	High	Neutral	High	Neutral	High	Neutral	High	Low
	Inventory fluctuations	Neutral	Neutral	Neutral	Neutral	High	High	High	High	High	High
	Prodution fluctuations		N/A		N/A		N/A		N/A		N/A
	Ordering fluctuations	Neutral	High	Neutral	Neutral	High	High	High	High	High	Neutral
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	
4256632	BW Effect	High	N/A	Low	N/A	High	N/A	High	N/A	High	N/A
	Inventory fluctuations	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High	High	High
	Prodution fluctuations		High		Neutral		Neutral		High		High
	Ordering fluctuations	High	N/A	Neutral	N/A	Neutral	N/A	High	N/A	High	N/A
	Forecasting accuracy		High		High		High		High		High
	Discounts received	High		High		High		High		High	

Table 13: Assessment of preferred forecast sharing horizons

8.2. Overall results

The overall results of the simulation for the specific case study are as follows: Legrand and the Technische Unie are able to simultaneously reduce the Bullwhip Effect and fluctuations in inventories, production and orders, while maintaining their service levels by adopting Forecast Accuracy Discount agreements with long order forecast sharing horizons of 5 weeks in combination with alleviating constraining increments ,reducing the order intervals of the Technische Unie and lead times of Legrand to an equal level of 13 or 7 days and raising the safety stock levels of both parties to maintain an acceptable service level. This may result in higher average inventories for both the Technische Unie as Legrand, which results in higher inventory holding costs, however lower fluctuations in inventories, production and orders will reduce the capacity investment costs and contingency costs of handling, manufacturing and transportation. These benefits are expected to be higher for Legrand as a manufacturer as for the Technische Unie as a distributor, especially because the shared forecast create more demand predictability for Legrand, however the discounts which the Technische Unie receives will compensate this inequality. This creates a Pareto Improvement in total operational costs and service levels for both Legrand as the Technische Unie.

8.3. Incentivized behaviour

Given the static systemic operational behaviour in the simulation model, both the Technische Unie as Legrand have aligned incentives in adopting and defining the conditions of the Forecast Accuracy agreements. Both Legrand and the Technische Unie benefit from minimizing the order increments for the Technische Unie. Since Legrand can determine the order increments they will set them at the minimal allowable quantities given the physical constraints of production. Furthermore, Legrand is incentivized to adapt the physical structure of its operational systems to suit smaller series sizes and negotiate smaller order increments to its suppliers to fully benefit on the long term.

According to the analysis, both Legrand as the Technische Unie prefer to shorten the order intervals and lead times to 7 days, resulting in predictable weekly orders from the Technische Unie. For slow moving product the simulation results have shown that there is no strong incentive to shorten from 13 days to 7 days, so for slow moving products a two week interval can be applicable. In order to be increase the accuracy of their forecast and received discounts, the Technische Unie is incentivized to adopt an ordering policy which is based on actual fixed order intervals, rather than the current Mean Days Between Orders.

For the conditions of the FAD agreements, the simulation shows that both the Technische Unie as Legrand prefer long time horizons, because it increases the predictability of the orders of the Technische Unie for Legrand and its increases the discounts for the Technische Unie. The simulation outcomes show that the Technische Unie is incentivized to follow the principals of honest forecast sharing and ordering according to their forecasts unless higher quantities are required.

For defining the discount bounds and the maximum discount percentages, the Technische Unie have constructive conflicting interests which will lead to optimal values. The Technische Unie will prefer higher bounds and maximum discount values and will only accept values that will lead to sufficient discount to reduce total costs. Legrand will prefer lower bounds and maximum discount values, but will have to provide enough maximum discounts and tolerance in the bounds to interest the Technische Unie. Then again, these minimal requirements of the Technische Unie should be small enough to remain total cost benefits for Legrand.

9. Design evaluation

Finally, we will evaluate the designs on the goals and requirements defined in chapter 3.3. For this evaluation we use the qualitative assessment of the Forecast Accuracy Discount Agreement mechanisms as described in Chapter 6 and the quantitative assessment of the agreements as described in chapter 8.

9.1. Verification towards goals

In the goals tree described in chapter 3.3 the overall goal for the design is stated as increasing to the competitiveness of Supply Chains by contributing to customer satisfaction through increasing service levels and contributing to the reduction of total costs by reducing contingency costs, operational costs and investment costs. This major goal should be achieved by reducing the oscillations of orders, inventories and production and their application, in order to reduce the capacity needs, average product quantities in the Supply Chain and stock outs, resulting in backlogging, lost sales and expediting. A copy of the goal tree is displayed here in Figure 33.

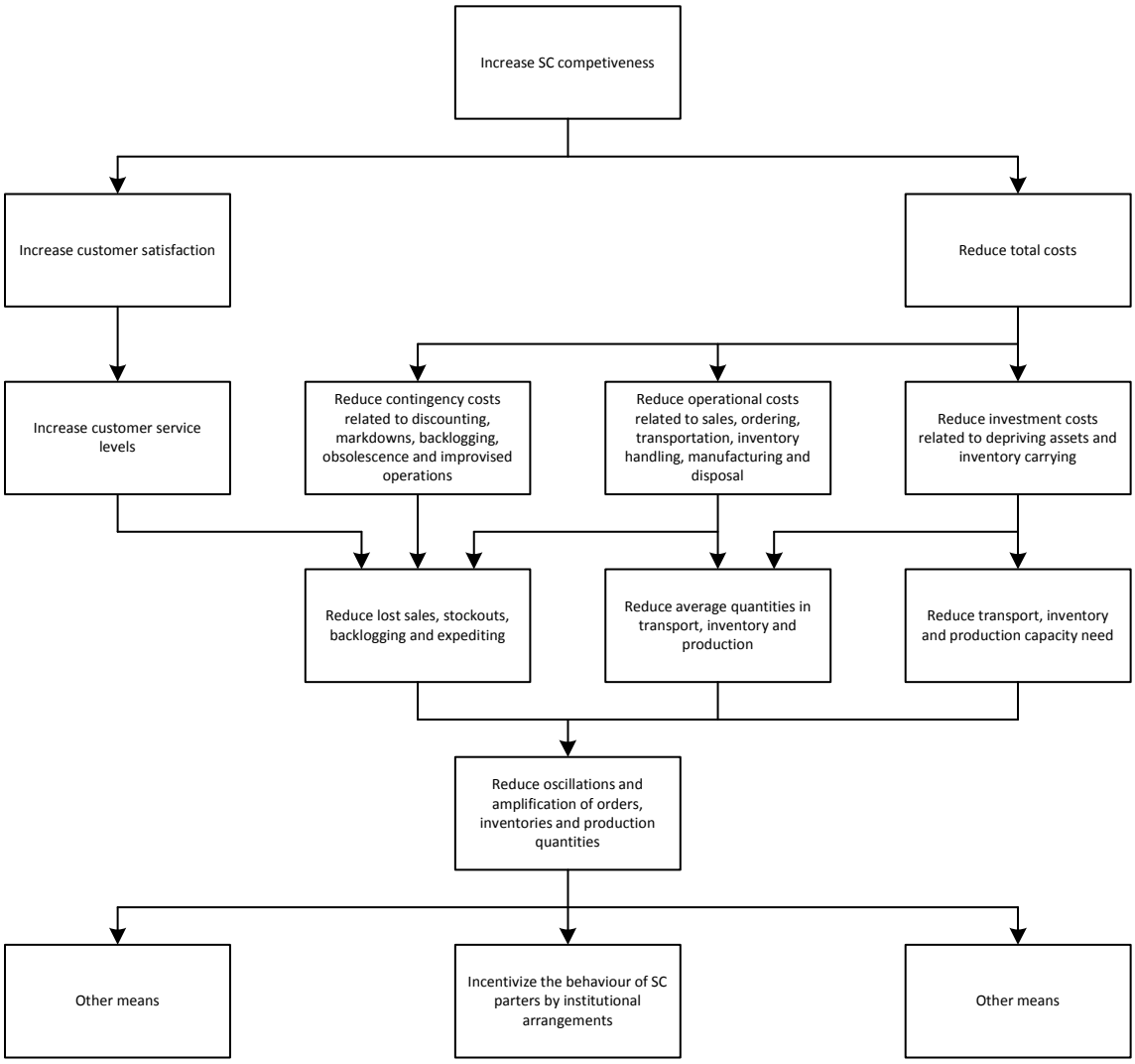


Figure 33: Copy of the goal tree displayed in Chapter 3.3

As described in chapter 8 the Forecast Accuracy Discount agreements lead to reductions in oscillations in inventories, production and orders for both the Technische Unie and Legrand as well as the amplification of these oscillations along the Supply Chain. The reduction of the maximum order sizes, production quantities and inventory inbounds and outbounds indicate the reduced transport, production and inventory capacity need, which contributes to the reduction of investment costs. The reduction of average orders, production quantities and inventory inbounds and outbounds indicate the average quantities in transport, production and inventory handling, which contribute to the reduction of operational costs caused

by additional unnecessary improvised activities. Inventory quantities. Average inventories are expected to rise when safety stocks are increased to maintain service levels. This results in higher inventory investment cost, however these costs are expected to be outweighed by the reduction of other costs and for the Technische Unie by the received discounts from Legrand. Stock outs are expected to remain equal by raised safety stocks so their effects on the service levels , contingency costs and operational costs are assumed to be neutral.

This results in the Forecast Accuracy Discount agreements to be increasing the competitiveness of Supply Chains by reducing the contingency cost of improvised operations, the operational costs of handling, transportation and production and the investment costs in inventory, transportation and production capacity, which outweigh the additional inventory investment costs, while maintaining the service levels to customers.

9.2. Verification towards requirements

Table 14 displays an overview of the assessment of the Forecast Accuracy Discount agreements towards the design requirements stated in chapter 3.3. The simulation results have shown that adopting the FAD agreements with its proposed parameters results in benefits for both the Technische Unie as Legrand, has positive externalities to suppliers of Legrand by reducing the order oscillations of Legrand and has no negative effects on other customers of Legrand and the Technische Unie since the service levels are maintained. Therefore adopting the FAD agreements is in the interests of the participants and acceptable by external parties. The agreements are also within the European market laws and regulations, however it is yet uncertain to which extent it is in accordance with informal institutions. The Technische Unie has already stated to be willing to adopt the FAD agreements, however to which extent Legrand or other suppliers consider the agreements appropriate is yet unknown.

The design is mostly within the requirements for feasibility. Within the case study the FAD agreements incentivizes the consistent application of operational policies and conditions of the agreement which results in Pareto Improvements for both the Technische Unie as Legrand, which contributes to the stable behaviour of the design and the applicability to the case study. Also the arrangement provided possibilities for short term adoption termination and adaptation, which qualifies it on the requirement to be sufficiently flexible. The discounting structure of the FAD agreements provides direct and clearly understandable feedback for the customer. Therefore the design is considered to have sufficient immediate and clear effect. The manageability is however a difficult aspect to assess, because it requires actual implementation or piloting to assess this. The Technische Unie has however plans to implement the agreements and has confidence that it will be feasible within current operational processes.

Group	Requirement	Within req.	Motivation/recommendations
Acceptability	Interest alignment of participant	Yes	Cost reduction for both parties while maintaining or improving customer service of both TU as LG
	Allowance by externals	Yes	Positive externalities to suppliers and customers
	According to formal institutions	Yes	Suitable within market laws and regulations
	According to informal institutions	Uncertain	Acceptance by both the Technische Unie as Legrand
Feasibility	Applicability within case study	Yes	Pareto improvement for both the Technische Unie as Legrand
	Stable behaviour	Yes	Aligned interests and constructive conflicts between the Technische Unie and Legrand
	Flexibility to change	Yes	Arrangement has conditions for termination and adaptation
	Manageability	Uncertain	Acceptance by both the Technische Unie as Legrand
	Immediate and clear effect	Yes	Direct effect on order quantities placed by buyer
General applicability	Within diverse company identities	Yes	No organization elements within the systems model which prevent applicability
	Within diverse Supply Network structures	Yes	No Supply Network structures in the systems model which prevent applicability
	In diverse configurations	Yes	Positive externalities to suppliers and customers
	In diverse product types	Yes	No product properties (size, perishability, value density and vulnerability) that prevent applicability

Table 14: Assessment of FAD agreements on the design requirements

Finally, the design is considered to be generally applicable. The systems model displays the generic Supply Network situation in which the Bullwhip Effect occurs. The functioning of the mechanisms of the FAD agreements are not constrained by any possible element in any structure. Therefore the design is alleged to be generally applicable within diverse companies and Supply Network structures. Also, the positive externalities to suppliers and customers of the Technische Unie and Legrand indicates that the design can be implemented in various commercial links in the Supply Network and reinforce each other's effectiveness, which makes it applicable in any Supply Network configuration. Finally there are no relevant product properties which interfere with the effectiveness of the FAD agreement.

9.3. Positioning the FAD agreements within existing solutions

In chapter 5 we have analysed the solutions for the Bullwhip Effect to define and structure the solution space for this problem in order to delineate the specific solution space for incentivizing agreement. Now we will use this structure, which is elaborated in Annex VII, to position the Forecast Accuracy Discount agreements within existing solutions and define how the FAD agreements are a different and new approach to the Bullwhip Effect.

In order to do this we have distinguished between conceptual solutions and predefined solutions which are, like FAD agreements, a specific configuration of conceptual solution elements. In Figure 34 the groups of conceptual solutions are displayed as solid white blocks, while similar predefined solutions are grouped into grey blocks and connected to the groups of conceptual solutions that are part of them.

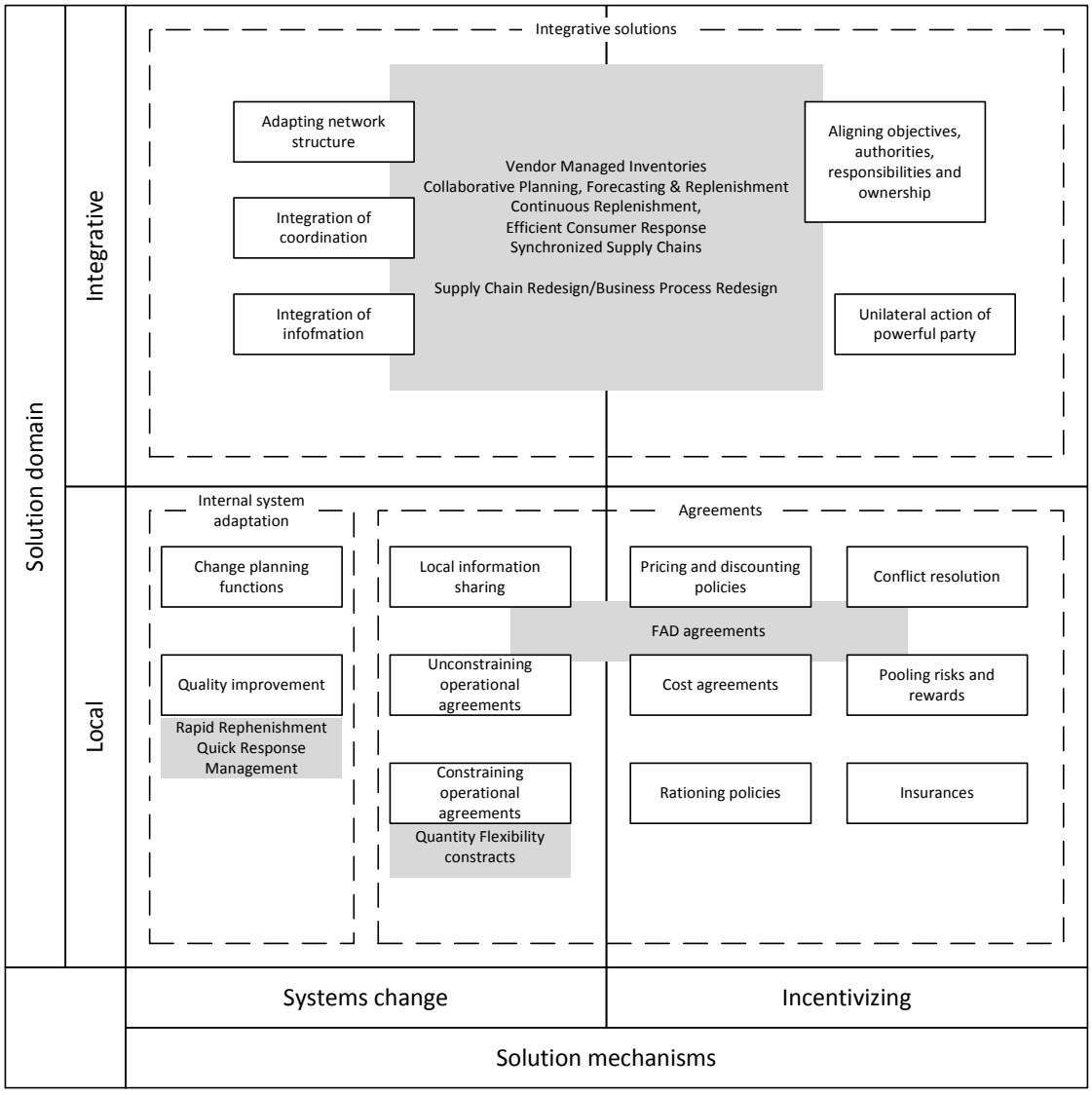


Figure 34: Positioning of conceptual solutions and predefined solutions to the Bullwhip Effect

Both conceptual as predefined solutions can be positioned according to two dimensions: First, solutions can have a local domain within a company or between two companies, or have an integrated domain spanning among two companies or more. Secondly, solutions can either be a systems change or incentivizing behaviour. The two other found solution areas, education and relationship building are not included, because no predefined solutions were found within these solution mechanisms. Unlike the solution domain dimension, the system change and incentivizing solution mechanisms are not mutually exclusive, meaning that a predefined solution may contain conceptual elements of both areas.

The analysis in Figure 34 shows that there are three groups of solutions, which are indicated by the broken lines: Integrative solutions, internal system changes and agreements. Common predefined integrative solutions contain vertical integration of coordination and integration of information systems as systems change solutions and the according alignment of objectives, authorities, responsibilities and ownership as according incentivizing solutions. Vendor Managed Inventories, Collaborative Planning, Forecasting & Replenishment, Continuous Replenishment, Efficient Consumer Response and Synchronized Supply Chains contain these integrative elements. Supply Chain Redesign and Business Process Redesign solutions even include the adaptation of Supply Network structures in addition to these solution elements.

Internal system changes are local system changes. This group includes changing planning functions by smoother and better forecasting, the application of higher safety stocks to allow fluctuations and dampened ordering, but also the improvement of the quality of processes by reducing lead times and increase their accuracy and flexibility. Rapid Replenishment and Quick Response management systems have been proposed as predefined solution for the Bullwhip Effect in this category and are both related to the quality improvement of processes group.

Finally agreements are local solutions which can contain both systems changes as incentivizing measures. Parties can agree to change their systemic behaviour by sharing local information and constrain their possibilities, such as disabling returning goods, bounding allowed order quantities and minimum purchase agreements. Quantity Flexibility Contracts are such constraining agreements (Tsay and Lovejoy 1999). Also operational agreements may contain constraining elements such as reducing minimum order quantities and increments and increase order frequencies. On the other hand agreements may contain conditions regarding pricing and discounting, charged costs to customers, redistribution of risks and benefits, conflict resolution, rationing in shortage situations and external insurances.

The Forecast Accuracy Discount agreements contain both systemic agreements on order increments sizes and order intervals as incentivizing elements, such as conflict resolution and the redefinition of discount and order cost structures, which indirectly is related to pooling the risks related to the uncertainty of external demand and benefits of providing predictable demand towards suppliers. The FAD agreement is an unique solution to the Bullwhip Effect, because it is the only local agreement that uses the mechanism of incentivizing to influence the behaviour of Supply Chain parties without the need of commitment to constraining their possibilities or integrating their operations with other parties. FAD agreements are combinable with containing agreements, such as Quantity Flexibility Contracts and internal systems changes, which are even incentivized. Integrative solutions interfere with the FAD mechanism and therefore they are mutually exclusive. FAD agreements cannot be combined with these solutions.

9.4. Assessing the areas of applicability of FAD agreements

In Chapter 2.2 we have delineated the environment and products to which the Bullwhip Effect is applicable: Relatively stable market structures in which companies place frequent orders of products which must be tangible, storable, have distinguishable discrete units which are traded in large volumes and have long life cycles and stable demand patterns which can be more or less forecasted. Within these requirements the Bullwhip Effect can manifest within varying types of markets and products. We will assess the effectiveness of the Forecasting Accuracy Agreements in comparison to other solutions within different market situations and for different product properties

Relevant product properties for the Bullwhip Effect are vulnerability to damage, perishability, size, value density and obsolescence risks of phase-out products, but they have little effect on the effectiveness of Forecast Accuracy Discount agreements and other solutions. For very small and invaluable products, reduction of the Bullwhip Effect is less important, because they cause less transportation, handling and inventory carrying cost. The potential benefits of reducing these costs don't provide enough financial incentives to adopt FAD agreement structures. This situation is however generic for all solutions to the Bullwhip Effect. FAD agreements do, however, perform better for phase-out products with high obsolescence risks, because they provide more flexibility to change operational policies and adaptiveness to abandon the arrangement for a specific product. This makes them more appealing than common integrative solutions which are more constraining and require higher investments. Perishable products provide natural incentives to smoothen flows of goods,

minimize inventories and abstain from strategic ordering, because of the inherent risk of spoiling. In order to control these risks, Integrative solutions may therefore be more acceptable than for other products, however these products offer no constraints to apply FAD agreement.

Unlike product properties, FAD agreements are more suitable for different Supply Network structures than most common integrative solutions. Supply Network structures may vary in number of links and nodes, determining its complexity and length of Supply Chain. These connections may also vary in dynamics of links and nodes, determining its stability. Because FAD agreements are local solutions they are little affected by these properties, however integrative solutions become more and more unfeasible as Supply Networks increase in complexity and dynamics. Also for more competitive Supply Networks, the FAD agreements are more feasible than integrative solutions, because they require low levels of trust to be acceptable. Finally, external governing formal institutions may be very strict in some markets towards the prevention of monopolies and cartels. Integrative solutions may not be acceptable to these regulations, however FAD agreements are less likely to interfere with regulation to protect free markets.

The effectiveness of FAD agreements is also dependent on internal and inter-organizational aspects. Commercial links of low strategic importance, for example when flows of goods are limited in volumes or of low value, are not feasible for any solution to the Bullwhip Effect, because they are not considered important enough by either or both of the involved parties, however since FAD agreements are more simple and require less investments they are suitable for more commercial links than integrative solutions. The effectiveness of FAD agreements are not presumed to be influenced by organizational structures or the type of activities of the actor, being either a manufacturer of a distributor, because FAD agreements do not interfere with these elements. There are, however, operational planning policies which align better with and are incentivized by the FAD agreements and are generally known to induce less Bullwhip Effect. Ordering policies that are based on fixed order intervals align better with FAD agreement, because also the agreements uses fixed planning intervals. As this study has shown it is however not necessary for ordering policies to have fixed order intervals to assure the effectiveness of FAD agreements. Also the FAD agreements operate better when forecasting policies are sufficiently able to forecast demand, however the results ofthis study towards slow moving goods has also shown that this is also not necessary

Finally, there are however two important organizational properties in which FAD agreements are not feasible which are related to the described problem perspectives in Chapter 6.4 which remain a barrier to the FAD agreements. First of all, in some organizations the interest to reduce costs by solving the Bullwhip Effect is predominated by other interests. Such organizations will not perceive the Bullwhip Effect as a problem, because they favour other performance factors. Secondly, organizations with a lack of sufficient competence of operations management, will not recognise the problem of the Bullwhip Effect and the potential of FAD agreements. These two barriers are however also present for the other solutions for the Bullwhip Effect.

10. Conclusions

In this Chapter we will conclude this research by first answering sub questions using the findings in the Chapters of this thesis. Finally we will answer the main question of this research.

1. What are the systemic and behavioural factors which contribute to the Bullwhip Effect?

From a systemic perspective the Supply Network consist of independent organizations which are linked though flows of goods, information and funds. From an operational perspective, each organization is centrally controlled by the definition of standards and objectives. An organization consists of a number of sites, such as factories, warehouses and distribution centres which are connected through the flows of goods and information. These sites are coordinated by one or more operational control systems, which are essentially offices which perform the relevant planning functions of ordering, inventory management, forecasting and sales and purchase negotiations with customers and suppliers. From a behavioural perspective organizations consist of divisions which behave as independent actors in hierarchical structures in which positions, responsibilities, authorities, procedures and rules are top down assigned to them. These actors are considered to be self-interested and bounded rational, meaning that they have a limited perceived reality and perception of available decision making options based on their available information and competences and external institutions. Within their perceived reality, actors compare their expected outcomes of decision on their interests and make decisions accordingly to these aspects. The outcomes of past decisions will add to their knowledge.

Regarding Supply Networks as such systems, the emergence, existence and persistence of the Bullwhip Effect can be explained by four types of problems: 1) Systemic problems, which are the result of the systemic behaviour of rational actors with asymmetric information, 2) knowledge problems, which are the result of bounded rational actors that behave systematically, 3) incentive problems, which are caused by rational actors which, in situations of information asymmetry, base decisions on the expected behaviour of other self-interested actors and 4) relational problems, which arise when actors are considered bounded rational, but anticipate on the behaviour of other actors, based on their own limited mental models.

2. Which goals related to the Bullwhip Effect have to be achieved by the Forecast Accuracy Discount agreements and which requirements are there for the institutional design?

The Forecast Accuracy Discount Agreements should reduce the oscillations of orders, inventories and production as well as their amplification along Supply Chains to the extent, that it leads to the reduction of total operational costs while maintaining or improving the service levels for all Supply Chain parties. The reduced oscillations and amplifications should cause the reduction of the capacity needs for transportation, production and inventory handling in order to reduce the investment costs in assets and inventory. Also the reductions should reduce the average units of products which are present in transport, production and inventories, resulting in lower operational costs due to more effective planning and lower investment costs in inventories. Finally, the reductions in oscillations and amplification of these should result in les stock outs, resulting in backlogs, lost sales and expediting, which causes extra contingency costs and reducing service levels.

The Forecast Accuracy Discount agreements should be decentralized institutional agreements between organizations in a supplier-buyer relationship that incentivizes the behaviour of these actors, which will result in the emergence of the goals stated above. The Forecast Accuracy Discount agreements should be acceptable, feasible and generally applicable. Acceptability includes alignment with the interests of the two involved organization, allowance by external parties and the compliance with formal and informal institution. In order for the Forecast Accuracy Discount agreements to be feasible it should result in stable operational behaviour of the involved actors and also on a tactical level there should be a stable consensus on the conditions of the agreement as well. Feasibility also includes enough flexibility to adopt, adapt and abandon the agreements, enough short term clarity to understand the right behaviour for less competent actors and the manageability of the processes resulting from applying the agreements. Finally the Forecast Accuracy Discount Agreement should be generally applicable for the most common forms and identities of organizations, as well as the most common Supply Network structures. It should be effective for products with diverse sizes, perishability properties, value densities and vulnerability properties and the agreements should be effective in any configuration in Supply Networks.

3. Why are Forecast Accuracy Discount agreements suitable institutional agreements to achieve the stated goals and requirements?

Forecast Accuracy Discount agreements are a simple and understandable mechanism which financially incentivizes customers to order more frequently and smoothen order quantities as much as possible in operational short terms, providing customers with a more predictable and stable demand. It incentivizes suppliers to reduce constraints in order sizes as much as possible. On a longer tactical and strategic time horizon the agreements incentivize customers to redefine their ordering policies and operations to suit more stable ordering and it incentivizes suppliers to reduce increment constraints in its physical operational systems to capitalize on the smoother and more predictable demand.

The Forecast Accuracy Discount mechanism works as follows: Along regular intervals, customers provide forecast of its own expected orders to its suppliers. The customer is required to share these forecast a predefined amount of time in advance. After this forecast sharing horizon the forecast cannot be changed anymore. The customer remains free to place any orders it wants, however ordering according to its shared forecasts will result in discounts on the purchase price. The more accurate the actual order total in a period according to its forecast, the higher the discount percentage will be for the customer up to a predefined maximum for full accurate ordering.

Essentially, the Forecast Accuracy discount agreement can be explained as the supplier rewarding its customers for more smooth and predictable ordering and sharing its cost savings by achieved operational efficiency. Customers are incentivized to use their inventories as buffers for fluctuations in demand, resulting in higher inventories, in order to reduce the more expensive fluctuations in transportation and production of its suppliers. The extra costs for the customer are overcompensated by the discounts received by suppliers.

Forecast Accuracy Discount agreements are able to improve the Supply Chain performance of both participating actors and create positive external effects to related parties in the Supply network. They are also compliant to most formal and informal institutions which makes them acceptable solutions for all stakeholders. The agreements are sufficiently simple to understand its effect, flexible to adapt and manageable to be feasible to implement. Also, they incentivize stable operational and tactical behaviour, which makes them feasible to maintain. Finally the Forecast Accuracy Discount agreements are generally applicable in most common companies, Supply networks for most products to which the Bullwhip Effect is applicable. Since they have positive external effects over the Supply network, any configuration of Forecast Accuracy Discount agreements over the Supply Network is expected to be effective.

4. What are the effects of Forecast Accuracy Discount agreements on the Bullwhip Effect for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland?

First of all, the alleviation of constraining order and production increments is a part of the Forecast Discount Agreements that significantly reduces the Bullwhip Effect and fluctuations in inventories, production and orders for both the Technische Unie and Legrand where applicable Also, reducing the order intervals of the Technische Unie by lowering their Mean Days Between Orders parameter, reduces their Bullwhip Effect and also the fluctuations in inventories, production and orders for both parties where applicable. The reduction of order intervals is only effective as long as they are exceed or equal the lead times of Legrand, which is 13 days for all simulated products. Further reduction of order intervals requires the reduction of lead times as well. For fast moving products reduction of the Mean Days Between Orders and led times from 13 days to 7 days is beneficial for the Bullwhip Effect and fluctuations, however for slow moving products the effects are limited.

Higher forecast sharing horizons of 5 weeks create the best outcomes regarding the Bullwhip Effect and fluctuations of inventories, production and orders for both Legrand as the Technische Unie in the feasible situations where the Forecast Accuracy Agreements create Pareto Improvements for both parties. For all tested products these situations include the alleviation of constraining order and production increments combined with the reduction of order intervals to 13 days or 7 days with according lead times. Regardless of any situation higher forecast sharing horizons create the best ordering accuracy towards its shared forecast to Legrand resulting in the highest discounts for the Technische Unie.

Both the alleviation of constraining increments, reduction of order intervals as higher forecast sharing horizons reduce the average inventories and service levels of both Legrand as the Technische Unie. A strong and consistent positive correlation was found between average inventories and service levels, a principle that is commonly known in among operations managers. In order to maintain the desired service levels, both parties can raise their safety stocks to correct this effect. The expected inventories after bringing the service levels back to the null case situation are expected to be slightly higher, because this was perceived in the simulation cases were the effect on service levels were neutral.

Legrand and the Technische Unie are therefore able to simultaneously reduce their Bullwhip Effect and fluctuations in inventories, production and orders, while maintaining their service levels and accepting a small raise in average inventories. This may result in higher inventory holding costs, however lower fluctuations in inventories, production and orders will reduce the capacity investment costs and contingency costs of handling, manufacturing and transportation. Legrand as a manufacturer is expected to have greater benefits than the Technische Unie as distributor, especially because the shared forecasts increase the predictability of demand and planability of operations, however the received discounts by the Technische Unie are expected to compensate this inequality. This results in a Pareto Improvement in total operational costs and service levels for both Legrand as the Technische Unie.

5. What is the sensitivity of the effects of Forecast Accuracy Discount agreements to changes in the Supply Chain coordination system for the Van Geel product portfolio in the Supply Chain of the Technische Unie and Legrand Nederland?

The sensitivity of different demand patterns has been tested by performing the simulation for four fast moving products and two slow moving products and sampling the demand patterns according to its founds distributions and seasonality. The effects of the Forecast Accuracy Discount agreement were similar in most ways, which indicates a low sensitivity of the agreement towards demand patterns. The improvements in effectiveness by lowering the order intervals and lead times from two weeks to one were significantly less for slow moving products. This indicates that the benefits and incentives to reduce order intervals and lead times for slow moving products is less than for fast moving products. The simulations have also been tested for both manufactured as trade products of Legrand. There was no difference found in the effectiveness of the Forecast Accuracy Discount agreements between these two products, indicating no sensitivity towards the effects of the agreements and the product type for Legrand.

The simulations have been based on the empirical ordering policies and forecast values. Therefore this research has not determined the sensitivity of the effects on Forecast Accuracy Discount agreements towards different ordering policies and forecasting methods. The ordering policies of Legrand are based on a system with fixed quantities and variable ordering intervals. The Technische Unie orders according to a system with variable quantities and preferably fixed intervals. The simulation results indicate that there is no sensitivity among these two ordering policies in the effects of Forecast Accuracy Discount agreement, however further research is needed to assess this sufficiently.

Main research question: ***"What are the effects of Forecast Accuracy Discount agreements between supply chain parties on the behaviour of actors in Supply Chains and the Bullwhip Effect?"***

Assuming full rationality of actors the effects of the Forecast Accuracy Discount agreements on the behaviour of the supplier and buyer who have engaged the agreement with each other can be divided in three categories: 1) The incentivized daily operational behaviour, given the conditions of the Forecast Accuracy Discount agreement and operational structure of their organizations, 2) the incentivized tactical behaviour regarding their preferences towards defining the conditions of the Forecast Accuracy Discount agreements and redefining their own planning parameters, given the operational structure of their organizations and 3) The incentivized strategic behaviour regarding redefining their planning policies and physical operational systems in order to increase their benefits from the agreements.

From an operational perspective, the customer is incentivized to order as much as possible according to its shared order forecasts unless higher order quantities are strictly necessary to prevent stock outs. The customer is also incentivized to keep deviations to a minimum in order to receive maximum discounts. The customer is also incentivized to share its forecast honestly according to its own expectations, however in case of deviations the customer is incentivized to adjust its order forecasts to the average expected demand. This operational behaviour reduces the fluctuations in orders and increases the demand predictability for the supplier. Furthermore, the customer is incentivized to increase its safety stock levels to allow more accurate ordering towards its forecasts while maintaining its service levels.

From a tactical perspective both the customer and the supplier have aligned incentives to alleviate constraining order and internal production constraints. The customer has incentives to lower the order intervals and time intervals for which it shares order forecasts to the lead time of product. Furthermore it benefits both the supplier and the customer when both order intervals, forecast sharing intervals and lead times can be further reduced, especially for fast moving products. Also for the forecast sharing horizon both customers as suppliers have the aligned incentives to adopt longer horizons, preferably up to the total throughput time of the operational system of the supplier. For the discount bounds and maximum discount percentage in the Forecast Accuracy Discount agreement, the supplier and customer have conflicting interests, however they are expected to lead to a constructive outcome. The supplier prefers short bounds and low maximum discount, where the customer prefers these values to be as large as possible. The definition of these values will

be the outcome of tactical negotiations and are expected to result in a situation where the transferred discounts result in total cost improvement for both parties.

Finally, from a strategic perspective, both the supplier as customer have incentives to adopt the Forecast Accuracy Discount agreements. Furthermore, the supplier has the incentives to adapt the physical structure of its operational systems to suit smaller series sizes which allow smaller increments in the future, as well as adapting its operational structure to support shorter lead times whenever possible. The customer has the incentives to revise its ordering policies towards a system with fixed order intervals and variable quantities to suit the nature of the Forecast Accuracy Discount agreements.

The above described behaviour assumes rational actors which are aware of the effects of Forecast Accuracy Discount agreement, however the validity of this rationality assumption is questionable. Most organizations operate from old industrial paradigms based on the principles of scales of economies and the ability of centralized control. Initially, organizations may not understand the potential benefits of adopting Forecast Accuracy Discount agreement and even when they do, there will be barriers to change. Due to the distribution of responsibilities and authorities in organizations, it may be in the interests of some divisions not to adopt the agreement. Especially for commercial divisions the Forecast Accuracy Discount agreements may be perceived as a threat for their authorities and performance. Also, priorities of organizations may lie at other issues, causing a lack of available resources to implement the agreements. Finally, in commercial relations where customers have strong power positions and are able to multisource at numerous suppliers, these cooperative agreements may not be in the interest of customers.

The Forecast Accuracy Discount agreements are not able to overcome these barriers, however their simple nature makes them easy to understand and implement. Their focus on cooperation and acquisition of mutual operational improvements makes it a suitable instrument in building and strengthening trust and relationships among Supply Chain parties which may be the key to other future cooperative Supply Chain initiatives.

11. Recommendations

In this chapter we will provide recommendations for further scientific research towards the effectiveness of Forecast Accuracy Discount agreements as well as practical recommendations for the implementation of the FAD agreements by the Technische Unie.

11.1. Scientific recommendations

In this research the Forecast Accuracy Discount agreements have been designed and tested on their basic effects in the specific case study. The results of this research indicate that the agreements are promising solutions to the Bullwhip Effect, however from a scientific perspective much more theoretical and empirical research is necessary to arrive at more solid knowledge about the effectiveness of Forecast Accuracy Discount agreements. We recommend the use of more case studies to test the robustness of these results. The application of theoretical Operations Research studies using mathematical analysis, can bring more certainty to the systemic effects of applied heuristics in the Forecast Accuracy Agreements. The application of Serious Gaming experiments can test the tactical behaviour of bounded rational actors towards negotiating the conditions of the Forecast Accuracy Discount agreements and the settings of operational parameters.

Specifically for the outcomes of this simulation case study, we would recommend to perform additional research to the effects of adjusting safety stocks to correct negative changes in service levels caused by the reduced average inventories. In this research we have supported the argument that this is possible, however we have not actually researched the effects of changing safety stocks.

Also the effects on costs have been estimated on the results in flows of goods, rather than an actual calculation of the relevant cost elements. This was necessary, because the availability of data to estimate costs according to the operational results were not sufficiently accurate or unavailable. We propose to research the effects on costs in a case study where accurate financial information is available according to the Activity based Costing structure. Also a theoretical study can be performed where these cost factors are estimated.

Finally we suggest to test the effects of Forecast Accuracy Discount agreements over multiple echelons in Supply Chain to assess the interactive effects of multiple Forecast Accuracy Discount agreements in the same Supply Network. We have assessed by the simulation results that the external effects of the agreements are positive and therefore multiple FAD agreements are expected to reinforce each other's effectiveness, however we have not been able to test this.

11.2. Practical recommendations for the Technische Unie

As a follow-up to this research the Technische Unie has requested guidelines for the implementation of Forecast Accuracy Discount agreements with suppliers. This section covers the generic principles for this implementation.

Three levels of cooperation

As described in the design description in chapter 6 the elements of the FAD agreements can be implemented independently. We propose three consecutive levels of cooperation with suppliers through agreements

1. Redefining increments, lead times and order intervals: As a first step the Technische Unie can inquire with suppliers whether it is possible for them to reduce order increments and lead times where necessary and explain them their aim to reduce the Bullwhip Effect. The Technische Unie can commit to more frequent ordering using smaller MDBO values when suppliers commit to lower order increments and lead times.
2. Adopting Forecast Accuracy Discount agreements: The optional next step is to adopt the FAD agreement mechanism as described in Chapter XXX.
3. Adopting additional agreements upon information sharing and communication: Furthermore the Technische Unie can adopt agreements upon sharing of operational information and frequent meetings to inform each other of expected trends in products and demand patterns.

Which products to select?

We propose to start the implementation by defining the products for which the Technische Unie would like to reduce the Bullwhip Effect. In order to do this the Technische Unie should make two types of assessment for each products: 1) Whether the product has problematic Bullwhip Effect which may be reduced and 2) Whether the product is of enough strategic importance to the Technische Unie to invest resources into solving the Bullwhip Effect.

Assessment of problematic Bullwhip Effect

This assessment can be done using a spread sheet model in which the Bullwhip Effect is defined according to the definition in chapter 3.2, preferably calculated on a weekly basis. Furthermore the percentage of increments towards the total yearly orders can be calculated to assess whether increments are a cause of the Bullwhip Effect and the percentage of lead times towards the MDBO's van be calculated in order to assess whether long lead times are causing the problem.

Assessment of strategic products

First of all, the product portfolio should be filtered by excluding F products and phase out products, because they are not relevant. Then an assessment should be made according to the relative share of these products in value, inventory space, sales quantities and handling operations. This assessment will resemble the ABC categories, except it has an extra focus on value and operations.

The products can then be categorized into four types according to the assessment whether they are strategic and have Bullwhip Effect problems. Figure 35 illustrates theses four categories. Exclamation marks are the products which require the immediate attention, because they are of strategic importance to operations and have problematic Bullwhip Effect. Question marks are strategic products without any direct Bullwhip Effect problems. These may be further examined to assess whether the FAD agreements may be beneficial. The comma's are products which encounter problematic Bullwhip Effects, but are not of strategic importance. The according strategy here is to address them later when possible. The dots are products which are not strategically important and have no Bullwhip Effect problems. These require no attention.

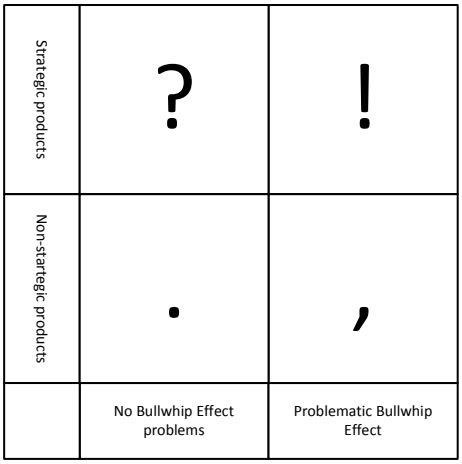


Figure 35: Product categorization according to strategic importance towards operations and Bullwhip Effect problems

Which suppliers to cooperate with?

Naturally, the Technische Unie should assess their suppliers according to their product types and amount of products they supply which are considered exclamation marks. The Technische Unie can prioritize suppliers according to this number and then assess which suppliers to address first. We recommend to initiate piloting the FAD agreements with mutual strategic relations with a long relationship history such as Legrand, Draka, Remeha and Itho Daalderop.

Arguments for internal support for reducing the Bullwhip Effect by FAD agreements

The implementation of FAD agreements will result in a total cost reduction in operations, while maintaining or improving the service levels. The major cost reductions result from the received discounts of suppliers and the effects of more smooth replenishment inbounds, which will lead to more stable and predictable inbound operations at the distribution centres and less fluctuations in inventories. This reduces the maximum inventory capacity needs and the extra operational costs of fluctuating staffing needs for inbound operations. These cost reductions will outweigh the expected increase in average inventories.

Arguments for acquiring support of suppliers to cooperate with implementing FAD agreements

The implementation of FAD agreements will result in more stable and predictable demand from the Technische Unie, which improves the planning capabilities. The reduced fluctuations in orders of all products will result in more stable transportation needs which will compensate the additional transportation movements due to more frequent ordering. For large suppliers of the Technische Unie less extra transportation movements are expected because of the consolidation of all products in trucks. The more stable and predictable demand will allow better production and replenishment planning,

reducing the operational costs and stock outs. Also, the lowered fluctuations in orders will result in lower fluctuations in inventories and production, which reduces capacity needs.

Implications for processes

Both for the Technische Unie as suppliers the implementation of Forecast Accuracy Discount agreements will affect their planning and administrative processes. For the initiation of the FAD agreements operational processes and parameters will need to be redefined for both parties. Also the agreements will result in additional repetitive operational and tactical processes for both parties. These are listed in Figure 36.

	Technische Unie	**Suppliers**
Initiation activities	- Redefining MDBO's and EOQ's - Redefine ordering policies taken FAD agreements into account	- Redefining lead times and increments/series sizes for customer orders, production and replenishment
Operational processes	- Increased workload due to more frequent ordering - Weekly forecast sharing - Added ordering considerations according to FAD agreements - Verifying FAD discounts on bills	- Increased workload due to more frequent order processing - Weekly forecast processing - Redefining forecasts and planning according to FAD forecasts - Defining FAD discounts on bills
Tactical processes	- Renegotiating conditions of the FAD agreements	- Renegotiating conditions of the FAD agreements

Figure 36: Implications for implementing and maintaining FAD agreements in administrative and planning processes for the Technische Unie and suppliers

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Annex I: Bullwhip Effect case study data list

			Data source	Data type
productinformatie		Levnr	Voorraden 2012	ID code
		Artnr TU	Voorraden 2012	ID code
		Leverancier artnr	Voorraden 2012	ID code
		Omschrijving	Voorraden 2012	String
		ABC codes	EOQ info per levnr	Quantitative
		jaarforecast	EOQ info per levnr	Quantitative
		Increment	EOQ info per levnr	Quantitative
		Minimum Days Between Orders	EOQ info per levnr	Quantitative
		Lead Time	EOQ info per levnr	Quantitative
		Distribution Centre	EOQ info per levnr	ID code
		Warehouse location	EOQ info per levnr	ID code
		Ordersize	EOQ info per levnr	Quantitative
		Volume	EOQ info per levnr	Quantitative
		Weight	EOQ info per levnr	Quantitative
		Days on stock	EOQ info per levnr	Quantitative
		EOQ	EOQ info per levnr	Quantitative
		Theoretical Minimum Days Between Orders	EOQ info per levnr	Quantitative
		Purchase price	EOQ info per levnr	Quantitative
		Weekly days for deliveries by suppliers	EOQ info per levnr	Categories: (Mo, tu, we, thu, fri)
Data on montly level over 2012	Demand	period_46	Vraag 2012 p01 tm p13	Quantitative
		period_47	Vraag 2012 p01 tm p13	Quantitative
		…	Vraag 2012 p01 tm p13	Quantitative
		period_58	Vraag 2012 p01 tm p13	Quantitative
	Orders	period_46	Vraag 2012 p01 tm p13	Quantitative
		period_47	Vraag 2012 p01 tm p13	Quantitative
		…	Vraag 2012 p01 tm p13	Quantitative
		period_58	Vraag 2012 p01 tm p13	Quantitative
	Demand statictics	total	Derived data	Quantitative
		average	Derived data	Quantitative
		variance	Derived data	Quantitative
		stdev	Derived data	Quantitative
		stdev/av	Derived data	Quantitative
	Order statistics	total	Derived data	Quantitative
		average	Derived data	Quantitative
		variance	Derived data	Quantitative
		stdev	Derived data	Quantitative
		stdev/av	Derived data	Quantitative
	BW Effect	Value	Derived data	Quantitative
Data on weekly level over 2012	Demand	period_46.1	Vraag 2012 p01 tm p13	Quantitative
		period_46.2	Vraag 2012 p01 tm p13	Quantitative
		…	Vraag 2012 p01 tm p13	Quantitative
		period_58.4	Vraag 2012 p01 tm p13	Quantitative
	Orders	period_46.1	Vraag 2012 p01 tm p13	Quantitative
		period_46.2	Vraag 2012 p01 tm p13	Quantitative
		…	Vraag 2012 p01 tm p13	Quantitative
		period_58.4	Vraag 2012 p01 tm p13	Quantitative
	Demand statictics	total	Derived data	Quantitative
		average	Derived data	Quantitative
		variance	Derived data	Quantitative
		stdev	Derived data	Quantitative
		stdev/av	Derived data	Quantitative
	Order statistics	total	Derived data	Quantitative
		average	Derived data	Quantitative
		variance	Derived data	Quantitative
		stdev	Derived data	Quantitative
		stdev/av	Derived data	Quantitative
	BW Effect	Value	Derived data	Quantitative
BW Effect applicability analysis		BW Effect applicability	Arbitration	Categories: (J, N, Limited)
		Start period linear trend	Arbitration	Quantitative
		linear a	Derived data	Quantitative
		linear b	Derived data	Quantitative
		% linear a of av demand 2012	Derived data	Quantitative
		% deviation orders tow demand	Derived data	Quantitative
		No orders	Derived data	Categories: (J, N)
		other problem	Arbitration	Categories: (J, N)
Further analysis		% increments of total orders 2012	Derived data	Quantitative
		% of BW effect on weekly level to monthly level	Derived data	Quantitative
		% Lead time of MBDO	Derived data	Quantitative

Annex II: Case study product selection

General information

Supplier	Count
Draka	561
Itho daalderop	209
Legrand	652
Remeha	311

Product ABC codes	Count
A	22
B	84
C	252
D	594
E	520
F	261

Demand total 2012	Count
<=10	166
10<=100	521
100<=1000	606
1000<=10000	353
10000<=100000	84
100000<=1000000	3

Order increments	Count
1	856
1<=10	305
10<=100	434
100<=1000	125
1000<=5000	13

% of increments of total orders 2012	Count
0%<=1%	482
1%<=5%	469
5%<=25%	501
25%<=100%	191
>=100%	3
No orders	87

Mean Days Between Orders	Count
4	1
7	130
14	358
21	43
28	1184
55	3
84	14

Lead Times	Count
4	83
5	575
6	2

7	94
8	32
9	2
10	284
13	622
14	28
21	11

% of Lead Times of total orders 2012	Count
0%<=25%	572
25%<=50%	803
50%<=75%	67
75%<=100%	197
>=100%	94

Bullwhip Effect analysis

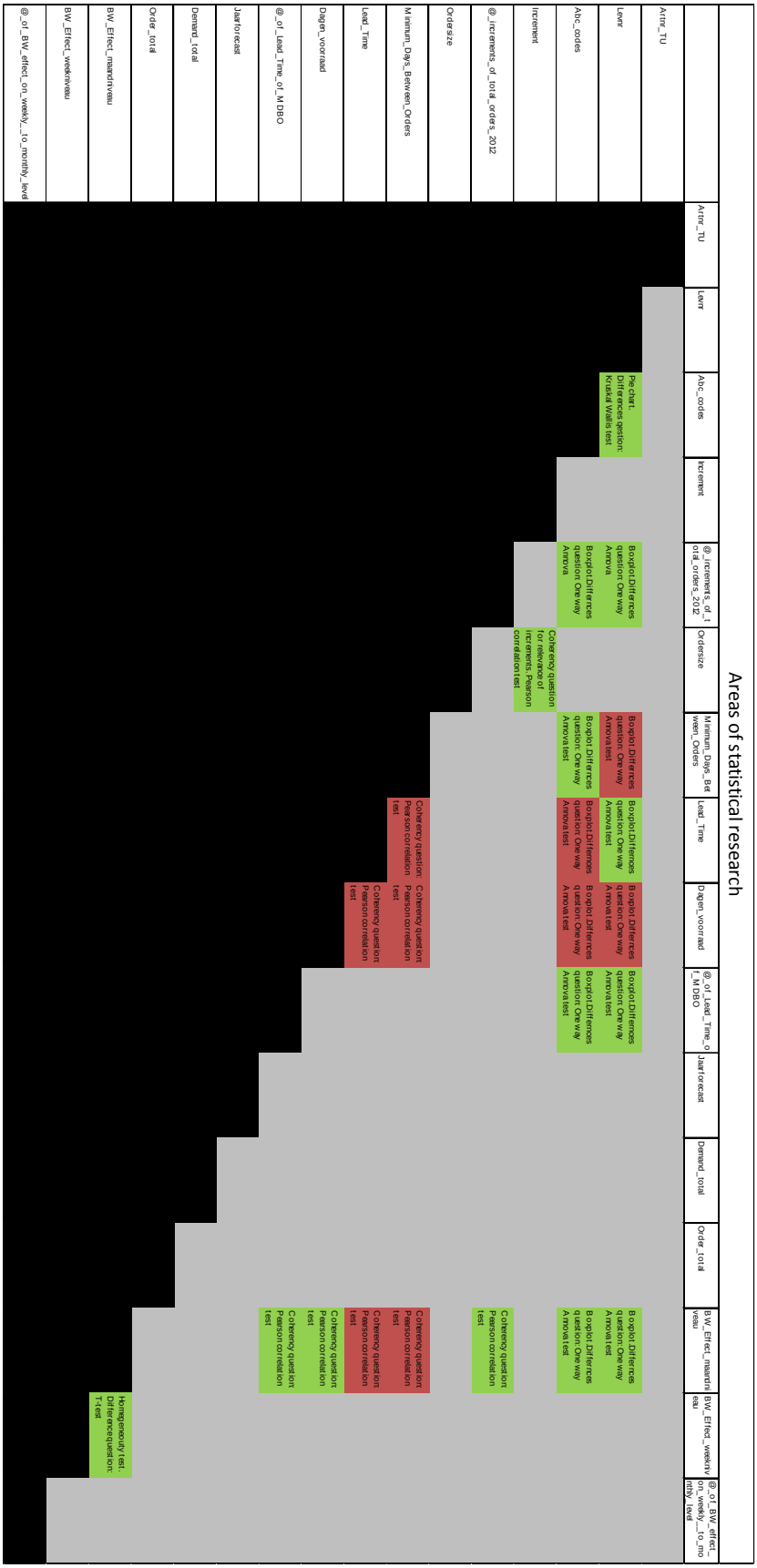
Bullwhip Effect applicability	Count
Yes	1577
Limited	66
No	90

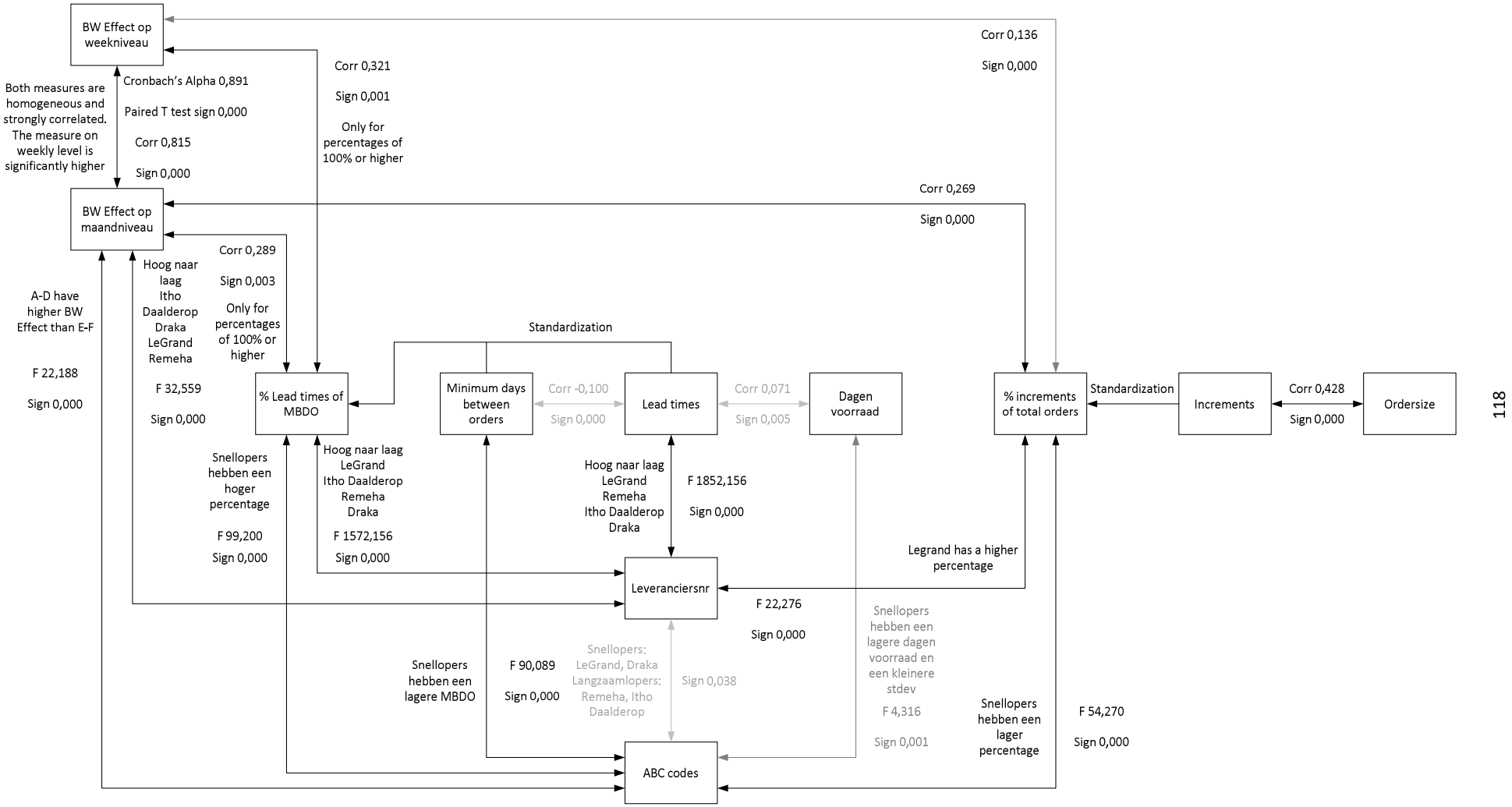
Bullwhip Effect	Count on monthly level	Count on weekly level
<=1	182	152
1<=1,5	509	385
1,5<=2	431	384
2<=2,5	236	253
2,5<=5	265	436
5<=25	19	32
No orders	91	91

% of linear regression coefficient of average monthly demand 2012	Count
<=-20%	5
-20%<=10%	19
-10%<=5%	57
-5%<=-2,5%	169
-2,5%<=0%	726
0%<=2,5%	650
2,5%<=5%	62
5%<=10%	9
10%<=20%	3
>=20%	1
No value	32

% of order deviation towards demand	Count
<=-20%	301
-20%<=-10%	196
-10%<=0%	515
0%<=10%	407
10%<=20%	120
>=20%	194

Annex III: Statistical analysis of Bullwhip Effect case study results




BW Effect op weekniveau
Corr 0,136
Sign 0,000
Corr 0,321
Sign 0,001
Only for percentages of 100% or higher
Both measures are homogeneous and strongly correlated. The measure on weekly level is significantly higher
Cronbach's Alpha 0,891
Paired T test sign 0,000
Corr 0,815
Sign 0,000
BW Effect op maandniveau
Corr 0,269
Sign 0,000
Corr 0,289
Sign 0,003
Only for percentages of 100% or higher
Hoog naar laag Itho Daalderop Draka LeGrand Remeha
A-D have higher BW Effect than E-F
F 22,188
Sign 0,000
F 32,559
Sign 0,000
Standardization
% Lead times of MBDO
Minimum days between orders
Corr -0,100
Sign 0,000
Lead times
Corr 0,071
Sign 0,005
Dagen voorraad
% increments of total orders
Standardization
Increments
Corr 0,428
Sign 0,000
Ordersize
Snellopers hebben een hoger percentage
F 99,200
Sign 0,000
Hoog naar laag LeGrand Itho Daalderop Remeha Draka
F 1572,156
Sign 0,000
Hoog naar laag LeGrand Remeha Itho Daalderop Draka
F 1852,156
Sign 0,000
Legrand has a higher percentage
Leveranciersnr
F 22,276
Sign 0,000
Snellopers hebben een lagere dagen voorraad en een kleinere stdev
F 4,316
Sign 0,001
Snellopers hebben een lagere MBDO
F 90,089
Sign 0,000
Snellopers: LeGrand, Draka Langzaamlopers: Remeha, Itho Daalderop
Sign 0,038
Snellopers hebben een lager percentage
F 54,270
Sign 0,000
ABC codes

Annex IV: Specification of relevant Supply Chain costs

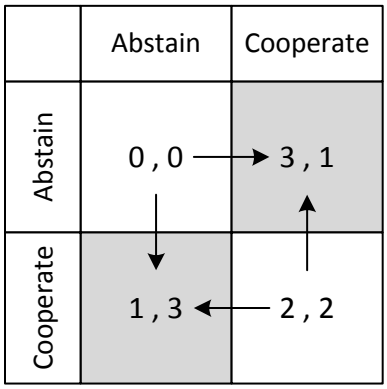
	Contingency cost			Operational costs			Investments costs
	Flexible labour cost	Utilization inefficiencies	Improvised operations + excess breach/disposal	labour hours	resources	breach and disposal	Assets
Planning and control	Overtime due to planning			management	office resources		Office facilities
Financial accounting	Overtime due to extra transactions			office employees	office resources		Office facilities
Purchasing	Overtime due to extra negotiations		Excess purchase prices and foregone discounts	office employees	office resources		Office facilities
Sales	Overtime due to extra negotiations		Lost sales and discounts	office employees	office resources		Office facilities
Inventory management	Overtime due to extra mutations		Disposal due to obsolescence	office employees	office resources		Office facilities
Forecasting				office employees	office resources		Office facilities
Ordering	Overtime due to extra orders		Extra orders with fixed order costs by suppliers	office employees	office resources		Office facilities
Manufacturing/ repackaging	Overtime and flexible labour	Less than full machine utilization	Set up times for machines	operational employees	Energy	yes	Machine capacity
Handling	Overtime and flexible labour	Less than full facilities utilization	Extra handling operations	operational employees	Energy	yes	Handling facilities capacity
Storage	Overtime and flexible labour	Less than full storage utilization	Excess inventories			yes	Storage capacity and inventory value
Inhouse transportation	Overtime and flexible labour	Less than full truckloads	Improvised expediting	operational employees	Energy	yes	Transportation modalities
Outsourced transportation			Premium shipping rates		External services	yes	

Annex V: Product categories of the Technische Unie

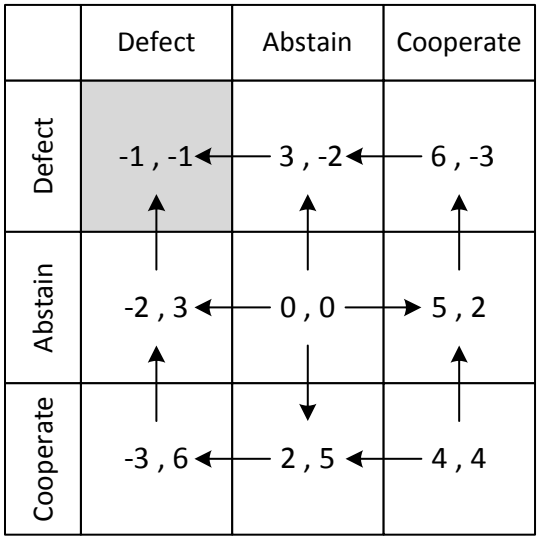
Code	Requirement	Desired service level	Nr of articles January 2004
A	Within top 25% order lines	99%	477
B	Within second 25% order lines	98%	6.507
C	Within third 25% order lines	97,5%	6.772
D	More than 51 order lines per year	97%	18.729
E	Between 12 and 52 order lines per year	96%	29.314
F	Less than 12 order lines per year	N/A	16.940
N	New articles	98%	Unknown

Annex VI: Analysis of Game Theory problem perspective

Game of chicken in information asymmetry situation



Prisoners dilemma in information transparency situation



Annex VII: Analysis of solution space

Annex VIII: Analysis of frameworks for design

Attributes of micro situational situations that affect the level of cooperation in social dilemmas as design principles for institutional design (Ostrom 2010; Poteete, Janssen et al. 2010).

Element	Solution space elements	Requirements	Fixed attributes
1. Personal communication	Agreements on communication	Personal communication	
2. Reputation and historical behaviour are known		Agreements improve relationships and trusts	
3. High marginal per capita return	Reimbursement agreements	Significant benefits for all parties	
4. Entry and exit capabilities	Entry and exit rules for the agreements		
5. Long time horizon	Duration of agreements	Long term orientation	
6. sanctioning capabilities	Agreements on sanctioning	Prevents possibilities for opportunistic behaviour	

Principles of institutional design:(Ostrom 2010)

Element	Solution space elements	Requirements	Fixed attributes
1. User boundaries			Two actors: supplier and customer
2. Resource boundaries	Agreements on applicable products		
3. Congruence with local conditions		Applicable in common market situations	
4. Appropriation and provision		In accordance with informal institutions	
5. Collective choice arrangements	Arrangements on shared decision making areas		
6. Monitoring users	Arrangements on shared information		
7. Monitoring resource	Arrangements on shared information		
8. Graduated sanctions	Agreements on sanctioning	Graduated sanctioning	
9. Conflict resolution mechanisms	Agreements on conflict resolution		
10. Minimal recognition of rights		Legally enforceable by contracts	
11. Nested enterprises			Two actors: supplier and customer

Rules relating to action situations:(Ostrom 2010)

Element	Solution space elements	Requirements	Fixed attributes
1. Boundary rules			Two actors: supplier and customer
2. Position rules			Supplier and customer roles
3. Choice rules	Action constraining agreements		
4. Information rules	Arrangements on shared information		
5. Aggregation rules			Given control over own organizations
6. Pay-off rules	Reimbursement		

	agreements		
7. Scope rules	Agreements on applicable products		

Design process for self-organized network function (Prehofer and Bettstetter 2005)

Element	Solution space elements	Requirements	Fixed attributes
1. Local behavioural rules			Given by arrangements
2. Implicit coordination			Given by arrangements
3. Create reduced states		Minimize complexity of arrangements	
4. Adaptability to changes in environment	Rules for adapting the agreement		

Elements of self-organizing protocols (Prehofer and Bettstetter 2005)

Element	Solution space elements	Requirements	Fixed attributes
1. Behavioural rules	Agreements on systemic behaviour		
2. Communication protocols	Agreements on communication		
3. Desired maintained states	Agreements on objectives		
4. Protocols for control tasks	Agreements on systemic behaviour		

Three elements of inter-organizational governance (Ferrier 2013)

Element	Solution space elements	Requirements	Fixed attributes
1. Financial governance	Reimbursement agreements		
2. Coordination governance	Agreements on coordination		
3. Trust governance		Agreements improve relationships and trusts	

The logic of consequence versus the logic of appropriateness

Element	Solution space elements	Requirements	Fixed attributes
1. Logic of consequence		Aligned with interests	
2. Logic of appropriateness		Adherence to norms	

Elements of SC contracts: (Fiala 2005)

Element	Solution space elements	Requirements	Fixed attributes
1. Prices	Prices and discount agreements		
2. Quantities	Agreements on order quantities		
3. Costs	Agreements on reimbursements		
4. Time	Agreements of ordering moments		
5. Quality			Quality is not within scope
6. Penalties	Sanctioning agreements		

Three levels of incentive creation (Simatupang and Sridharan 2002)

Element	Solution space elements	Requirements	Fixed attributes
1. Rewarding productive behaviour	Agreements on reimbursements		
2. Pay for performance	Agreements on reimbursements		
3. Equitable sharing	Cost sharing agreements		

Annex IX: Solution space for FAD agreements

Group	Solution space dimension	Relevant options
Information sharing	Information type	Forecasts on expected order quantities for the next order interval period before expiration date
	Aggregation on product detail	Per product
	Aggregation on time intervals	Per order interval
	Sharing frequency	Per order interval
Personal meetings	Involved actors	Logistical/operational divisions of both parties
	Agenda topics	Forecast expectations, arrangement parameters
	Communication frequency	Monthly/yearly
Commitment	Commitment on systemic behaviour	
	Commitment on objectives	
Authorities and responsibilities	Ordering and availability	
Finances	Price arrangements	
	Price promotions	
	Volume discounting policies	Discount percentage over total yearly turnover of individual products
	Forecast accuracy discounting policies	Discount percentage over absolute deviation of order totals in a period towards the forecast
	Reimbursing fluctuation costs	
	Third party insurances	
Constraints	Minimum order quantities	
	Maximum order quantities	
	Minimum purchase agreements	
	Maximum purchase agreements	
	Orders bounded by forecasts	
	Orders bounded by history	
	Returning	
	Order increments	Units set by supplier
	Order intervals	Interval set by buyer
	Returning	
Contingencies	Rationing policies	
	Sanctioning rules	Interest costs for not or late provision of discounts
	Conflict resolution rules	Procedures for renegotiating the parameters of the arrangement
Arrangement conditions	Scope of agreement	Applicable to selection of products for the divisions that concern ordering and order processing
	Duration of agreement	Yearly revision
	Termination conditions	Unilateral cancellation possible after each year
	Adaptation conditions	Review of paramters: increments, order intervals, expiration intervals for adapting forecasts, volume discount percentages, forecast accuracy percentages

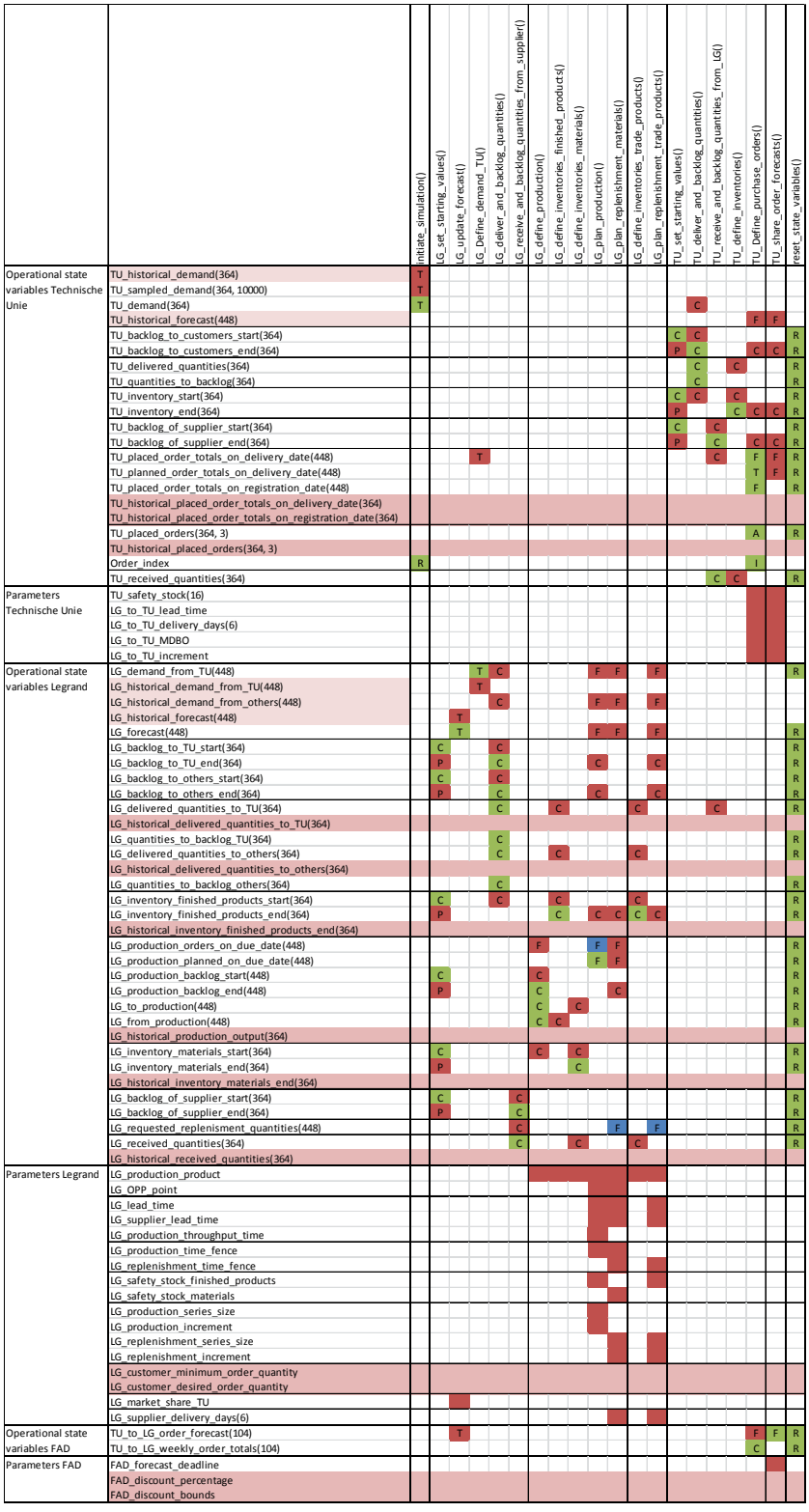
Annex X: Simulation model variables

Group	Name	Type	Description
Simulation configuration	input_file_loaded	Boolean	States whether the input file of the specific case is loaded
	output_file_loaded	Boolean	States whether an output file has been assigned to write result to
	output_file_path	String	The directory of the loaded output file
	simulation_mode	String	The simulation mode, either "Emperical Validation", "Emperical Showcase" or "Stochastic Series"
	model_situation	String	The model situation, either "Nullcase" of "FAD"
Global parameters	product	Integer	The product code of the technische Unie
	nr_simulations	Integer	The number of simulation casesperformed in the "Stochastic Series" mode
	current_simulation	Integer	The current simulation case during the "Stochastic Series" mode
Global state variables	time_table(448, 5)	String	Col 1: index nr, Col 2: date as dd-mm-yyyy, Col 3: day of the week as 0-6, Col 4: week, col 5: TU period nr
	current_day	Integer	The current day in the simulation case
TU operational state variables	TU_historical_demand(364)	Integer	Actual customer demand
	TU_sampled_demand(364, 10000)	Integer	10000 cases sampled demand similar to the historical demand
	TU_demand(364)	Integer	Demand of the current simulation case
	TU_historical_forecast(448)	Integer	Actual forecast over 2012 + 3 three months
	TU_backlog_to_customers_start(364)	Integer	Backlog to customers at the start of the day
	TU_backlog_to_customers_end(364)	Integer	Backlog to customers at the end of the day
	TU_delivered_quantities(364)	Integer	Delivered quantities
	TU_quantities_to_backlog(364)	Integer	Ordered quantity total not delivered at the day
	TU_inventory_start(364)	Integer	Inventory at the start of the day
	TU_inventory_end(364)	Integer	Inventory at the end of the day
	TU_backlog_of_supplier_start(364)	Integer	Backlog of Legrand at the start of the day
	TU_backlog_of_supplier_end(364)	Integer	Backlog of Legrand at the end of the day
	TU_placed_order_totals_on_delivery_date(448)	Integer	Total order quantities due to deliver that day by Legrand to the TU
	TU_planned_order_totals_on_delivery_date(448)	Integer	Planned order quantities due to deliver that day by Legrand to the TU
	TU_placed_order_totals_on_registration_date(448)	Integer	Total order quantities ordered that day by the TU
	TU_historical_placed_order_totals_on_delivery_date(364)	Integer	Actual total order quantities due to deliver that day by Legrand to the TU
	TU_historical_placed_order_totals_on_registration_date(364)	Integer	Actual total order quantities ordered that day by the TU
	TU_placed_orders(364, 3)	Integer	Col 1: registration date of order, Col 2: delivery date of order, Col 3: order size
	TU_historical_placed_orders(364, 3)	Integer	Actual orders with similar structure as above
	Order_index	Integer	Index variable for writing orders in the current simulation case
	TU_received_quantities(364)	Integer	Received quantities
TU KPI's	TU_service_level_perc_of_quant_delivered	Decimal	Service level measured as the % of total quantities delivered on time
	TU_service_level_perc_of_days_with_no_backlogs	Decimal	Service level measured as the % of days without any backlogs
	TU_inventory_turnover_speed	Decimal	Turnover speed as "total demand"/"average inventory"
	TU_BW_Effect_on_weekly_level	Decimal	Bullwhip Effect on weekly level according to thesis definition
	TU_average_inventory	Decimal	Average inventory
	TU_max_inventory_capacity	Integer	Maximum inventory level
	TU_average_inventory_outbound	Decimal	Average quantity of sent goods (excluding days with 0 quantities)
	TU_max_inventory_outbound	Integer	Maximum quantity of sent goods in one day
	TU_outbound_nr	Integer	Number of days with outbound sent goods
	TU_average_inventory_inbound	Decimal	Average quantity of received goods (excluding days with 0 quantities)
	TU_max_inventory_inbound	Integer	Maximum quantity of received goods in one day
	TU_inbound_nr	Integer	Number of days with inbound received goods
	TU_nr_of_days_with_orders	Integer	Number of days with an order due date to Legrand
	TU_average_order_quantity	Decimal	Average total order quantities by the TU (exluding days with no orders)

	TU_max_order_quantity	Integer	Maximum order quantities by the TU in one day
TU parameters	TU_safety_stock(16)	Decimal	Safety stock value for each 4 week period over 2012 + 3 periods
	LG_to_TU_lead_time	Integer	Lead time in days of Legrand according to the TU planning system
	LG_to_TU_delivery_days(6)	Integer	Delivery days as 0-6 of Legrand to the TU
	LG_to_TU_MDBO	Integer	Mean Days Between Orders of the TU planning system
	LG_to_TU_increment	Integer	Order increment according to the TU planning system
LG operational state variables	LG_demand_from_TU(448)	Integer	Order totals placed by the TU
	LG_historical_demand_from_TU(448)	Integer	Actual order totals placed by the TU
	LG_historical_demand_from_others(448)	Integer	Actual order totals placed by other customers
	LG_historical_forecast(448)	Integer	Actual demand forecasts
	LG_forecast(448)	Integer	Adjusted forecast according to shared order forecasts by the TU
	LG_backlog_to_TU_start(364)	Integer	Backlog to the TU at the start of the day
	LG_backlog_to_TU_end(364)	Integer	Backlog to the TU at the end of the day
	LG_backlog_to_others_start(364)	Integer	Backlog to other customers at the start of the day
	LG_backlog_to_others_end(364)	Integer	Backlog to other customers at the end of the day
	LG_delivered_quantities_to_TU(364)	Integer	Delivered quantities to the TU
	LG_historical_delivered_quantities_to_TU(364)	Integer	Actual delivered quantities to the TU
	LG_quantities_to_backlog_TU(364)	Integer	Ordered quantity total not delivered to the TU at the day
	LG_delivered_quantities_to_others(364)	Integer	Delivered quantities to other customers
	LG_historical_delivered_quantities_to_others(364)	Integer	Actual delivered quantities to other customers
	LG_quantities_to_backlog_others(364)	Integer	Ordered quantity total not delivered to other customers at the day
	LG_inventory_finished_products_start(364)	Integer	Inventory of finished products at the start of the day
	LG_inventory_finished_products_end(364)	Integer	Inventory finished products at the end of the day
	LG_historical_inventory_finished_products_end(364)	Integer	Actual inventory finished products at the end of the day
	LG_production_orders_on_due_date(448)	Integer	Total ordered quantities for production
	LG_production_planned_on_due_date(448)	Integer	Total planned order quantities for production
	LG_production_backlog_start(448)	Integer	Backlogged production quantities the start of the day
	LG_production_backlog_end(448)	Integer	Backlogged production quantities the end of the day
	LG_to_production(448)	Integer	Total material quantities entering production
	LG_from_production(448)	Integer	Total finished products leaving production
	LG_historical_production_output(364)	Integer	Actual total finished products leaving production
	LG_inventory_materials_start(364)	Integer	Inventory of materials at the start of the day
	LG_inventory_materials_end(364)	Integer	Inventory materials at the end of the day
	LG_historical_inventory_materials_end(364)	Integer	Actual inventory materials at the end of the day
	LG_backlog_of_supplier_start(364)	Integer	Backlog of supplier at the start of the day
	LG_backlog_of_supplier_end(364)	Integer	Backlog of supplier at the end of the day
	LG_requested_replenisment_quantities(448)	Integer	Total order quantities due to deliver that day by the supplier to Legrand
	LG_received_quantities(364)	Integer	Received quantities
	LG_historical_received_quantities(364)	Integer	Actual received quantities
LG KPI's	LG_service_level_perc_of_quant_delivered	Decimal	Service level measured as the % of total quantities delivered on time
	LG_service_level_perc_of_days_with_no_backlogs	Decimal	Service level measured as the % of days without any backlogs
	LG_inventory_finished_products_turnover_speed	Decimal	Turnover speed of finished products as "total demand"/"average inventory"
	LG_inventory_materials_turnover_speed	Decimal	Turnover speed of materials as "total demand"/"average inventory"
	LG_BW_Effect_on_weekly_level	Decimal	Bullwhip Effect on weekly level according to thesis definition
	LG_average_inventory_finished_products	Decimal	Average inventory of finished products
	LG_max_inventory_finished_products_capacity	Integer	Maximum inventory level of finished products
	LG_average_inventory_finished_products_outbound	Decimal	Average quantity of sent finished products (excluding days with 0 quantities)
	LG_max_inventory_finished_products_outbound	Integer	Maximum quantity of sent finished products in one day
	LG_outbound_nr	Integer	Number of days with outbound sent goods

	LG_average_inventory_materials	Decimal	Average inventory of materials
	LG_max_inventory_materials_capacity	Integer	Maximum inventory level of materials
	LG_average_inventory_materials_inbound	Decimal	Average quantity of received materials (excluding days with 0 quantities)
	LG_max_inventory_materials_inbound	Integer	Maximum quantity of received materials in one day
	LG_inbound_nr	Integer	Number of days with inbound received goods
	LG_average_production_quantity	Decimal	Average production quantity (excluding days with 0 quantities)
	LG_max_production_quantity	Integer	Maximum produced quantities in one day
	LG_production_runs_nr	Integer	Number of days with production
	LG_nr_of_orders	Integer	Number of days with an order due date to suppliers
	LG_average_order_quantity	Decimal	Average total order quantities by Legrand (exluding days with no orders)
	LG_max_order_quantity	Integer	Maximum order quantities by Legrand in one day
LG parameters	LG_production_product	Integer	"1" for manufactured products, "0" for trade products
	LG_OPP_point	String	The OPP point either "Finished products" or "Materials"
	LG_lead_time	Integer	Lead time in days to customers
	LG_supplier_lead_time	Integer	Lead time in days of supplier
	LG_production_throughput_time	Integer	Throughput time of production in days
	LG_production_time_fence	Integer	Time fence value for production planning
	LG_replenishment_time_fence	Integer	Time fence value for replenishment planning
	LG_safety_stock_finished_products	Integer	Fixed safety stock value of finished products
	LG_safety_stock_materials	Integer	Fixed safety stock value of materials
	LG_production_series_size	Integer	The desired batch size for a single production run
	LG_production_increment	Integer	The multitide in which a production order can be placed
	LG_replenishment_series_size	Integer	The desired batch size for a single replenishment order
	LG_replenishment_increment	Integer	The multitide in which a replenishment order can be placed
	LG_customer_minimum_order_quantity	Integer	The minimum required order size for customers
	LG_customer_desired_order_quantity	Integer	The desired order size for customers
	LG_market_share_TU	Integer	% of the demand of the TU towards total demand in 2012
	LG_supplier_delivery_days(6)	Integer	Days of the week as 0-6 in which suppliers can deliver
FAD operational parameters	TU_to_LG_order_forecast(104)	Integer	Shared forecast of weekly order totals by the TU
	TU_to_LG_weekly_order_totals(104)	Integer	Weekly order totals by the TU
FAD agreement parameters	FAD_forecast_deadline	Integer	Number of weeks from the current week in which forecast may be adjusted
	FAD_discount_percentage	Decimal	Maximum discount percentage for ordering according to forecasts
	FAD_discount_bounds	Integer	Boundary in product units in which discounts are applicable
FAD KPI's	Average_forecast_deviation	Decimal	Average deviation of weekly order forecasts
	average_forecast_deviation_in_perc_of_av_demand	Decimal	% of the average forecast deviation towards average weekly demand
	average_discount_percentage	Decimal	Average discount % on total demand
	average_discount_percentage_in_perc_of_max_discount	Decimal	% of the total discount toward the maximum possible discount

Annex XI: Inputs and outputs of conceptual simulation processes



Annex XII: Static structure of input text file

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TU demand
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TU Forecast
[TU_historical_forecast(1)]
[TU_historical_forecast(2)]
[TU_historical_forecast(3)]
…
[TU_historical_forecast(448)]

TU historical orders
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[TU_historical_placed_orders(2, 1)]; [TU_historical_placed_orders(2, 2)]; [TU_historical_placed_orders(2, 3)]
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TU historical order totals
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[TU_historical_placed_order_totals_on_registration_date(3)];[TU_historical_placed_order_totals_on_delivery_date(3)]
…
[TU_historical_placed_order_totals_on_registration_date(364)];[TU_historical_placed_order_totals_on_delivery_date(364)]

TU initial values
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[TU_inventory_end(0)]
[TU_backlog_of_supplier_end(0)]

TU operational parameters
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[LG_to_TU_delivery_days(0)]
[LG_to_TU_delivery_days(1)]
[LG_to_TU_delivery_days(2)]
…
[LG_to_TU_delivery_days(6)]
[LG_to_TU_MDBO]
[LG_to_TU_increment]

LG demand from TU
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[LG_historical_demand_from_TU(2)]
[LG_historical_demand_from_TU(3)]
…
[LG_historical_demand_from_TU(448)]

LG demand from others
[LG_historical_demand_from_others(1)]
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[LG_historical_demand_from_others(3)]
…
[LG_historical_demand_from_others(448)]

LG forecast
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[LG_historical_forecast(2)]
[LG_historical_forecast(3)]
…
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LG delivered quantities to TU
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[LG_historical_delivered_quantities_to_TU(2)]
[LG_historical_delivered_quantities_to_TU(3)]
…
[LG_historical_delivered_quantities_to_TU(364)]

LG delivered quantities to others
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[LG_historical_delivered_quantities_to_others(2)]
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LG inventory finished products
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[LG_historical_inventory_finished_products_end(2)]
[LG_historical_inventory_finished_products_end(3)]
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LG production output
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LG inventory materials
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[LG_historical_inventory_materials_end(3)]
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LG replenisment quantities
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[LG_historical_received_quantities(3)]
…
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LG initial values
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[LG_historical_inventory_finished_products_end(0)]
[LG_production_backlog_end(0)]
[LG_inventory_materials_end(0)]
[LG_historical_inventory_materials_end(0)]
[LG_backlog_of_supplier_end(0)]

LG operational parameters
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[LG_supplier_lead_time]
[LG_production_throughput_time]
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[LG_replenishment_time_fence]
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[LG_replenishment_series_size]
[LG_replenishment_increment]

[LG_customer_minimum_order_quantity]
[LG_customer_desired_order_quantity]
[LG_market_share_TU]
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[LG_supplier_delivery_days(2)]
…
[LG_supplier_delivery_days(6)]

FAD parameters
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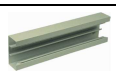
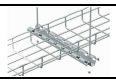
[FAD_discount_percentage]
[FAD_discount_bounds]

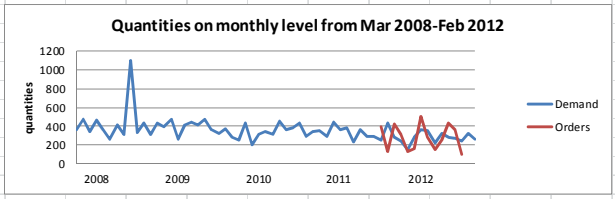
Annex XIII: Information on simulation product selection

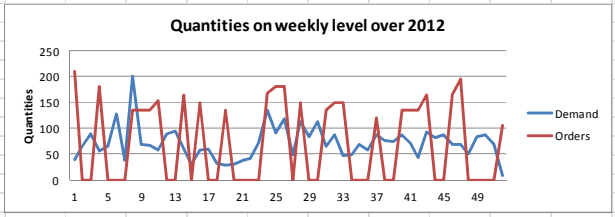
General product information							
Article nr Technische Unie	4536827	4536835	4255030	4536553	4531430	3407384	4256632
Article nr Legrand	8555101	8555103	341443	8555023	8234000	CM013500	344784
Description Technische Unie	GEEL EINDSCHOT GW05 130 CR	GEEL EINDSCHOT GW05 130 W	GEEL DEKSEL STIJGST 60X200	GEEL WAND-GOOT GW05 130 W LG3	GEEL M10 DRAADSTANG LG1	CAB MONTA-GEPR. RCSN L500 ELVZ	GEEL AFTAKSTUK 60X300 9010
Description Legrand	Eindschot 130 x63 r1013	Eindschot 130 x63 r9010	Deksel stijgst P31 60x200 Sdz	Wandgoot 3m 130 x63 r9010	Draadstang m10 l=1m	Ophangrail RCSN B500 elvz	Aftakstuk P31 60x300 9010
Product image							
% Lead Time of MDBO TU	93%	93%	46%	186%	186%	46%	46%
Lead Time vs MDBO problem	No	No	No	Yes	Yes	No	No
% incr. of yearly order total TU	0,41%	0,21%	11%	0,33%	17%	0,39%	20%
Increment problem	No	No	Yes	No	Yes	No	Yes
Fast or slow mover	Fast	Fast	Fast	Fast	Fast	Slow	Slow
BW Effect TU on monthly level	1,92	1,83	3,27	1,31	4,36	1,51	1,36
BW Effect TU on weekly level	2,50	2,59	3,12	1,57	4,46	1,25	1,64

Technische Unie product information							
Article nr	4536827	4536835	4255030	4536553	4531430	3407384	4256632
Description	GEEL EINDSCHOT GW05 130 CR	GEEL EINDSCHOT GW05 130 W	GEEL DEKSEL STIJGST 60X200	GEEL WAND-GOOT GW05 130 W LG3	GEEL M10 DRAADSTANG LG1	CAB MONTA-GEPR. RCSN L500 ELVZ	GEEL AFTAKSTUK 60X300 9010
ABC code	B	B	D	B	C	E	E
Yearly demand 2012	3719	6726	173	8911	14885	322	46
Increment	15	15	20	30	2000	1	10
Mean Days between Orders	14	14	28	7	7	28	28
Lead Time	13	13	13	13	13	13	13
Order size	135	285	20	210	2000	13	10
Average days on stock	14,6	14,5	113,2	7,6	97,0	28,0	138,4
Economic Order Quantity	200,6	291,5	24,9	130,4	532,5	57,6	10,4
Theoretical MDBO	21,6	14,9	141,0	4,7	25,8	124,4	144,4
Delivery days of supplier	Thu	Thu	Thu	We, Thu, Fri	We, Thu, Fri	Thu	Thu
Average Safety Stock 2012	106,7	167,4	7,8	249,0	1272,2	7,0	1,8

Legrand Nederland product information							
Article nr	8555101	8555103	341443	8555023	8234000	CM013500	344784
Description	Eindschot 130 x63 r1013	Eindschot 130 x63 r9010	Deksel stijgst P31 60x200 Sdz	Wandgoot 3m 130 x63 r9010	Draadstang m10 l=1m	Ophangrail RCSN B500 elvz	Aftakstuk P31 60x300 9010
Product type	Production	Production	Trade	Production	Trade	Trade	Production
Material article nr	8555100	8555100		N/A			340784
Material description	Eindschot 130 x63 zink	Eindschot 130 x63 zink		N/A			Aftakstuk P31 60x300 Sdz
Comments	Similar material as 8555103	Similar material as 8555101		Material is generic steel sheets			Material is also trade product
Order Penetration Point	Materials	Materials	Finished prod	Materials	Finished prod	Finished prod	Materials
Safety Stock finished products	0	0	101	0	0	142	0
Safety Stock materials	0	0	0	0	0	0	70
Lead Time to customer	10	10	1	10	1	1	5
Customer minimum order quan.	1	1	1	1	1	1	1
Customer desired order quan.	15	15	20	30	25	20	10
Lead Time of supplier	8	8	8	N/A	5	6	8
Replenishment Time fence	8	8	8	N/A	5	6	8
Replenishment series size	1200	1200	160	N/A	12000	80	240
Replenishment increment	150	150	80	N/A	2000	20	80
Supplier delivery days	Tue, Fri	Tue, Fri	Tue, Fri	N/A	Mon - Fri	Wed, Fri	Tue, Fri
Production throughput time	1	1		1			1
Production time fence	1	1		2			1
Production series size	300	600		600			7
Production increment	15	15		30			1

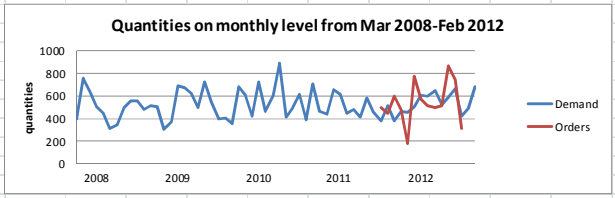
Annex XIV: Demand and order visualization of simulation product selection

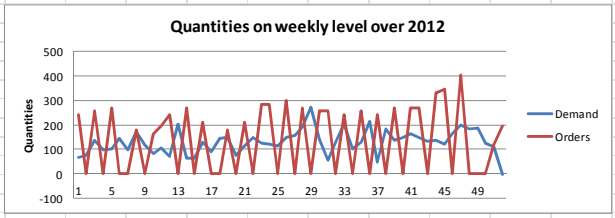




	Demand	Orders
Total of 2012	3719	3666
Monthly average	286,0769	282
Monthly variance	5122,41	18360,67
Monthly stdev	71,57102	135,5015
stdev/av	0,250181	0,480502
BW Effect on monthly level		1,920617
	Demand	Orders
Total of 2012	3719	3666
Weekly average	71,51923	70,5
Weekly variance	1021,156	6183,863
Weekly stdev	31,95554	78,63754
stdev/av	0,44681	1,115426
BW Effect on weekly level		2,496419

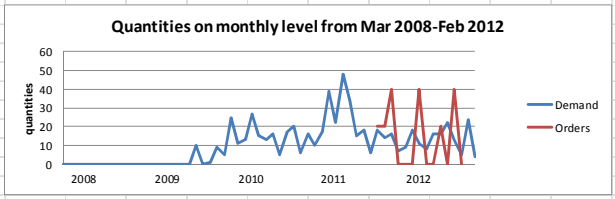
Name	GEEL EINDSCHOT GW05 130 CR
artnr TU	4536827
artnr Legrand	8555101
ABC code	B
Volume	20,25
Weight	11,475
Price	6,31
Increment	15
Th EOQ	21,6298419
EOQ	200,5725165
Order size	135
% incr. Of orders	0,409%
MDBO	14
Lead time	13
Dagen voorraad	14,55846846
Delivery days	do
% LT of MBDO	92,857%

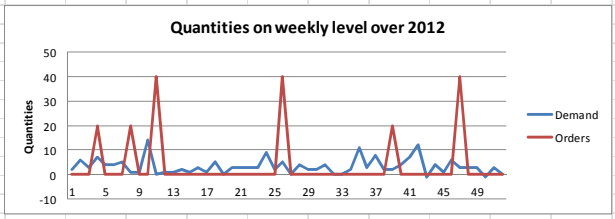




	Demand	Orders
Total of 2012	6726	7003
Monthly average	517,3846	538,6923
Monthly variance	9440,423	34324,73
Monthly stdev	97,16184	185,2693
stdev/av	0,187794	0,343924
BW Effect on monthly level		1,831389
	Demand	Orders
Total of 2012	6726	7003
Weekly average	129,3462	134,6731
Weekly variance	2417,094	17622,03
Weekly stdev	49,16395	132,748
stdev/av	0,380096	0,985705
BW Effect on weekly level		2,593307

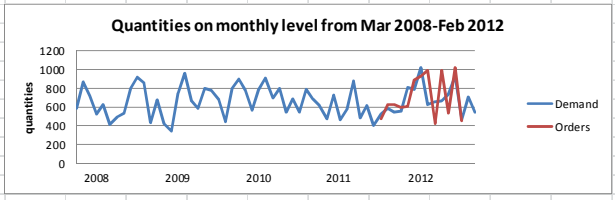
Name	GEEL EINDSCHOT GW05 130 W
artnr TU	4536835
artnr Legrand	8555103
ABC code	B
Volume	42,75
Weight	22,8
Price	6,31
Increment	15
Th EOQ	14,88070119
EOQ	291,5421637
Order size	285
% incr. Of orders	0,214%
MDBO	14
Lead time	13
Dagen voorraad	14,54678043
Delivery days	do
% LT of MBDO	92,857%

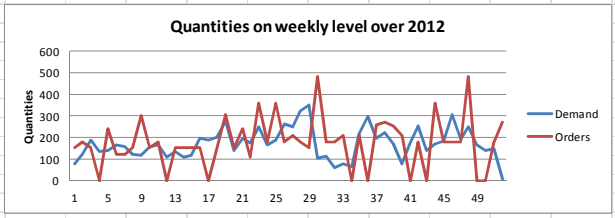




	Demand	Orders
Total of 2012	173	180
Monthly average	13,30769	13,84615
Monthly variance	25,23077	292,3077
Monthly stdev	5,023024	17,09701
stdev/av	0,377453	1,234784
BW Effect on monthly level		3,271361
	Demand	Orders
Total of 2012	173	180
Weekly average	3,326923	3,461538
Weekly variance	10,02828	105,4299
Weekly stdev	3,166746	10,2679
stdev/av	0,951854	2,966284
BW Effect on weekly level		3,116321

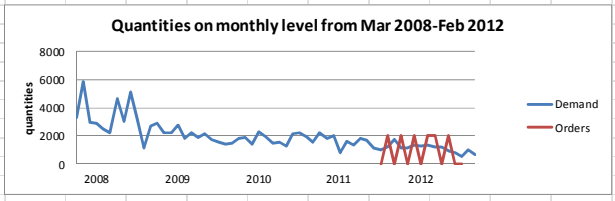
Name	GEEL DEKSEL STIJGST 60X200
artnr TU	4255030
artnr Legrand	341443
ABC code	D
Volume	80
Weight	8,2
Price	7,8
Increment	20
Th EOQ	140,9514038
EOQ	24,89947096
Order size	20
% incr. Of orders	11,111%
MDBO	28
Lead time	13
Dagen voorraad	113,2163844
Delivery days	do
% LT of MBDO	46,429%

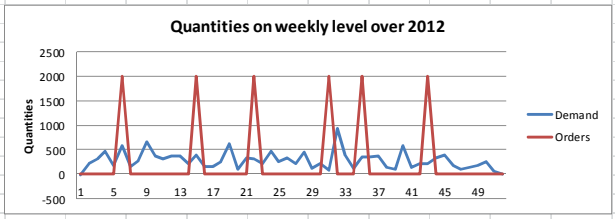




	Demand	Orders
Total of 2012	8911	9174
Monthly average	685,4615	705,6923
Monthly variance	27257,77	50116,4
Monthly stdev	165,0993	223,8669
stdev/av	0,240859	0,31723
BW Effect on monthly level		1,317081
	Demand	Orders
Total of 2012	8911	9174
Weekly average	171,3654	176,4231
Weekly variance	4959,452	12928,92
Weekly stdev	70,42338	113,7054
stdev/av	0,410955	0,644504
BW Effect on weekly level		1,56831

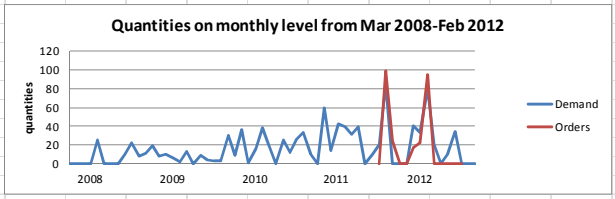
Name	GEEL WANDGOOT GW05 130 W
artnr TU	4536553
artnr Legrand	8555023
ABC code	B
Volume	5569,2
Weight	1050
Price	44,35
Increment	30
Th EOQ	4,732606126
EOQ	130,4247888
Order size	210
% incr. Of orders	0,327%
MDBO	7
Lead time	13
Dagen voorraad	7,620079706
Delivery days	wo_do_vr
% LT of MBDO	185,714%

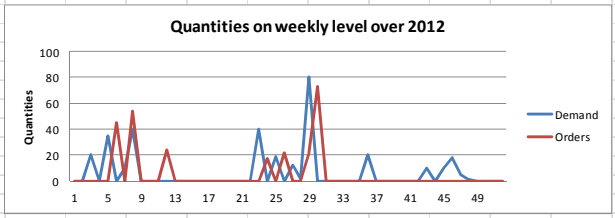




	Demand	Orders
Total of 2012	14885	12000
Monthly average	1145	923,0769
Monthly variance	86860,33	1076923
Monthly stdev	294,7208	1037,749
stdev/av	0,257398	1,124228
BW Effect on monthly level		4,367664
	Demand	Orders
Total of 2012	14885	12000
Weekly average	286,25	230,7692
Weekly variance	32154,66	416289,6
Weekly stdev	179,3172	645,2051
stdev/av	0,626436	2,795889
BW Effect on weekly level		4,46317

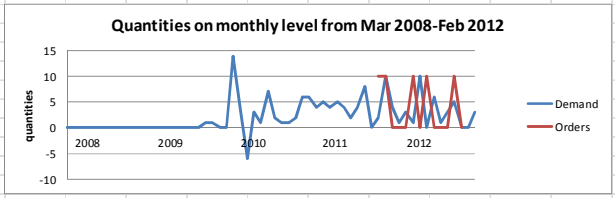
Name	GEEL M10 DRAADSTANG LG1
artnr TU	4531430
artnr Legrand	8234000
ABC code	C
Volume	200
Weight	980
Price	1,99
Increment	2000
Th EOQ	25,83234066
EOQ	532,5216784
Order size	2000
% incr. Of orders	16,667%
MDBO	7
Lead time	13
Dagen voorraad	97,01892604
Delivery days	wo_do_vr
% LT of MBDO	185,714%

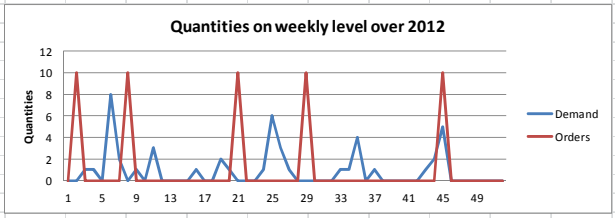




	Demand	Orders
Total of 2012	322	257
Monthly average	24,76923	19,76923
Monthly variance	866,1923	1257,859
Monthly stdev	29,43115	35,46631
stdev/av	1,188214	1,794016
BW Effect on monthly level		1,509842
	Demand	Orders
Total of 2012	322	257
Weekly average	6,192308	4,942308
Weekly variance	211,5701	212,4084
Weekly stdev	14,54545	14,57424
stdev/av	2,348955	2,948873
BW Effect on weekly level		1,255398

Name	CAB MONTAGEPR.RCSN L500 EL
artnr TU	3407384
artnr Legrand	CM013500
ABC code	E
Volume	13,65
Weight	7,15
Price	3,82
Increment	1
Th EOQ	124,3525394
EOQ	57,62833959
Order size	13
% incr. Of orders	0,389%
MDBO	28
Lead time	13
Dagen voorraad	28,05187557
Delivery days	do
% LT of MBDO	46,429%





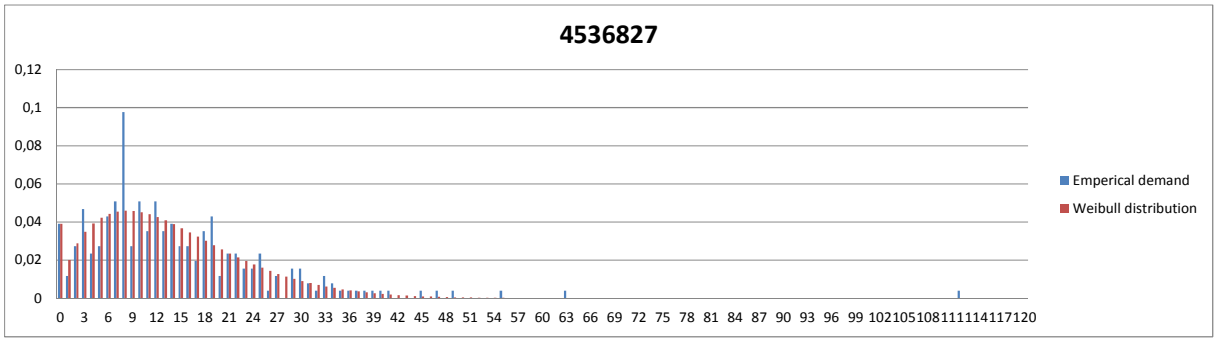
	Demand	Orders
Total of 2012	46	50
Monthly average	3,538462	3,846154
Monthly variance	11,60256	25,64103
Monthly stdev	3,406254	5,063697
stdev/av	0,962637	1,316561
BW Effect on monthly level		1,367661

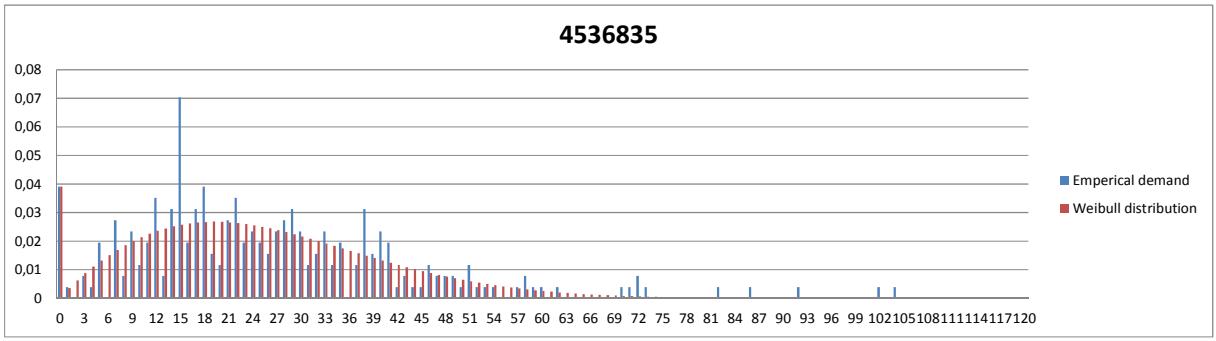
	Demand	Orders
Total of 2012	46	50
Weekly average	0,884615	0,961538
Weekly variance	2,770739	8,861237
Weekly stdev	1,664554	2,976783
stdev/av	1,881669	3,095854
BW Effect on weekly level		1,64527

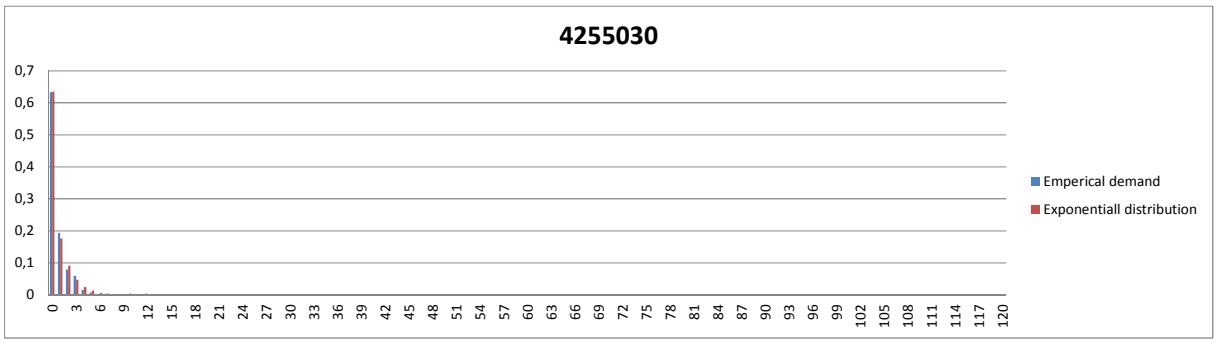
Name	GEEL AFTAKSTUK 60X300 9010
artnr TU	4256632
artnr Legrand	344784
ABC code	E
Volume	77,8
Weight	8,5
Price	18,16
Increment	10
Th EOQ	144,4323243
EOQ	10,43695674
Order size	10
% incr. Of orders	20,000%
MDBO	28
Lead time	13
Dagen voorraad	138,3854775
Delivery days	do
% LT of MBDO	46,429%

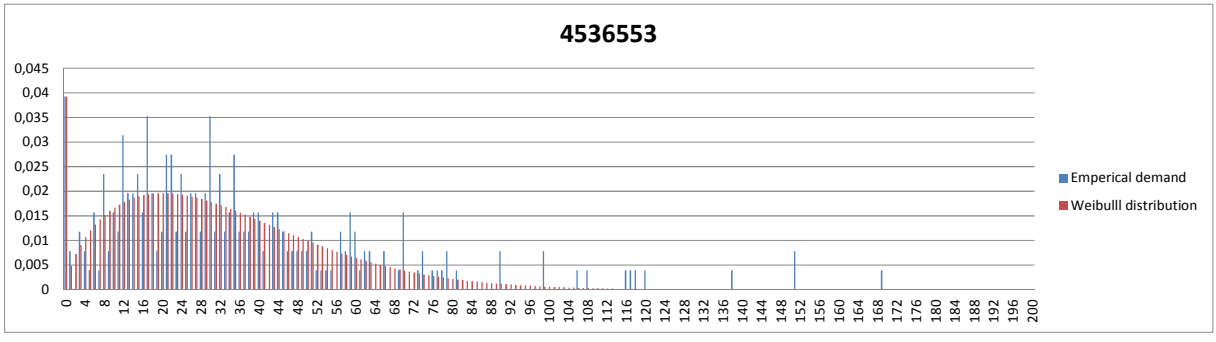
Annex XV: product demand distributions for sampling

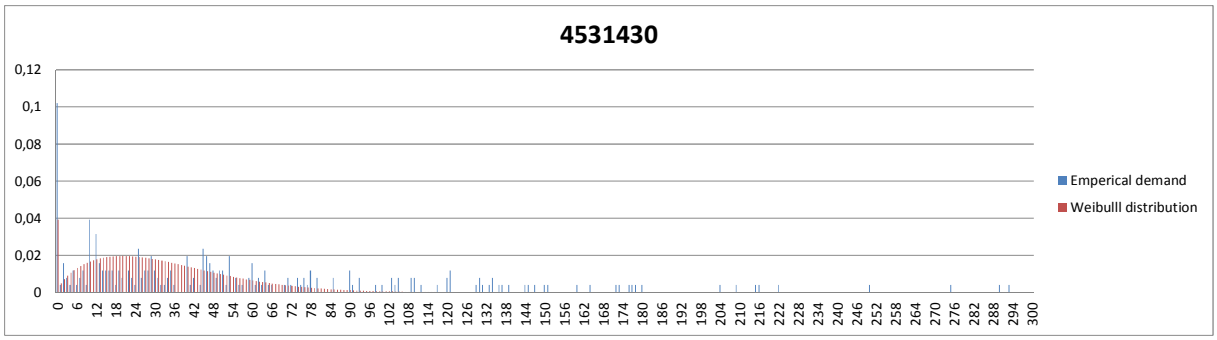
Article nr TU	Distribution type	Parameters	Exp value of average demand per period	Average empirical demand per period	% deviation of exp val towards emp val
4536827	Weibull distribution	a: 1,56 b: 15,82	274,35	277,46	-1,1%
4536835	Weibull distribution	a: 1,84 b: 29,21	499,00	517,38	-3,6%
4255030	Exponential distribution	λ: 0,6614	15,08	13,31	+13,3%
4536553	Weibull distribution	a: 1,60 b: 36,88	642,41	685,46	-6,3%
4531430	Weibull distribution	a: 1,19 b: 55,80	1149,29	1145,00	+0,4%
3407384	Emperical distribution	Increment: 5	27,31	24,77	+10,3%
4256632	Emperical distribution	Increment: 1	3,23	3,54	-8,8%

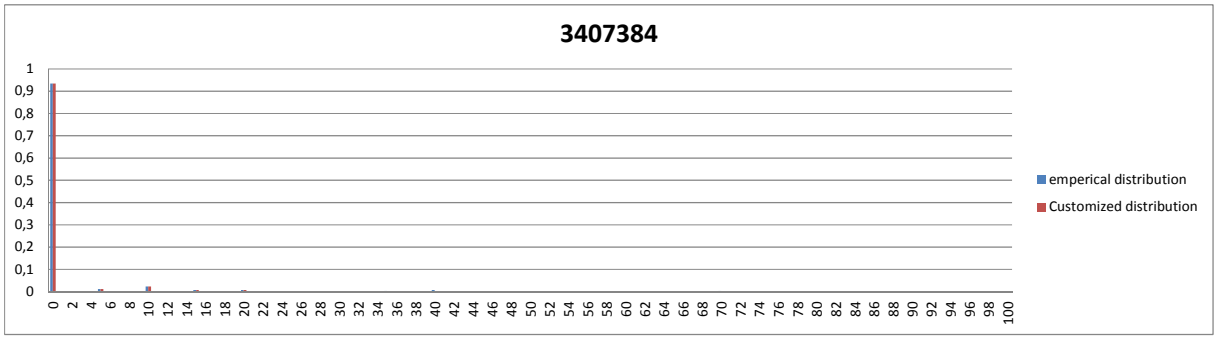


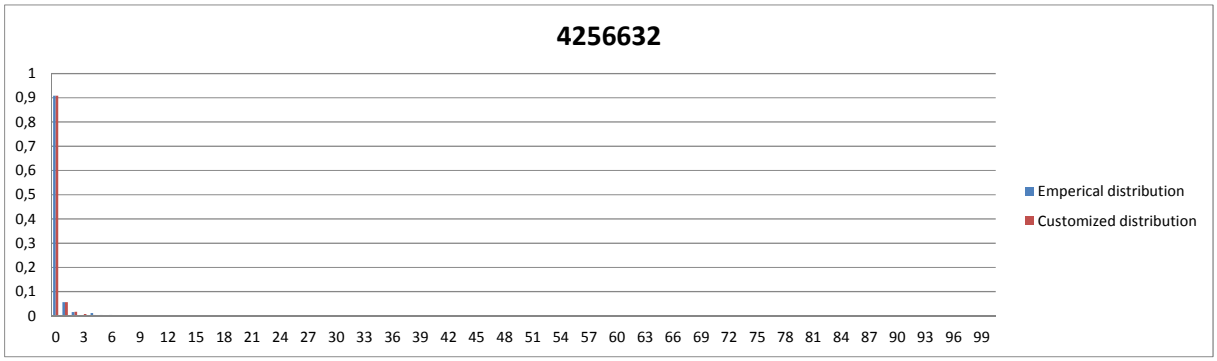








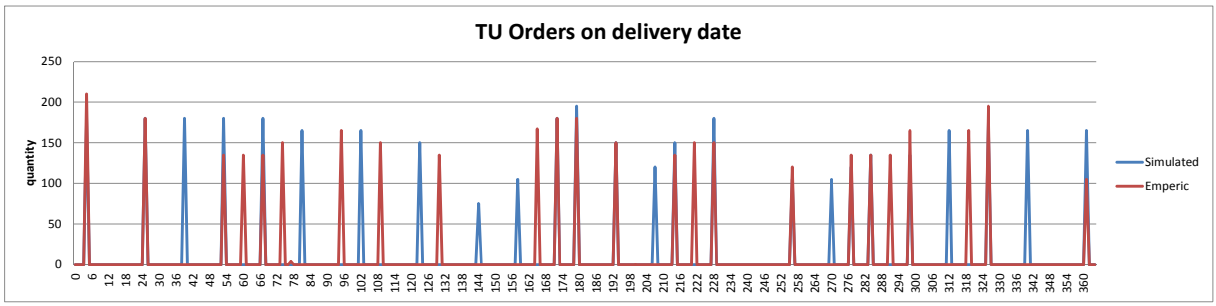


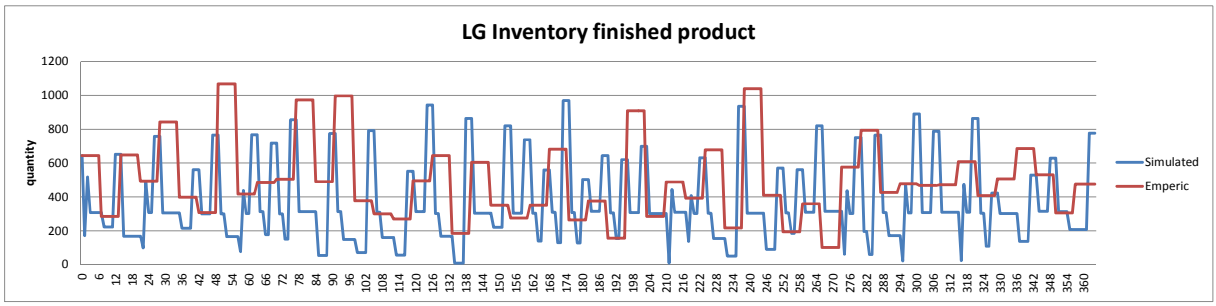


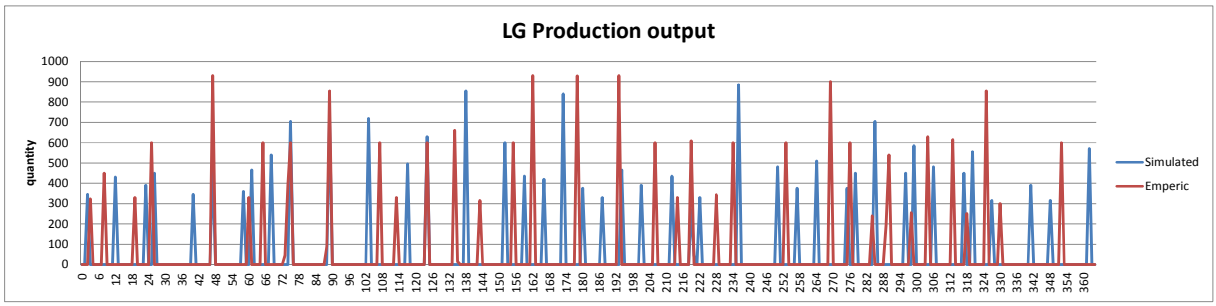
Demand scale factors per period							
Period	**4536827**	**4536835**	**4255030**	**4536553**	**4531430**	**3407384**	**4256632**
1	0,911252	0,755504	1,193453	0,820347	0,867489	1	1
2	1,170048	1,028046	0,928241	0,909076	1,062391	1	1
3	1,027892	0,757508	1,060847	0,85615	1,506141	1	1
4	0,878447	0,919831	0,464121	0,867046	0,995393	1	1
5	0,550396	0,917827	0,596727	1,257762	0,996263	1	1
6	1,046117	1,012014	1,193453	1,218846	1,163322	1	1
7	1,345008	1,220429	0,729333	1,592439	1,097195	1	1
8	1,275753	1,192373	0,530424	0,969784	1,187685	1	1
9	0,805547	1,294577	1,060847	1,01804	1,079793	1	1
10	1,184628	1,038066	1,060847	1,033606	1,044119	1	1
11	1,046117	1,174338	1,458665	1,155024	0,799621	1	1
12	1,002377	1,330649	0,861938	1,450785	0,70304	1	1
13	0,903962	0,837667	0,331515	0,722279	0,448971	1	1

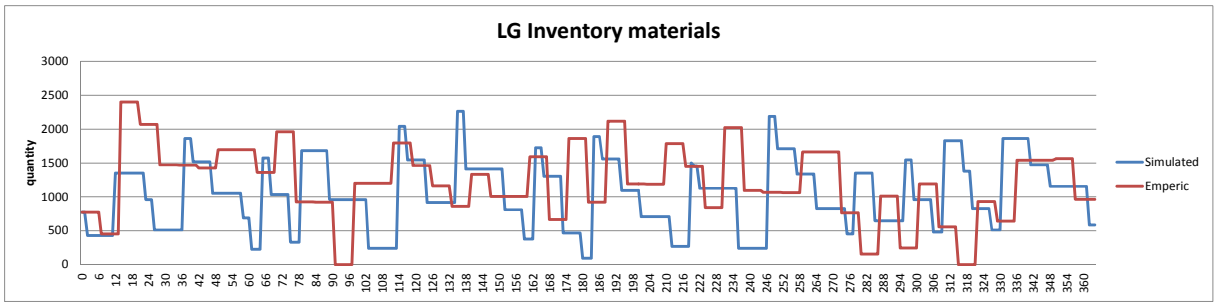
Annex XVI: Validation output charts

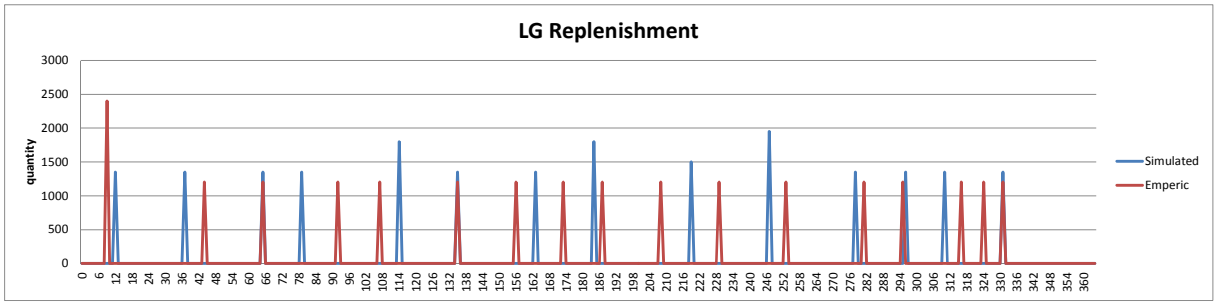
4536827

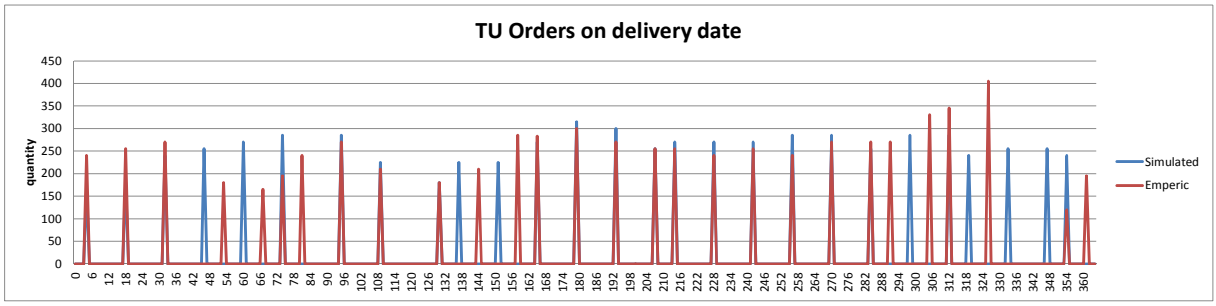


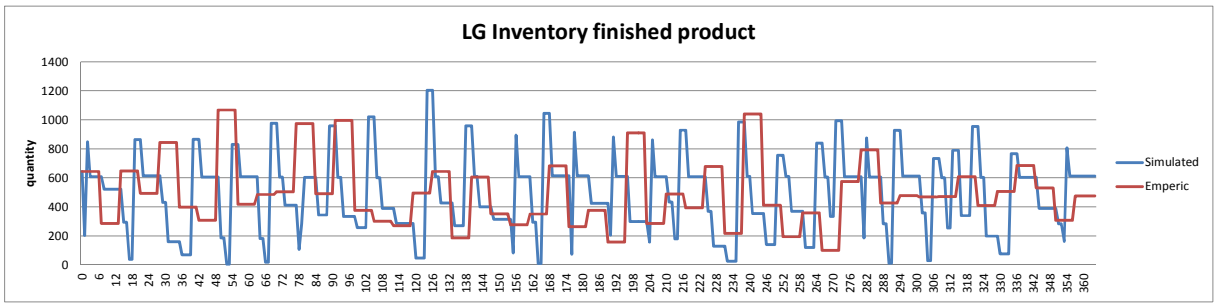


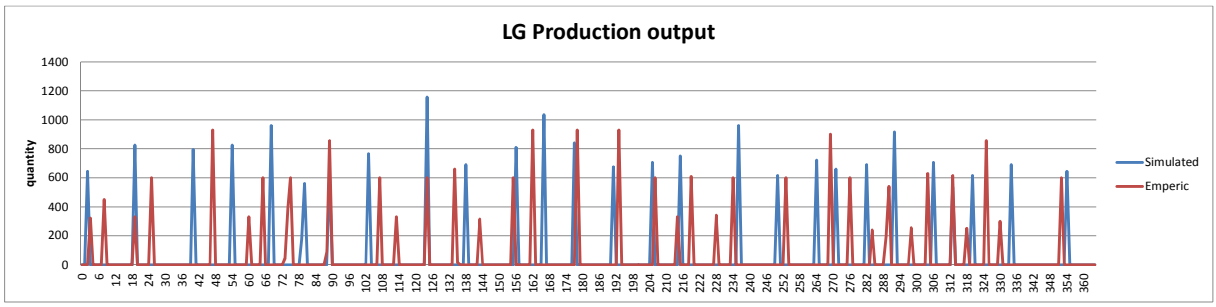


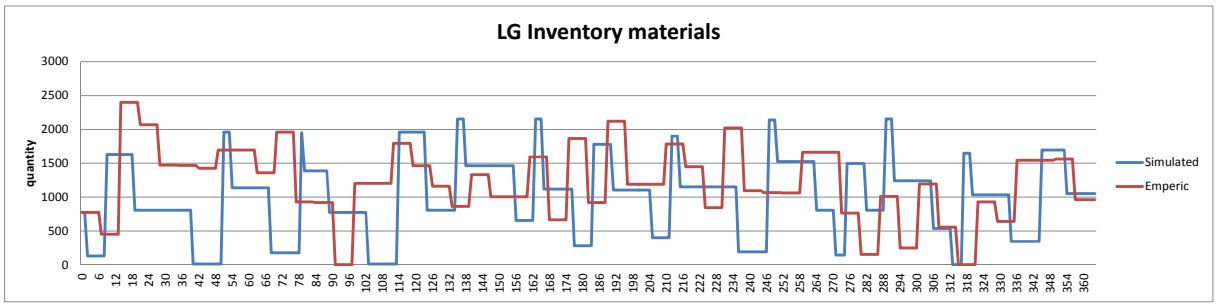


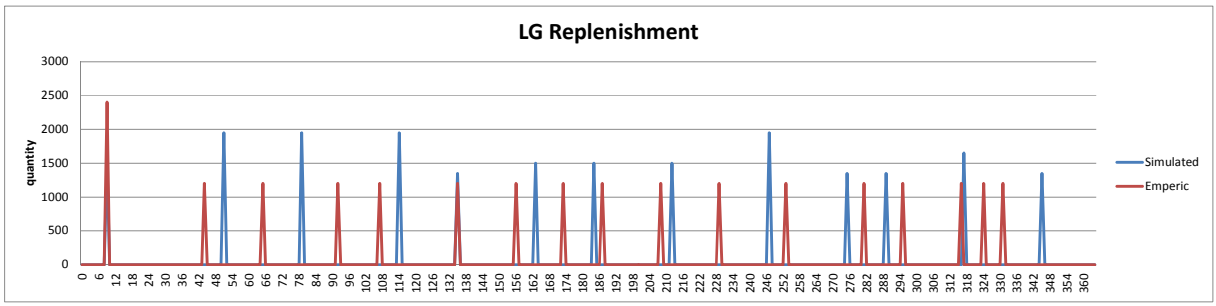


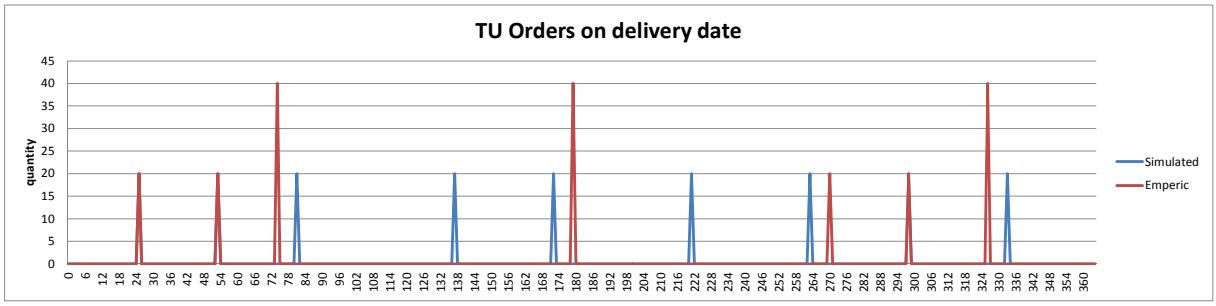

TU Orders on delivery date
quantity
Simulated
Emperic

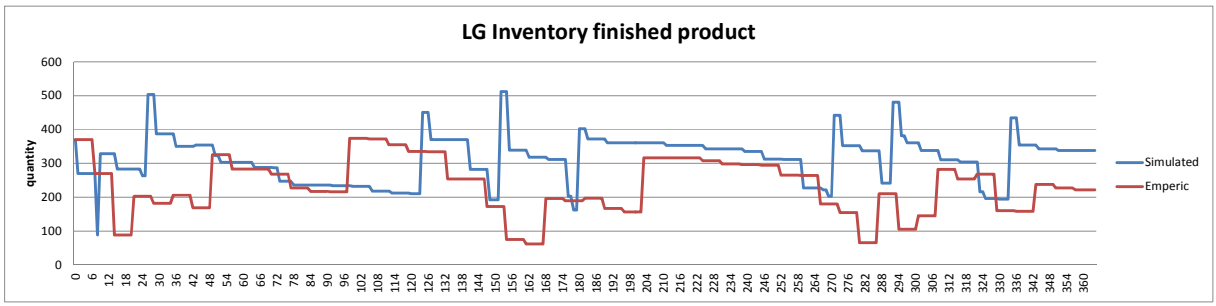

LG Inventory finished product
quantity
Simulated
Emperic

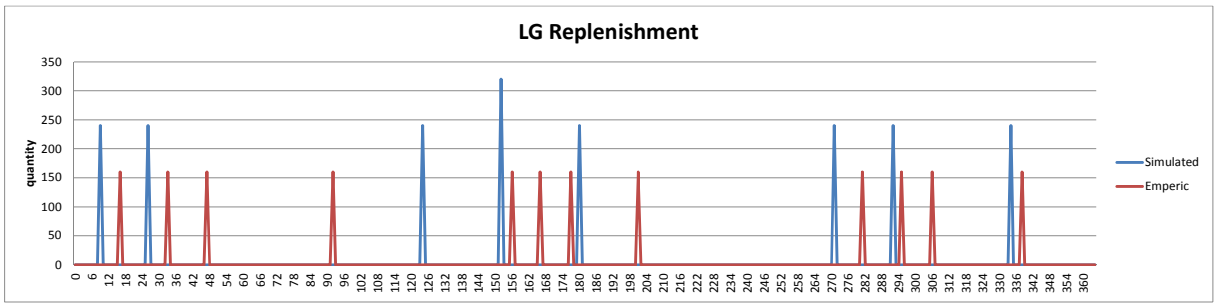

LG Production output
quantity
Simulated
Emperic

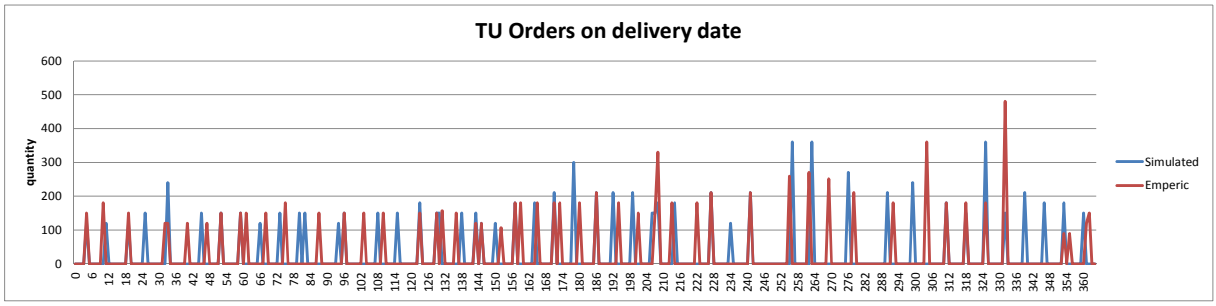

LG Inventory materials
quantity
Simulated
Emperic

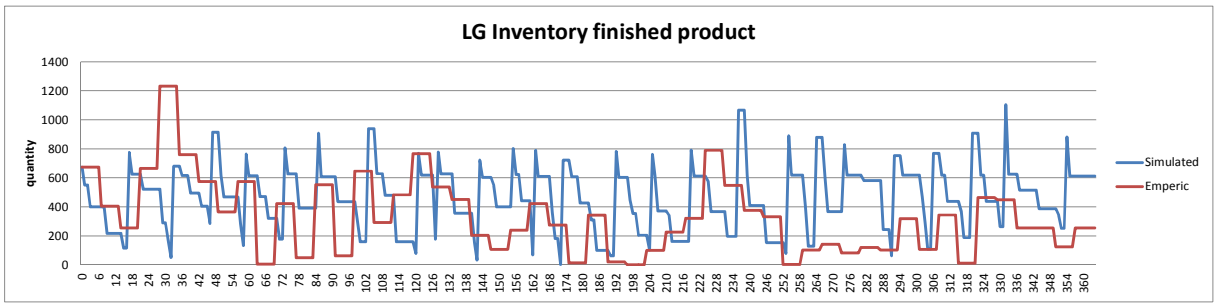

LG Replenishment
quantity
Simulated
Emperic

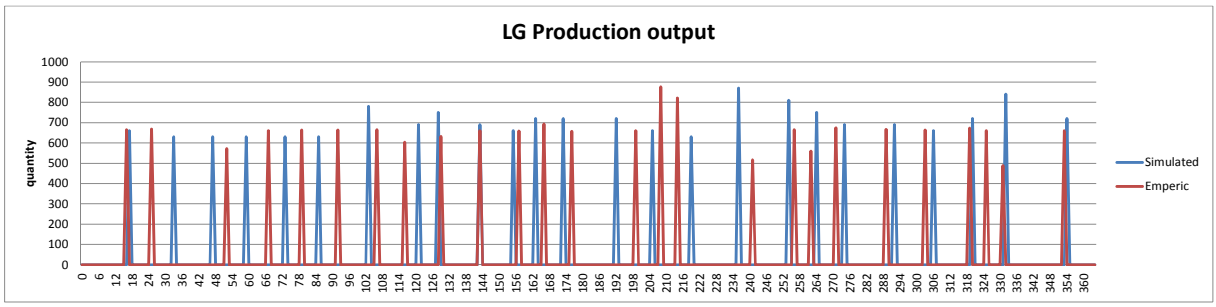

TU Orders on delivery date
quantity
Simulated
Emperic

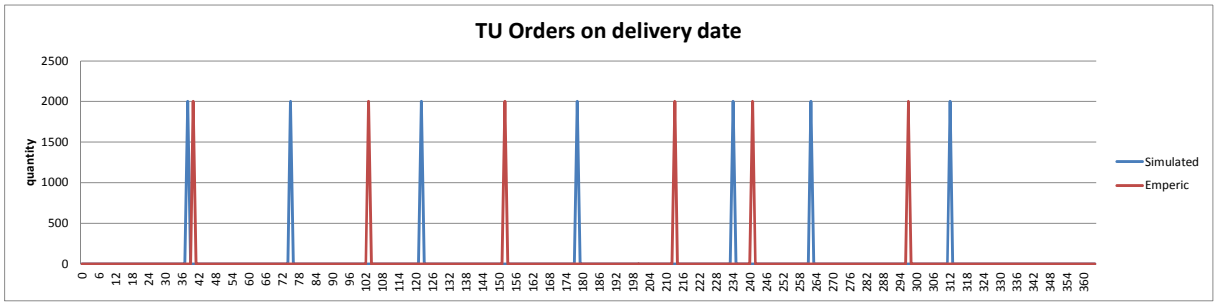

LG Inventory finished product
quantity
Simulated
Emperic

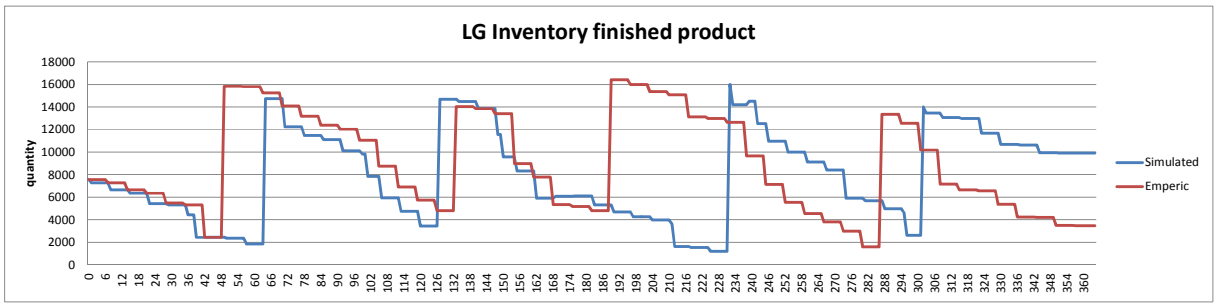

LG Replenishment
quantity
Simulated
Emperic

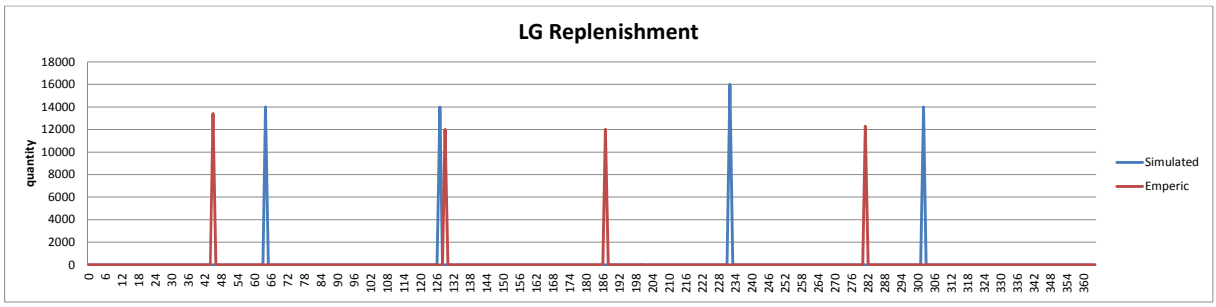

TU Orders on delivery date
quantity
Simulated
Emperic

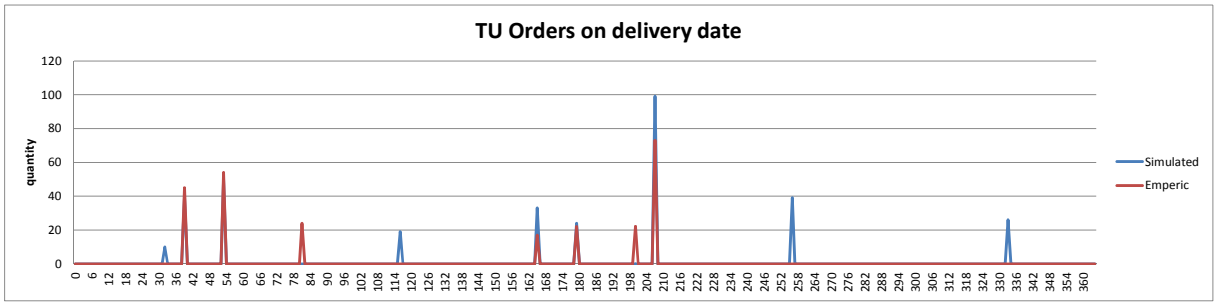

LG Inventory finished product
quantity
Simulated
Emperic

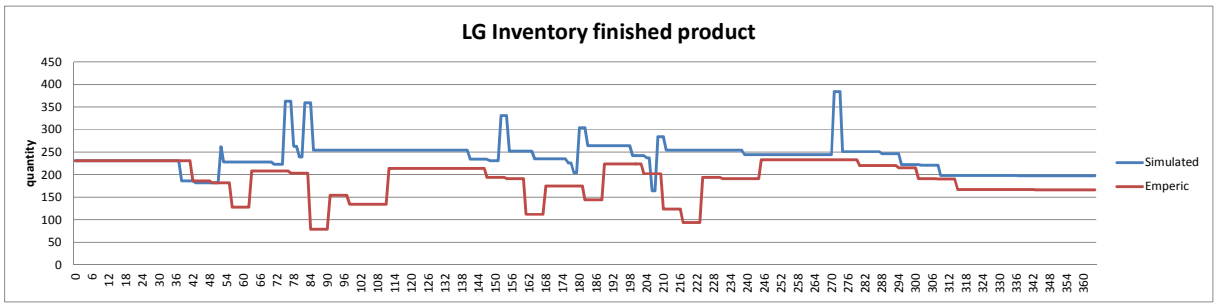

LG Production output
quantity
Simulated
Emperic

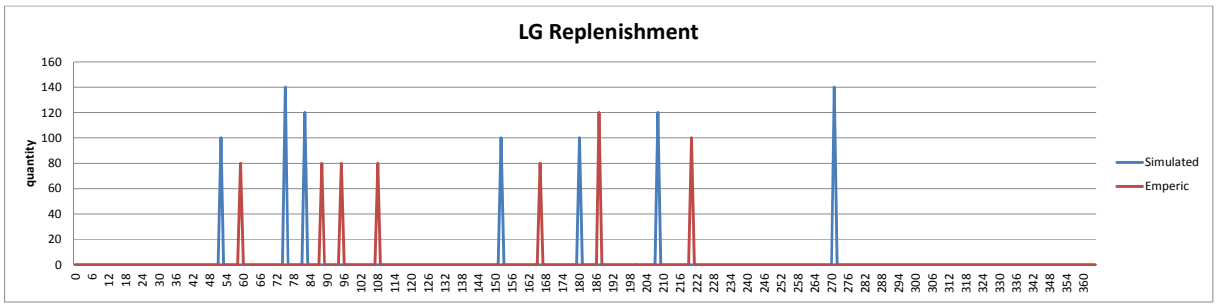

TU Orders on delivery date
quantity
2500
2000
1500
1000
500
0
Simulated
Emperic

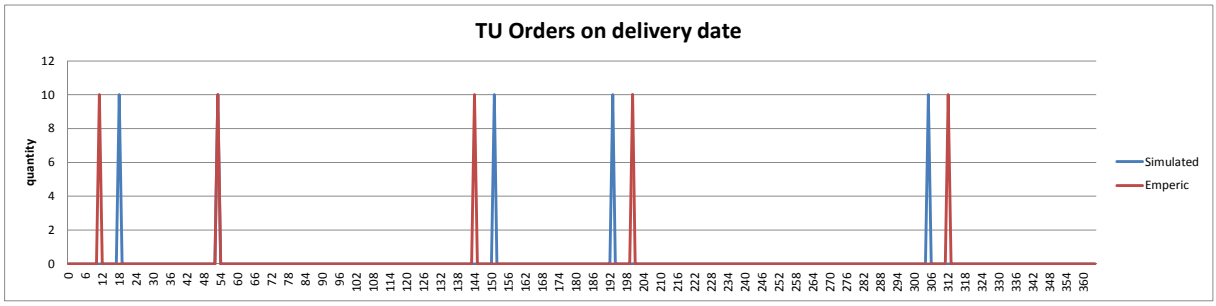

LG Inventory finished product
quantity
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Simulated
Emperic

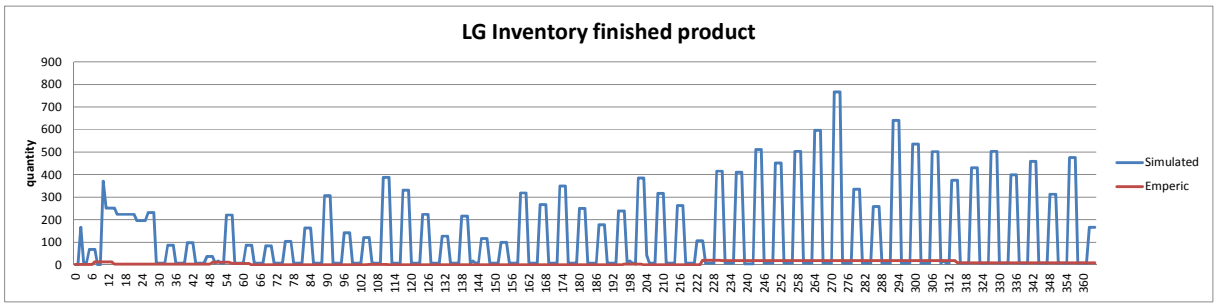

LG Replenishment
quantity
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Simulated
Emperic

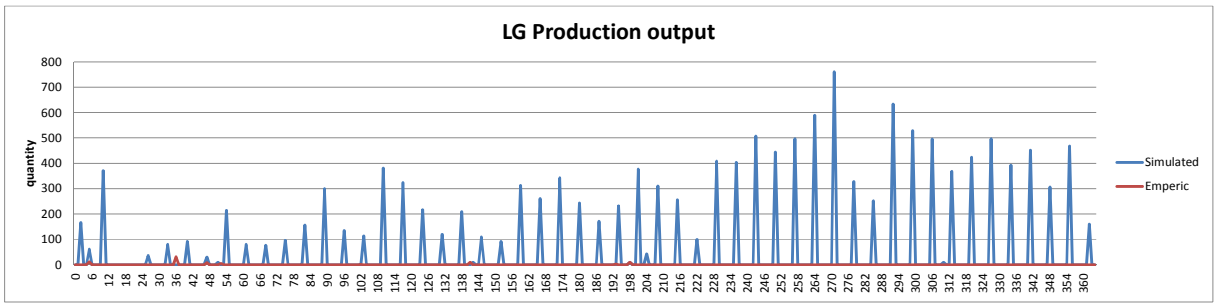

TU Orders on delivery date
quantity
Simulated
Emperic

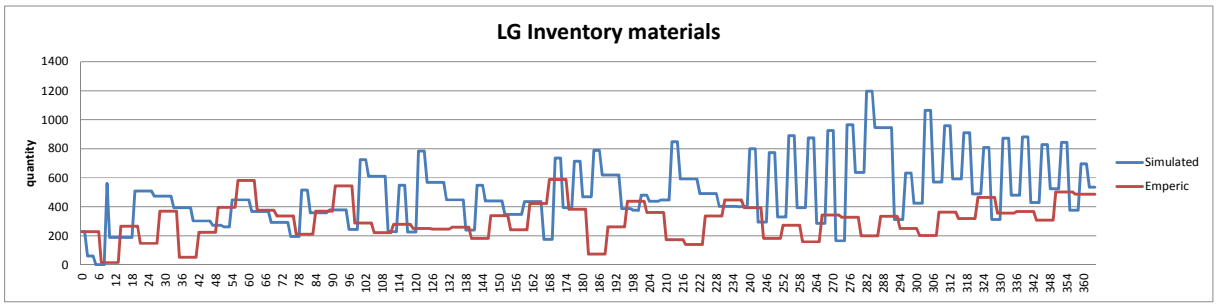

LG Inventory finished product
quantity
Simulated
Emperic

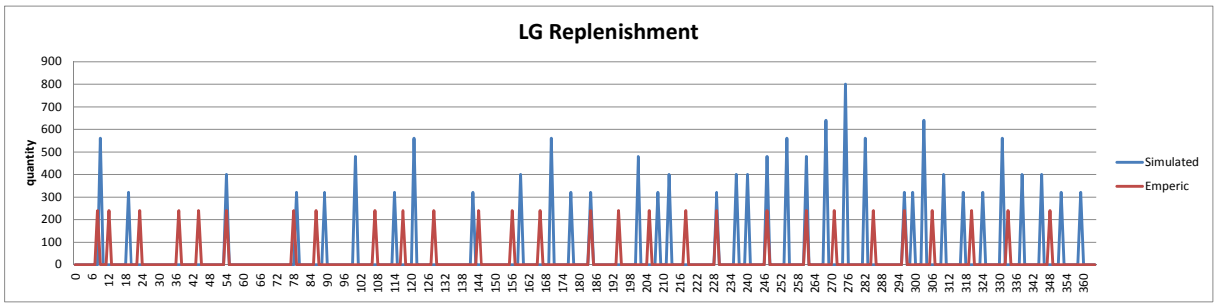

LG Replenishment
quantity
Simulated
Emperic


TU Orders on delivery date
quantity
Simulated
Emperic


LG Inventory finished product
quantity
Simulated
Emperic


LG Production output
quantity
Simulated
Emperic


LG Inventory materials
quantity
Simulated
Emperic


LG Replenishment
quantity
Simulated
Emperic

Annex XVII: Simulation outcome values

4536827 and 4536835		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,86836	0,81969	0,85289	0,8926	0,87964	0,99764	0,99756	0,99826	0,99802	0,99853
	By percentage of days without any backlogs	0,85202	0,79677	0,83437	0,87855	0,8641	0,99366	0,99316	0,99459	0,99464	0,99538
Inventory turnover	Times per year for finished products	54,0728	70,5163	59,3416	45,7415	48,4654	47,9703	49,5628	48,8629	48,3306	48,5904
	Times per year for materials						24,5588	24,9193	24,6752	24,6667	24,5949
Bullwhip Effect	Amplification on weekly level	2,96517	1,6963	2,42235	2,62232	2,52603	3,18482	4,74498	3,79382	3,56153	3,7313
Inventory KPI's											
Average inventory	Average of finished products	249,597	191,668	228,187	296,885	284,836	486,159	469,731	477,474	485,625	481,858
	Average of materials						951,201	935,519	946,643	953,642	953,241
Max inventory	Maximum of finished products	636,519	507,999	638,528	910,426	860,462	1151,26	1077,86	1135,54	1144,52	1130,02
	Maximum of materials						2254,75	2265,61	2245,03	2241,91	2245,58
Average inbound	Average inbound of materials/products	401,065	293,036	335,335	359,25	351,087	1555,5	1568,04	1588	1587,37	1589,96
Max inbound	Maximum inbound of materials/products	553,064	474,668	546,323	558,19	535,681	1989,9	1952,85	1980,3	1998,75	1988,55
Inbound frequency	Number of inbounds of materials/products	33,307	45,496	39,918	37,638	38,404	15,08	14,84	14,822	14,92	14,831
Average outbound	Average outbound of finished products	56,5464	58,3925	57,025	55,4642	55,9997	274,959	239,63	255,129	263,293	260,61
Max outbound	Maximum outbound of finished products	339,692	326,758	331,673	307,265	313,697	553,064	491,414	546,386	558,2	535,878
Outbound frequency	Number of outbounds of finished products	237,94	230,689	236,119	242,651	240,443	84,72	97,091	91,378	89,075	89,795
Production KPI's											
Average production	Average production quantity						732,554	703,233	729,887	730,358	725,006
Max production	Maximum production quantity						1045,25	978,04	1025,51	1026,73	1016,2
Production frequency	Number of production runs						31,814	33,001	31,881	32,134	32,242
Ordering KPI's											
Average orders	Average order quantity	401,527	293,151	335,411	359,355	351,142	1555,5	1568,04	1588	1587,37	1589,96
Max orders	Maximum order quantity	553,29	474,9	546,435	558,225	536,055	1989,9	1952,85	1980,3	1998,75	1988,55
Order frequency	Number of orders	33,267	45,478	39,909	37,627	38,398	15,08	14,84	14,822	14,92	14,831
FAD KPI's											
Forecast deviation	Average forecast deviation		250,009	104,174	72,1846	96,874					
	Av forecast deviation as a perc of av demand		0,96721	0,40253	0,27897	0,37408					
Discount percentage	Average discount percentage		0,00521	0,01434	0,01609	0,01445					
	Av disc perc as a perc of the max possible discount		0,26046	0,71706	0,80431	0,72225					

4536827 and 4536835		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,87836	0,82177	0,85269	0,89326	0,88041	0,88761	0,88972	0,9109	0,91762	0,91656
	By percentage of days without any backlogs	0,86233	0,79885	0,83439	0,87912	0,86478	0,76068	0,76828	0,79033	0,80881	0,79919
Inventory turnover	Times per year for finished products	52,8647	70,0298	59,3134	45,6248	48,1531	170,473	177,107	173,51	172,775	173,17
	Times per year for materials						63,2768	70,3801	67,9064	64,6934	65,8219
Bullwhip Effect	Amplification on weekly level	2,96563	1,72383	2,42555	2,62625	2,52965	1,41131	1,64108	1,43912	1,51792	1,50125
Inventory KPI's											
Average inventory	Average of finished products	255,514	193,022	228,306	297,741	286,65	136,834	131,41	134,413	135,811	135,161
	Average of materials						369,949	331,049	343,713	363,046	355,825
Max inventory	Maximum of finished products	667,524	509,142	633,384	910,831	870,558	625,999	516,983	630,452	633,25	584,757
	Maximum of materials						1150,98	864,315	846,33	861,41	836,615
Average inbound	Average inbound of materials/products	366,542	286,071	329,231	354,75	345,553	401,267	364,924	373,295	386,993	376,767
Max inbound	Maximum inbound of materials/products	540,782	462,212	536,678	552,577	530,51	972,3	691,8	714,15	729,45	696
Inbound frequency	Number of inbounds of materials/products	36,579	46,629	40,667	38,147	39,039	56,054	61,173	60,107	58,524	59,845
Average outbound	Average outbound of finished products	56,1107	58,2575	56,9937	55,4212	55,9484	235,551	201,359	216,652	225,859	221,644
Max outbound	Maximum outbound of finished products	331,087	324,777	330,266	305,225	311,264	553,068	468,91	548,361	565,469	536,108
Outbound frequency	Number of outbounds of finished products	239,809	231,195	236,247	242,838	240,652	98,979	115,611	107,693	103,912	105,664
Production KPI's											
Average production	Average production quantity						243,815	204,604	219,879	229,43	224,553
Max production	Maximum production quantity						614,235	503,155	617,505	617,22	566,535
Production frequency	Number of production runs						93,952	111,7	104,204	100,462	102,461
Ordering KPI's											
Average orders	Average order quantity	401,776	294,341	335,876	359,9	351,546	401,267	364,924	373,295	386,993	376,767
Max orders	Maximum order quantity	552,285	480,555	546,015	559,65	536,4	972,3	691,8	714,15	729,45	696
Order frequency	Number of orders	33,261	45,295	39,863	37,581	38,363	56,054	61,173	60,107	58,524	59,845
FAD KPI's											
Forecast deviation	Average forecast deviation		249,988	103,708	72,5175	97,0685					
	Av forecast deviation as a perc of av demand		0,96714	0,40073	0,28023	0,37487					
Discount percentage	Average discount percentage		0,00516	0,01436	0,01605	0,01442					
	Av disc perc as a perc of the max possible discount		0,25796	0,71819	0,80259	0,72125					

4536827 and 4536835		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,86824	0,822	0,85013	0,89575	0,88457	0,88894	0,88926	0,90503	0,91085	0,91349
	By percentage of days without any backlogs	0,85154	0,79917	0,8301	0,88154	0,86913	0,76882	0,76683	0,78717	0,80118	0,80141
Inventory turnover	Times per year for finished products	55,7806	70,0489	61,4545	46,1318	48,5511	170,717	177,17	174,235	174,06	173,429
	Times per year for materials						64,8098	70,6049	69,1096	65,914	67,2534
Bullwhip Effect	Amplification on weekly level	2,70386	1,71345	2,21735	2,4215	2,36863	1,46402	1,64856	1,51562	1,55456	1,5208
Inventory KPI's											
Average inventory	Average of finished products	242,185	192,96	220,349	294,408	283,107	136,578	131,362	133,8	134,81	134,996
	Average of materials						360,784	329,983	337,536	356,262	348,343
Max inventory	Maximum of finished products	637,73	508,732	604,358	891,134	843,425	616,509	517,1	616,389	594,328	564,918
	Maximum of materials						1138,92	866,18	832,225	831,27	837,745
Average inbound	Average inbound of materials/products	346,181	285,467	317,104	341,549	335,947	395,355	365,278	372,571	382,168	373,463
Max inbound	Maximum inbound of materials/products	515,206	462,198	507,208	520,059	504,661	928,65	693	702,9	688,65	679,05
Inbound frequency	Number of inbounds of materials/products	38,658	46,726	42,179	39,609	40,148	56,752	61,113	60,149	59,261	60,366
Average outbound	Average outbound of finished products	56,4633	58,2453	57,082	55,3195	55,7629	229,742	200,925	212,72	220,109	219,332
Max outbound	Maximum outbound of finished products	330,632	324,836	323,618	300,632	308,968	534,316	468,771	521,141	530,828	511,321
Outbound frequency	Number of outbounds of finished products	238,352	231,237	235,905	243,298	241,425	101,433	115,861	109,627	106,624	106,776
Production KPI's											
Average production	Average production quantity						239,302	205,05	217,065	224,364	223,516
Max production	Maximum production quantity						605,895	503,275	605,82	577,755	547,255
Production frequency	Number of production runs						95,689	111,457	105,495	102,724	102,931
Ordering KPI's											
Average orders	Average order quantity	375,339	293,705	323,385	345,855	341,621	395,355	365,278	372,571	382,168	373,463
Max orders	Maximum order quantity	535,875	480,465	517,98	526,62	514,41	928,65	693	702,9	688,65	679,05
Order frequency	Number of orders	35,578	45,391	41,356	39,102	39,462	56,752	61,113	60,149	59,261	60,366
FAD KPI's											
Forecast deviation	Average forecast deviation		250,372	111,902	70,0976	88,7005					
	Av forecast deviation as a perc of av demand		0,96862	0,43253	0,27092	0,34269					
Discount percentage	Average discount percentage		0,00515	0,01385	0,01617	0,01488					
	Av disc perc as a perc of the max possible discount		0,25754	0,69266	0,80861	0,74421					

4536827 and 4536835		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,77066	0,8214	0,82262	0,8344	0,83707	0,85619	0,89057	0,89316	0,89535	0,893
	By percentage of days without any backlogs	0,74438	0,79875	0,80058	0,81653	0,82049	0,73254	0,76882	0,77235	0,77607	0,78208
Inventory turnover	Times per year for finished products	80,7581	70,1565	69,6872	61,1993	59,6857	179,327	176,915	176,904	177,622	178,176
	Times per year for materials						71,7196	70,7473	70,8235	71,7985	72,2374
Bullwhip Effect	Amplification on weekly level	1,71163	1,69666	1,65077	1,31421	1,19165	1,88003	1,65489	1,66129	1,76142	1,77849
Inventory KPI's											
Average inventory	Average of finished products	167,456	192,67	194,01	221,584	227,813	129,603	131,557	131,574	131,492	131,032
	Average of materials						324,543	329,257	328,824	325,447	323,3
Max inventory	Maximum of finished products	508,263	504,858	505,231	606,603	600,836	576,565	514,376	507,371	485,276	476,778
	Maximum of materials						997,57	847,395	822,99	831,555	826,105
Average inbound	Average inbound of materials/products	250,122	285,086	283,914	268,653	262,752	379,058	364,484	361,889	357,678	356,769
Max inbound	Maximum inbound of materials/products	496,348	460,103	457,594	449,605	446,462	770,4	673,95	640,95	641,25	637,8
Inbound frequency	Number of inbounds of materials/products	53,17	46,795	46,975	49,936	51,017	58,803	61,244	61,737	62,624	62,696
Average outbound	Average outbound of finished products	60,5817	58,2688	58,203	57,6451	57,5374	200,299	200,517	199,322	192,933	191,147
Max outbound	Maximum outbound of finished products	361,959	325,259	324,661	321,15	322,158	510,156	465,006	461,055	455,081	449,398
Outbound frequency	Number of outbounds of finished products	222,267	231,151	231,417	233,633	234,077	116,021	116,104	116,805	121,09	122,162
Production KPI's											
Average production	Average production quantity						206,646	204,57	203,015	195,425	193,257
Max production	Maximum production quantity						567,87	500,655	493,845	466,035	455,745
Production frequency	Number of production runs						110,396	111,724	112,586	117,444	118,622
Ordering KPI's											
Average orders	Average order quantity	273,468	292,273	289,142	272,431	265,933	379,058	364,484	361,889	357,678	356,769
Max orders	Maximum order quantity	513,045	478,74	478,05	472,185	469,635	770,4	673,95	640,95	641,25	637,8
Order frequency	Number of orders	48,596	45,62	46,118	49,236	50,401	58,803	61,244	61,737	62,624	62,696
FAD KPI's											
Forecast deviation	Average forecast deviation		252,933	167,817	77,4049	64,5545					
	Av forecast deviation as a perc of av demand		0,97854	0,64916	0,29889	0,24927					
Discount percentage	Average discount percentage		0,00504	0,01009	0,01512	0,01584					
	Av disc perc as a perc of the max possible discount		0,25178	0,50434	0,75602	0,79199					

4536827 and 4536835		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,82354	0,90198	0,91648	0,92127	0,92374	0,79322	0,83238	0,85119	0,85504	0,85718
	By percentage of days without any backlogs	0,79829	0,88169	0,89947	0,90557	0,90914	0,67187	0,68778	0,71318	0,72061	0,72123
Inventory turnover	Times per year for finished products	73,0868	59,8797	54,1958	52,7661	50,7454	174,561	164,922	165,669	166,076	166,933
	Times per year for materials						66,8095	85,0634	94,8143	98,1144	98,8374
Bullwhip Effect	Amplification on weekly level	1,9109	1,84546	1,43523	1,27379	1,21842	2,33498	2,1059	2,1866	2,25429	2,25144
Inventory KPI's											
Average inventory	Average of finished products	184,678	225,164	249,525	256,853	267,608	133,346	141,414	141,109	140,84	140,023
	Average of materials						357,394	277,263	248,61	239,945	238,023
Max inventory	Maximum of finished products	572,845	568,109	601,796	601,808	629,888	773,367	819,567	796,214	778,745	770,097
	Maximum of materials						1686,59	1224,17	1109,87	1065,61	1053,04
Average inbound	Average inbound of materials/products	233,456	258,836	248,468	244,363	243,006	465,045	445,179	433,09	427,993	427,143
Max inbound	Maximum inbound of materials/products	535,098	515,43	479,325	460,933	456,37	1246,5	1088,25	978,3	925,95	921
Inbound frequency	Number of inbounds of materials/products	57,029	51,657	54,026	54,971	55,223	48,257	50,31	51,652	52,187	52,305
Average outbound	Average outbound of finished products	57,6866	54,5988	54,0468	53,8597	53,7729	219,722	224,946	219,669	217,361	216,447
Max outbound	Maximum outbound of finished products	324,786	267,538	252,075	249,154	248,012	595,686	613,385	580,377	565,027	559,657
Outbound frequency	Number of outbounds of finished products	233,261	246,373	248,885	249,745	250,136	105,78	103,527	106,301	107,486	107,878
Production KPI's											
Average production	Average production quantity						244,41	254,844	246,932	243,94	242,491
Max production	Maximum production quantity						772,71	819,54	796,17	778,68	770,07
Production frequency	Number of production runs						93,228	89,785	92,88	93,992	94,524
Ordering KPI's											
Average orders	Average order quantity	280,327	298,198	276,419	269,337	267,262	465,045	445,179	433,09	427,993	427,143
Max orders	Maximum order quantity	556,29	521,205	495,15	481,605	479,625	1246,5	1088,25	978,3	925,95	921
Order frequency	Number of orders	47,467	44,759	48,511	49,837	50,171	48,257	50,31	51,652	52,187	52,305
FAD KPI's											
Forecast deviation	Average forecast deviation		123,78	93,0421	74,1938	64,5479					
	Av forecast deviation as a perc of av demand		0,47893	0,35942	0,28649	0,24918					
Discount percentage	Average discount percentage		0,01225	0,01408	0,01523	0,0158					
	Av disc perc as a perc of the max possible discount		0,61237	0,7039	0,76125	0,78986					

4255030		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,97129	0,96862	0,96915	0,97355	0,97642	1	1	1	1	1
	By percentage of days without any backlogs	0,97395	0,97186	0,97245	0,97628	0,97907	0,9804	0,98058	0,98053	0,9806	0,98062
Inventory turnover	Times per year for finished products	8,72178	9,55628	8,4012	6,96659	6,37436	6,42598	6,60262	6,56684	6,634	6,67193
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	2,65766	2,49927	2,55793	2,51829	2,50936	1,94436	1,95259	1,96	1,96054	1,95339
Inventory KPI's											
Average inventory	Average of finished products	19,6799	17,8951	20,5283	24,9693	27,485	315,051	306,451	308,708	306,197	304,578
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	41,482	35,021	43,078	54,969	62,502	518,962	518,023	517,239	512,917	510,366
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	21,4825	20,0793	20,7771	20,6285	20,5573	249,98	245,928	245,676	245,587	245,422
Max inbound	Maximum inbound of materials/products	29,92	20,58	25,56	24,38	24,1	320	320	316,24	314,32	310,72
Inbound frequency	Number of inbounds of materials/products	8,036	8,505	8,39	8,577	8,612	8	8,029	8,025	8,054	8,058
Average outbound	Average outbound of finished products	1,95047	1,94998	1,95156	1,95016	1,94803	39,6629	39,2797	39,4276	39,3364	39,3141
Max outbound	Maximum outbound of finished products	9,304	9,258	9,29	9,332	9,305	182	182	182	182	182
Outbound frequency	Number of outbounds of finished products	87,161	87,18	87,108	87,172	87,259	51,036	51,505	51,39	51,577	51,612
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	21,4825	20,0793	20,7771	20,6285	20,5573	249,98	245,928	245,676	245,587	245,422
Max orders	Maximum order quantity	29,92	20,58	25,56	24,38	24,1	320	320	316,24	314,32	310,72
Order frequency	Number of orders	8,036	8,505	8,39	8,577	8,612	8	8,029	8,025	8,054	8,058
FAD KPI's											
Forecast deviation	Average forecast deviation		2,69923	1,32269	1,21615	1,11615					
	Av forecast deviation as a perc of av demand		0,82651	0,39974	0,36629	0,3366					
Discount percentage	Average discount percentage		0,00472	0,01246	0,01346	0,01408					
	Av disc perc as a perc of the max possible discount		0,23599	0,62294	0,67307	0,70413					

4255030		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,95248	0,91165	0,90504	0,91644	0,93031	1	1	1	1	1
	By percentage of days without any backlogs	0,95677	0,92038	0,91346	0,92334	0,93572	0,98164	0,98409	0,98385	0,98348	0,98279
Inventory turnover	Times per year for finished products	10,5805	13,5953	11,8693	9,64037	7,61964	10,321	10,4387	10,1803	10,2133	10,1521
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	2,15703	1,81926	1,96653	1,99804	2,08588	1,09984	1,09427	1,11797	1,11063	1,10386
Inventory KPI's											
Average inventory	Average of finished products	16,1761	12,6771	14,5422	18,2404	23,0467	195,698	193,059	197,93	197,429	199,077
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	33,309	29,396	35,856	48,16	58,231	348,871	343,602	349,036	348,304	346,895
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	14,5917	8,37465	8,80266	9,62789	11,3155	69,9289	68,9924	69,8352	69,9776	69,2429
Max inbound	Maximum inbound of materials/products	20,953	17,696	20,36	19,942	20,707	175,06	174,46	172,52	171,98	171,5
Inbound frequency	Number of inbounds of materials/products	11,514	20,136	19,207	17,817	15,231	27,07	27,418	27,044	27,004	27,355
Average outbound	Average outbound of finished products	1,96091	1,97599	1,98383	1,9799	1,97495	37,0661	32,0415	32,5202	33,2959	34,7741
Max outbound	Maximum outbound of finished products	9,309	9,395	9,54	9,519	9,53	182	182	182	182	182
Outbound frequency	Number of outbounds of finished products	86,705	86,043	85,726	85,887	86,102	54,514	63,136	62,207	60,817	58,231
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	14,5917	8,37465	8,80266	9,62789	11,3155	69,9289	68,9924	69,8352	69,9776	69,2429
Max orders	Maximum order quantity	20,953	17,696	20,36	19,942	20,707	175,06	174,46	172,52	171,98	171,5
Order frequency	Number of orders	11,514	20,136	19,207	17,817	15,231	27,07	27,418	27,044	27,004	27,355
FAD KPI's											
Forecast deviation	Average forecast deviation		2,55433	1,47996	1,31829	0,7944					
	Av forecast deviation as a perc of av demand		0,78143	0,44786	0,39626	0,23949					
Discount percentage	Average discount percentage		0,0108	0,01511	0,01559	0,0175					
	Av disc perc as a perc of the max possible discount		0,53997	0,75567	0,77943	0,87507					

4255030		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,92579	0,90144	0,91082	0,90754	0,925	1	1	1	1	1
	By percentage of days without any backlogs	0,93224	0,91094	0,91993	0,91534	0,93225	0,98445	0,98469	0,98416	0,98465	0,98452
Inventory turnover	Times per year for finished products	13,745	14,2747	12,6977	11,639	9,25534	10,3645	10,523	10,3527	10,3595	10,3544
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,42938	1,69748	1,65811	1,5878	1,53828	1,10434	1,09596	1,10806	1,10156	1,09518
Inventory KPI's											
Average inventory	Average of finished products	12,4663	12,0281	13,5128	14,8532	18,7285	194,618	191,376	195,093	194,617	195,033
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	25,76	29,384	29,774	35,692	45,343	347,436	343,664	348,583	346,655	346,157
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	7,72262	7,27576	8,33387	7,43751	7,74124	71,3109	69,6311	69,9957	70,1127	70,0174
Max inbound	Maximum inbound of materials/products	14,371	17,375	17,544	16,868	16,058	174,42	174,62	176,34	174,24	170,84
Inbound frequency	Number of inbounds of materials/products	21,395	22,47	20,228	22,337	21,742	26,506	27,107	27,116	26,953	27,038
Average outbound	Average outbound of finished products	1,97377	1,97959	1,98422	1,98564	1,97598	31,3588	30,8281	31,9884	30,9301	31,2402
Max outbound	Maximum outbound of finished products	9,218	9,389	9,564	9,543	9,524	182	182	182	182	182
Outbound frequency	Number of outbounds of finished products	86,159	85,891	85,708	85,638	86,05	64,395	65,47	63,228	65,337	64,742
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	7,72262	7,27576	8,33387	7,43751	7,74124	71,3109	69,6311	69,9957	70,1127	70,0174
Max orders	Maximum order quantity	14,371	17,375	17,544	16,868	16,058	174,42	174,62	176,34	174,24	170,84
Order frequency	Number of orders	21,395	22,47	20,228	22,337	21,742	26,506	27,107	27,116	26,953	27,038
FAD KPI's											
Forecast deviation	Average forecast deviation		2,7249	1,28444	1,40315	0,98581					
	Av forecast deviation as a perc of av demand		0,83318	0,38937	0,42367	0,29612					
Discount percentage	Average discount percentage		0,01009	0,01497	0,01485	0,01641					
	Av disc perc as a perc of the max possible discount		0,50437	0,74832	0,74226	0,82067					

4255030		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,90425	0,92023	0,90742	0,91774	0,92424	1	1	1	1	1
	By percentage of days without any backlogs	0,91384	0,92839	0,91693	0,92521	0,93105	0,98636	0,98445	0,98505	0,98584	0,98606
Inventory turnover	Times per year for finished products	15,5946	13,4264	13,4676	11,8535	10,2636	10,3665	10,4684	10,4455	10,4149	10,4056
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,11319	1,68397	1,56988	1,35883	1,30078	1,10684	1,09311	1,10141	1,09373	1,09266
Inventory KPI's											
Average inventory	Average of finished products	11,003	12,7603	12,7458	14,5042	16,7864	194,45	192,454	193,208	193,816	194,005
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	22,816	29,369	28,963	32,004	38,178	347,174	343,734	347,794	345,89	345,241
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	5,38219	7,62781	6,94973	6,01907	5,78686	71,2302	69,4651	70,7311	70,1752	70,3318
Max inbound	Maximum inbound of materials/products	12,544	17,336	17,336	16,426	16,052	174,22	174,66	175,92	175,3	170,02
Inbound frequency	Number of inbounds of materials/products	30,408	21,426	24,008	27,753	28,859	26,515	27,204	26,847	27,036	26,92
Average outbound	Average outbound of finished products	1,97966	1,97182	1,98283	1,97932	1,976	27,4945	31,3179	30,1646	28,5732	28,133
Max outbound	Maximum outbound of finished products	9,194	9,237	9,473	9,385	9,387	182	182	182	182	182
Outbound frequency	Number of outbounds of finished products	85,892	86,232	85,766	85,915	86,059	73,408	64,426	67,008	70,753	71,859
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	5,38219	7,62781	6,94973	6,01907	5,78686	71,2302	69,4651	70,7311	70,1752	70,3318
Max orders	Maximum order quantity	12,544	17,336	17,336	16,426	16,052	174,22	174,66	175,92	175,3	170,02
Order frequency	Number of orders	30,408	21,426	24,008	27,753	28,859	26,515	27,204	26,847	27,036	26,92
FAD KPI's											
Forecast deviation	Average forecast deviation		2,41475	1,75085	1,22556	1,08558					
	Av forecast deviation as a perc of av demand		0,73972	0,53248	0,36996	0,32695					
Discount percentage	Average discount percentage		0,01066	0,01329	0,01541	0,01599					
	Av disc perc as a perc of the max possible discount		0,53297	0,66462	0,77046	0,79936					

4255030		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,91238	0,92027	0,92409	0,93127	0,9375	1	1	1	1	1
	By percentage of days without any backlogs	0,92108	0,92879	0,93171	0,93773	0,94292	0,98612	0,98523	0,98612	0,98617	0,98651
Inventory turnover	Times per year for finished products	16,9285	14,7304	12,8213	10,8075	9,72661	10,3616	10,4	10,4	10,3977	10,4218
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,18099	1,49137	1,28876	1,24543	1,16393	1,1079	1,09568	1,0959	1,0917	1,08855
Inventory KPI's											
Average inventory	Average of finished products	10,1054	11,6169	13,3868	15,9246	17,7398	194,422	193,807	194,072	194,192	193,779
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	20,377	25,222	29,434	36,376	40,438	346,23	344,279	345,489	344,948	345,572
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	5,56985	6,60609	5,71328	5,68565	5,36853	71,2801	69,7377	70,3054	70,1982	70,1904
Max inbound	Maximum inbound of materials/products	13,624	16,477	15,691	15,203	14,247	174,58	174,24	176,4	170,28	168,24
Inbound frequency	Number of inbounds of materials/products	29,18	24,837	29,165	29,428	31,222	26,47	27,1	26,974	27,018	26,963
Average outbound	Average outbound of finished products	1,96804	1,96739	1,9646	1,9632	1,9601	27,9492	29,755	28,0083	27,9141	27,2441
Max outbound	Maximum outbound of finished products	9,07	9,093	9,094	9,093	9,147	182	182	182	182	182
Outbound frequency	Number of outbounds of finished products	86,39	86,413	86,53	86,603	86,738	72,18	67,837	72,165	72,428	74,222
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	5,56985	6,60609	5,71328	5,68565	5,36853	71,2801	69,7377	70,3054	70,1982	70,1904
Max orders	Maximum order quantity	13,624	16,477	15,691	15,203	14,247	174,58	174,24	176,4	170,28	168,24
Order frequency	Number of orders	29,18	24,837	29,165	29,428	31,222	26,47	27,1	26,974	27,018	26,963
FAD KPI's											
Forecast deviation	Average forecast deviation		1,54133	1,19921	1,02517	0,89992					
	Av forecast deviation as a perc of av demand		0,46858	0,36123	0,30826	0,26974					
Discount percentage	Average discount percentage		0,01403	0,01574	0,01644	0,01694					
	Av disc perc as a perc of the max possible discount		0,70133	0,78703	0,82215	0,84702					

4536553		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,96504	0,96998	0,97272	0,97675	0,9793	0,99999	0,99999	0,99999	1	0,99999
	By percentage of days without any backlogs	0,96682	0,97187	0,9742	0,97816	0,98077	0,99998	0,99999	0,99999	1	0,99999
Inventory turnover	Times per year for finished products	30,6688	29,1905	27,7447	24,3145	22,0859	38,9193	38,6491	38,4659	38,827	39,0236
	Times per year for materials						0,01753	0,01754	0,01757	0,01764	0,01767
Bullwhip Effect	Amplification on weekly level	1,52434	1,59157	1,56287	1,39346	1,36009	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	291,893	306,471	322,593	369,313	410,164	447,015	450,411	453,175	450,778	449,457
	Average of materials						991539	991521	991502	991457	991417
Max inventory	Maximum of finished products	649,971	651,618	706,505	952,374	1075,07	1046,03	1063,3	1060,65	1059,17	1056,36
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	179,384	207,241	206,894	197,932	198,341	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	375,18	390,78	386,76	382,71	377,4	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	49,932	43,287	43,466	45,777	45,872	0	0	0	0	0
Average outbound	Average outbound of finished products	36,1223	36,0698	36,0142	35,9321	35,8975	173,973	186,481	186,375	182,6	182,791
Max outbound	Maximum outbound of finished products	180,712	180,789	176,101	171,115	168,811	449,33	451,188	449,414	450,024	449,628
Outbound frequency	Number of outbounds of finished products	246,789	247,149	247,518	248,082	248,308	99,932	93,287	93,466	95,777	95,872
Production KPI's											
Average production	Average production quantity						720,79	730,338	728,779	724,409	721,207
Max production	Maximum production quantity						917,55	928,5	925,5	923,31	923,73
Production frequency	Number of production runs						23,894	23,583	23,672	23,892	24,032
Ordering KPI's											
Average orders	Average order quantity	179,392	207,246	206,898	197,932	198,345	0	0	0	0	0
Max orders	Maximum order quantity	375,18	390,78	386,76	382,71	377,43	0	0	0	0	0
Order frequency	Number of orders	49,93	43,286	43,465	45,777	45,871	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		167,484	56,434	38,5829	30,5331					
	Av forecast deviation as a perc of av demand		0,97734	0,32863	0,22408	0,17733					
Discount percentage	Average discount percentage		0,00111	0,01245	0,01519	0,01623					
	Av disc perc as a perc of the max possible discount		0,05551	0,62253	0,7594	0,81164					

4536553		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,96504	0,97001	0,97272	0,97677	0,9793	0,99996	0,99997	0,99999	0,99998	0,99999
	By percentage of days without any backlogs	0,96682	0,97189	0,9742	0,97818	0,98077	0,99995	0,99996	0,99999	0,99998	0,99999
Inventory turnover	Times per year for finished products	30,668	29,1893	27,7445	24,3139	22,0858	116,759	117,856	117,946	118,227	118,363
	Times per year for materials						0,01753	0,01754	0,01756	0,01763	0,01767
Bullwhip Effect	Amplification on weekly level	1,52435	1,59152	1,56288	1,39332	1,36009	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	291,901	306,482	322,594	369,32	410,165	148,873	147,575	147,667	147,904	148,024
	Average of materials						991837	991823	991807	991760	991719
Max inventory	Maximum of finished products	649,988	651,66	706,505	952,374	1075,07	551,36	551,978	551,375	551,748	551,323
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	179,371	207,228	206,894	197,92	198,341	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	375,18	390,84	386,76	382,68	377,4	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	49,936	43,29	43,466	45,78	45,872	0	0	0	0	0
Average outbound	Average outbound of finished products	36,1222	36,0692	36,014	35,9315	35,8975	173,966	186,476	186,375	182,595	182,791
Max outbound	Maximum outbound of finished products	180,712	180,743	176,101	171,099	168,811	449,33	451,25	449,414	450,024	449,628
Outbound frequency	Number of outbounds of finished products	246,79	247,153	247,519	248,086	248,308	99,936	93,29	93,466	95,78	95,872
Production KPI's											
Average production	Average production quantity						187,608	202,231	202,073	197,436	197,637
Max production	Maximum production quantity						451,56	453,24	451,41	452,01	451,65
Production frequency	Number of production runs						89,951	83,505	83,684	85,999	86,093
Ordering KPI's											
Average orders	Average order quantity	179,388	207,244	206,898	197,928	198,345	0	0	0	0	0
Max orders	Maximum order quantity	375,18	390,87	386,76	382,71	377,43	0	0	0	0	0
Order frequency	Number of orders	49,931	43,287	43,465	45,778	45,871	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		167,473	56,4375	38,576	30,5331					
	Av forecast deviation as a perc of av demand		0,97728	0,32865	0,22405	0,17733					
Discount percentage	Average discount percentage		0,00111	0,01245	0,01519	0,01623					
	Av disc perc as a perc of the max possible discount		0,05555	0,62252	0,75947	0,81165					

4536553		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,97916	0,97014	0,97857	0,97808	0,98493	0,99997	0,99997	0,99999	0,99998	0,99999
	By percentage of days without any backlogs	0,9801	0,97198	0,97948	0,9794	0,98575	0,99998	0,99996	0,99998	0,99997	0,99998
Inventory turnover	Times per year for finished products	24,936	29,147	24,5955	22,8196	18,2826	118,823	118,209	118,913	119,125	119,126
	Times per year for materials						0,01757	0,01754	0,01762	0,01769	0,01768
Bullwhip Effect	Amplification on weekly level	2,45927	1,62435	2,33442	2,20994	2,36546	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	358,662	306,937	363,927	395,065	494,199	146,672	147,131	146,975	147,256	147,147
	Average of materials						991772	991823	991766	991735	991635
Max inventory	Maximum of finished products	818,218	651,605	869,083	1015,89	1351,25	590,843	551,978	605,084	596,528	599,341
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	307,074	211,109	278,213	264,518	283,227	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	537,18	392,1	559,8	540,99	551,25	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	29,309	42,498	32,57	34,583	32,218	0	0	0	0	0
Average outbound	Average outbound of finished products	35,9541	36,0677	35,9522	35,9598	35,8497	219,745	188,074	211,709	207,521	213,287
Max outbound	Maximum outbound of finished products	175,71	180,467	174,92	174,762	166,549	537,208	451,664	559,8	545,138	552,44
Outbound frequency	Number of outbounds of finished products	247,914	247,163	247,932	247,881	248,626	79,309	92,498	82,57	84,583	82,218
Production KPI's											
Average production	Average production quantity						239,335	202,165	229,354	224,291	231,027
Max production	Maximum production quantity						537,27	453,63	559,8	545,46	553,83
Production frequency	Number of production runs						70,687	83,53	73,998	75,995	73,702
Ordering KPI's											
Average orders	Average order quantity	307,083	211,125	278,223	264,537	283,243	0	0	0	0	0
Max orders	Maximum order quantity	537,18	392,1	559,8	540,99	551,25	0	0	0	0	0
Order frequency	Number of orders	29,308	42,495	32,569	34,58	32,216	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		168,067	29,2281	57,889	33,4027					
	Av forecast deviation as a perc of av demand		0,98075	0,16985	0,33608	0,19413					
Discount percentage	Average discount percentage		0,00102	0,01695	0,01389	0,01664					
	Av disc perc as a perc of the max possible discount		0,05083	0,84744	0,69444	0,83209					

4536553		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,96504	0,97001	0,97272	0,97677	0,9793	0,99996	0,99997	0,99999	0,99998	0,99999
	By percentage of days without any backlogs	0,96682	0,97189	0,9742	0,97818	0,98077	0,99995	0,99996	0,99999	0,99998	0,99999
Inventory turnover	Times per year for finished products	30,668	29,1893	27,7445	24,3139	22,0858	116,759	117,856	117,946	118,227	118,363
	Times per year for materials						0,01753	0,01754	0,01756	0,01763	0,01767
Bullwhip Effect	Amplification on weekly level	1,52435	1,59152	1,56288	1,39332	1,36009	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	291,901	306,482	322,594	369,32	410,165	148,873	147,575	147,667	147,904	148,024
	Average of materials						991837	991823	991807	991760	991719
Max inventory	Maximum of finished products	649,988	651,66	706,505	952,374	1075,07	551,36	551,978	551,375	551,748	551,323
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	179,371	207,228	206,894	197,92	198,341	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	375,18	390,84	386,76	382,68	377,4	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	49,936	43,29	43,466	45,78	45,872	0	0	0	0	0
Average outbound	Average outbound of finished products	36,1222	36,0692	36,014	35,9315	35,8975	173,966	186,476	186,375	182,595	182,791
Max outbound	Maximum outbound of finished products	180,712	180,743	176,101	171,099	168,811	449,33	451,25	449,414	450,024	449,628
Outbound frequency	Number of outbounds of finished products	246,79	247,153	247,519	248,086	248,308	99,936	93,29	93,466	95,78	95,872
Production KPI's											
Average production	Average production quantity						187,608	202,231	202,073	197,436	197,637
Max production	Maximum production quantity						451,56	453,24	451,41	452,01	451,65
Production frequency	Number of production runs						89,951	83,505	83,684	85,999	86,093
Ordering KPI's											
Average orders	Average order quantity	179,388	207,244	206,898	197,928	198,345	0	0	0	0	0
Max orders	Maximum order quantity	375,18	390,87	386,76	382,71	377,43	0	0	0	0	0
Order frequency	Number of orders	49,931	43,287	43,465	45,778	45,871	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		167,473	56,4375	38,576	30,5331					
	Av forecast deviation as a perc of av demand		0,97728	0,32865	0,22405	0,17733					
Discount percentage	Average discount percentage		0,00111	0,01245	0,01519	0,01623					
	Av disc perc as a perc of the max possible discount		0,05555	0,62252	0,75947	0,81165					

4536553		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,98939	0,99202	0,99335	0,99374	0,99451	0,97651	0,98842	0,9914	0,99264	0,99419
	By percentage of days without any backlogs	0,98966	0,99199	0,99345	0,9938	0,9947	0,96836	0,98408	0,98876	0,99002	0,99207
Inventory turnover	Times per year for finished products	29,4504	27,1913	23,7999	21,3269	20,7467	117,322	118,338	118,633	118,764	118,733
	Times per year for materials						0,0175	0,01754	0,01764	0,01768	0,01767
Bullwhip Effect	Amplification on weekly level	1,54845	1,56718	1,37928	1,35093	1,2678	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	303,218	328,459	376,442	423,08	437,093	147,931	146,969	147,431	147,587	147,597
	Average of materials						991825	991801	991752	991706	991692
Max inventory	Maximum of finished products	586,014	643,16	879,443	1046,09	1033,23	555,256	555,482	553,407	552,902	553,137
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	170,108	198,767	192,657	193,399	192,128	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	341,48	381,268	373,495	373,602	362,713	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	52,536	45,144	47,075	47,094	47,371	0	0	0	0	0
Average outbound	Average outbound of finished products	35,7549	35,7244	35,7052	35,7084	35,6988	169,326	182,85	180,22	180,578	180,016
Max outbound	Maximum outbound of finished products	155,442	152,071	151,086	150,868	150,486	448,728	450,902	449,614	450,139	449,882
Outbound frequency	Number of outbounds of finished products	249,252	249,461	249,591	249,568	249,635	102,536	95,144	97,075	97,094	97,371
Production KPI's											
Average production	Average production quantity						190,081	202,427	197,539	197,587	196,281
Max production	Maximum production quantity						469,23	466,29	459,78	458,88	458,67
Production frequency	Number of production runs						88,639	83,413	85,974	86,149	86,701
Ordering KPI's											
Average orders	Average order quantity	180,412	205,118	196,883	197,159	195,1	0	0	0	0	0
Max orders	Maximum order quantity	354,6	386,13	378,09	377,82	365,64	0	0	0	0	0
Order frequency	Number of orders	49,495	43,719	46,043	46,177	46,638	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		50,1317	38,5615	30,4448	28,5635					
	Av forecast deviation as a perc of av demand		0,29196	0,22398	0,17661	0,16571					
Discount percentage	Average discount percentage		0,0129	0,01509	0,01625	0,01656					
	Av disc perc as a perc of the max possible discount		0,64485	0,7543	0,81254	0,82777					

4531430		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1	1	1	1	1	0,95901	0,96541	0,97572	0,97436	0,97686
	By percentage of days without any backlogs	1	1	1	1	1	0,89279	0,89429	0,90481	0,9037	0,90447
Inventory turnover	Times per year for finished products	6,49932	6,50814	6,14377	5,38483	5,09586	7,78203	7,93845	6,85945	7,08701	7,27012
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	5,09862	5,10468	5,0645	4,96165	4,93476	3,46303	3,45881	3,47621	3,48498	3,45626
Inventory KPI's											
Average inventory	Average of finished products	2295,9	2293,11	2435,93	2787,12	2963,63	7405,77	7253,52	8462,14	8280,48	8098,2
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	3651,25	3668,53	4162,51	5130,53	5615,77	15565,9	15171,4	16417	16153	16095,8
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	1849,05	1764,57	1826,69	1854,22	1856,35	14455,5	14128	14191,5	14150,5	14129
Max inbound	Maximum inbound of materials/products	2000	2000	2000	2000	2000	15196	14512	14514	14452	14410
Inbound frequency	Number of inbounds of materials/products	7,547	7,906	7,752	7,918	7,982	4	4	4	4,011	4,023
Average outbound	Average outbound of finished products	63,8212	63,8212	63,8212	63,8212	63,8212	956,962	958,063	969,04	972,024	973,902
Max outbound	Maximum outbound of finished products	325,708	325,708	325,708	325,708	325,708	2987,07	3088,11	3123,79	3129,61	3129,52
Outbound frequency	Number of outbounds of finished products	233,287	233,287	233,287	233,287	233,287	60,086	59,983	59,516	59,874	59,912
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	2000	2000	2000	2000	2000	14455,5	14128	14191,5	14150,5	14129
Max orders	Maximum order quantity	2000	2000	2000	2000	2000	15196	14512	14514	14452	14410
Order frequency	Number of orders	6,927	6,912	7,011	7,276	7,352	4	4	4	4,011	4,023
FAD KPI's											
Forecast deviation	Average forecast deviation		263,462	66,8462	70,7692	71,5385					
	Av forecast deviation as a perc of av demand		0,92044	0,23168	0,24518	0,24784					
Discount percentage	Average discount percentage		0,00029	0,0142	0,01465	0,0148					
	Av disc perc as a perc of the max possible discount		0,01461	0,71021	0,7325	0,74003					

4531430		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1	1	1	1	1	0,86274	0,82471	0,84487	0,83949	0,8435
	By percentage of days without any backlogs	1	1	1	1	1	0,86034	0,82365	0,84067	0,84262	0,8423
Inventory turnover	Times per year for finished products	9,70783	9,59205	9,19583	8,5969	7,99668	26,7713	28,9006	27,4797	27,6896	27,4317
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,84673	1,92013	1,93385	1,79878	1,76568	1,252	1,23514	1,23324	1,26562	1,25572
Inventory KPI's											
Average inventory	Average of finished products	1536,41	1554,76	1622,44	1738,23	1871,45	2118,43	1962,01	2068,87	2061,71	2087,2
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	2949,24	2949,24	2951,73	3092,88	3111,04	7280	7280	7280	7280	7280
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	356,508	411,642	416,44	394,092	401,719	1352,89	1400,01	1425,61	1447,29	1456,11
Max inbound	Maximum inbound of materials/products	758,35	758,628	779,862	776,633	777,208	3253	3315	3375	3386,5	3364
Inbound frequency	Number of inbounds of materials/products	36,628	31,732	31,721	34,112	33,894	37,6	36,127	35,67	35,255	35,207
Average outbound	Average outbound of finished products	63,8212	63,8212	63,8212	63,8212	63,8212	591,729	607,942	618,911	604,282	607,515
Max outbound	Maximum outbound of finished products	325,708	325,708	325,708	325,708	325,708	2240,31	2136	2106,42	2056,54	2074,08
Outbound frequency	Number of outbounds of finished products	233,287	233,287	233,287	233,287	233,287	95,858	93,292	91,875	94,483	94,26
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	356,519	411,858	416,637	394,207	401,794	1352,89	1400,01	1425,61	1447,29	1456,11
Max orders	Maximum order quantity	758,425	759	780,2	776,925	777,4	3253	3315	3375	3386,5	3364
Order frequency	Number of orders	36,627	31,715	31,706	34,102	33,888	37,6	36,127	35,67	35,255	35,207
FAD KPI's											
Forecast deviation	Average forecast deviation		246,312	72,7048	58,1495	34,3827					
	Av forecast deviation as a perc of av demand		0,86021	0,25271	0,20149	0,11906					
Discount percentage	Average discount percentage		0,01337	0,01652	0,01704	0,01765					
	Av disc perc as a perc of the max possible discount		0,66856	0,82605	0,85188	0,88274					

4531430		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1	1	1	1	1	0,87247	0,82813	0,8604	0,84747	0,85545
	By percentage of days without any backlogs	1	1	1	1	1	0,83872	0,82599	0,82838	0,82715	0,82821
Inventory turnover	Times per year for finished products	8,96786	9,50219	8,724	8,22934	7,40315	26,3753	28,8158	26,6864	27,2295	26,9127
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	2,60163	1,95534	2,56773	2,49966	2,57785	1,22012	1,23202	1,23738	1,26761	1,26662
Inventory KPI's											
Average inventory	Average of finished products	1662,94	1569,43	1710,39	1818,53	2024,16	2154,14	1969,86	2134,18	2101,58	2133,02
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	2968,12	2949,24	3009,39	3320,89	3468,4	7280	7280	7280	7280	7280
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	588,721	417,866	561,807	541,678	598,048	1360,4	1397,94	1446,65	1446,5	1450,79
Max inbound	Maximum inbound of materials/products	1148,53	774,349	1172,05	1153,39	1150,44	3235,5	3340,5	3474	3465	3436,5
Inbound frequency	Number of inbounds of materials/products	22,386	31,408	23,733	25,211	23,136	37,465	36,241	35,231	35,354	35,45
Average outbound	Average outbound of finished products	63,8212	63,8212	63,8212	63,8212	63,8212	699,656	612,933	682,607	671,263	693,396
Max outbound	Maximum outbound of finished products	325,708	325,708	325,708	325,708	325,708	2179,97	2172,4	2207,65	2175,7	2176,47
Outbound frequency	Number of outbounds of finished products	233,287	233,287	233,287	233,287	233,287	81,206	92,633	83,449	85,299	82,821
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	588,966	419,031	563,743	543,12	598,795	1360,4	1397,94	1446,65	1446,5	1450,79
Max orders	Maximum order quantity	1148,65	779,7	1172,23	1153,73	1150,6	3235,5	3340,5	3474	3465	3436,5
Order frequency	Number of orders	22,377	31,32	23,649	25,144	23,106	37,465	36,241	35,231	35,354	35,45
FAD KPI's											
Forecast deviation	Average forecast deviation		244,272	38,9322	70,8928	36,7096					
	Av forecast deviation as a perc of av demand		0,85323	0,13493	0,24567	0,12709					
Discount percentage	Average discount percentage		0,01351	0,01725	0,01703	0,01784					
	Av disc perc as a perc of the max possible discount		0,67549	0,86273	0,85136	0,8918					

4531430		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1	1	1	1	1	0,86274	0,82471	0,84487	0,83949	0,8435
	By percentage of days without any backlogs	1	1	1	1	1	0,86034	0,82365	0,84067	0,84262	0,8423
Inventory turnover	Times per year for finished products	9,70783	9,59205	9,19583	8,5969	7,99668	26,7713	28,9006	27,4797	27,6896	27,4317
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,84673	1,92013	1,93385	1,79878	1,76568	1,252	1,23514	1,23324	1,26562	1,25572
Inventory KPI's											
Average inventory	Average of finished products	1536,41	1554,76	1622,44	1738,23	1871,45	2118,43	1962,01	2068,87	2061,71	2087,2
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	2949,24	2949,24	2951,73	3092,88	3111,04	7280	7280	7280	7280	7280
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	356,508	411,642	416,44	394,092	401,719	1352,89	1400,01	1425,61	1447,29	1456,11
Max inbound	Maximum inbound of materials/products	758,35	758,628	779,862	776,633	777,208	3253	3315	3375	3386,5	3364
Inbound frequency	Number of inbounds of materials/products	36,628	31,732	31,721	34,112	33,894	37,6	36,127	35,67	35,255	35,207
Average outbound	Average outbound of finished products	63,8212	63,8212	63,8212	63,8212	63,8212	591,729	607,942	618,911	604,282	607,515
Max outbound	Maximum outbound of finished products	325,708	325,708	325,708	325,708	325,708	2240,31	2136	2106,42	2056,54	2074,08
Outbound frequency	Number of outbounds of finished products	233,287	233,287	233,287	233,287	233,287	95,858	93,292	91,875	94,483	94,26
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	356,519	411,858	416,637	394,207	401,794	1352,89	1400,01	1425,61	1447,29	1456,11
Max orders	Maximum order quantity	758,425	759	780,2	776,925	777,4	3253	3315	3375	3386,5	3364
Order frequency	Number of orders	36,627	31,715	31,706	34,102	33,888	37,6	36,127	35,67	35,255	35,207
FAD KPI's											
Forecast deviation	Average forecast deviation		246,312	72,7048	58,1495	34,3827					
	Av forecast deviation as a perc of av demand		0,86021	0,25271	0,20149	0,11906					
Discount percentage	Average discount percentage		0,01337	0,01652	0,01704	0,01765					
	Av disc perc as a perc of the max possible discount		0,66856	0,82605	0,85188	0,88274					

4531430		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1	1	1	1	1	0,85353	0,84072	0,84272	0,84129	0,84407
	By percentage of days without any backlogs	1	1	1	1	1	0,85866	0,84217	0,84432	0,8431	0,84295
Inventory turnover	Times per year for finished products	9,89043	9,45457	8,72565	8,05743	7,67426	26,6597	27,3407	27,5928	27,4898	27,4932
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,7696	1,84636	1,7438	1,7189	1,70723	1,26842	1,23125	1,23775	1,26038	1,26593
Inventory KPI's											
Average inventory	Average of finished products	1506,77	1576,62	1710,69	1854,94	1953,88	2124,39	2074,23	2064,32	2080,45	2088,3
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	2949,24	2949,24	3038,04	3090,9	3178,4	7280	7280	7280	7280	7280
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	344,084	397,656	386,945	392,778	399,503	1362,72	1426,08	1439,35	1457,76	1458,43
Max inbound	Maximum inbound of materials/products	654,454	757,7	754,554	758,854	768,05	3260,5	3400	3355	3402	3398,5
Inbound frequency	Number of inbounds of materials/products	37,711	32,85	34,407	34,488	34,502	37,308	35,55	35,407	35,117	35,256
Average outbound	Average outbound of finished products	63,8212	63,8212	63,8212	63,8212	63,8212	582,503	609,557	601,684	602,873	605,113
Max outbound	Maximum outbound of finished products	325,708	325,708	325,708	325,708	325,708	2146,73	2128,39	2053,53	2095,99	2091,21
Outbound frequency	Number of outbounds of finished products	233,287	233,287	233,287	233,287	233,287	97,239	93,051	94,681	94,874	94,904
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	344,109	397,902	387,046	392,904	399,573	1362,72	1426,08	1439,35	1457,76	1458,43
Max orders	Maximum order quantity	654,525	757,7	754,675	759,025	768,05	3260,5	3400	3355	3402	3398,5
Order frequency	Number of orders	37,708	32,829	34,397	34,477	34,496	37,308	35,55	35,407	35,117	35,256
FAD KPI's											
Forecast deviation	Average forecast deviation		71,8952	50,7197	32,6317	25,2346					
	Av forecast deviation as a perc of av demand		0,25014	0,17567	0,11286	0,08718					
Discount percentage	Average discount percentage		0,01635	0,01702	0,01763	0,01804					
	Av disc perc as a perc of the max possible discount		0,81729	0,85099	0,88141	0,90224					

3407384		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,61224	0,53815	0,58937	0,63141	0,65432	1	1	1	1	1
	By percentage of days without any backlogs	0,6407	0,56448	0,59263	0,63221	0,66649	1	1	1	1	1
Inventory turnover	Times per year for finished products	14,6785	19,0949	14,3806	12,1157	11,8223	4,11646	4,31987	4,18564	4,26236	4,27494
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,04336	0,9497	0,91701	0,86853	0,85163	1,36968	1,41489	1,36886	1,39863	1,43063
Inventory KPI's											
Average inventory	Average of finished products	24,5154	18,8839	25,2917	31,1598	33,5232	232,749	220,417	229,827	227,909	226,54
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	81,012	76,153	75,561	90,96	98,089	387,47	376,062	373,437	376,996	383,803
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	35,7592	23,128	24,6661	24,0209	23,5855	120,651	121,582	115,893	116,815	118,739
Max inbound	Maximum inbound of materials/products	80,504	76,112	72,284	69,238	68,224	174,66	176,54	159,66	162,5	167,56
Inbound frequency	Number of inbounds of materials/products	10,166	15,513	14,929	15,761	15,881	7,932	7,667	8,286	8,251	8,028
Average outbound	Average outbound of finished products	17,746	16,7965	16,9973	17,2491	17,4871	34,0255	28,4885	29,2697	28,8534	28,6491
Max outbound	Maximum outbound of finished products	60,237	61,961	62,136	63,123	62,861	133,118	133,063	133,072	133,062	133,018
Outbound frequency	Number of outbounds of finished products	19,963	21,121	20,901	20,605	20,336	28,166	33,513	32,929	33,761	33,881
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	35,7592	23,128	24,6661	24,0209	23,5855	120,651	121,582	115,893	116,815	118,739
Max orders	Maximum order quantity	80,504	76,112	72,284	69,238	68,224	174,66	176,54	159,66	162,5	167,56
Order frequency	Number of orders	10,166	15,513	14,929	15,761	15,881	7,932	7,667	8,286	8,251	8,028
FAD KPI's											
Forecast deviation	Average forecast deviation		6,54623	4,68246	4,27304	4,08033					
	Av forecast deviation as a perc of av demand		0,96146	0,68492	0,6223	0,59212					
Discount percentage	Average discount percentage		0,00471	0,00896	0,01075	0,01084					
	Av disc perc as a perc of the max possible discount		0,2355	0,44778	0,5377	0,54196					

3407384		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,61224	0,53815	0,58937	0,63141	0,65432	1	1	1	1	1
	By percentage of days without any backlogs	0,6407	0,56448	0,59263	0,63221	0,66649	1	1	1	1	1
Inventory turnover	Times per year for finished products	14,6785	19,0949	14,3806	12,1157	11,8223	4,7753	4,99527	4,83253	4,92819	4,93878
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,04336	0,9497	0,91701	0,86853	0,85163	1,10516	1,12005	1,11296	1,11441	1,14397
Inventory KPI's											
Average inventory	Average of finished products	24,5154	18,8839	25,2917	31,1598	33,5232	200,59	190,576	198,965	197,056	196,042
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	81,012	76,153	75,561	90,96	98,089	327,781	317,165	322,024	322,698	327,36
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	35,7592	23,128	24,6661	24,0209	23,5855	65,1346	63,3755	60,9114	59,4041	60,502
Max inbound	Maximum inbound of materials/products	80,504	76,112	72,284	69,238	68,224	141,34	143,38	127,1	128,18	131,9
Inbound frequency	Number of inbounds of materials/products	10,166	15,513	14,929	15,761	15,881	14,175	14,217	15,262	15,716	15,225
Average outbound	Average outbound of finished products	17,746	16,7965	16,9973	17,2491	17,4871	34,0255	28,4885	29,2697	28,8534	28,6491
Max outbound	Maximum outbound of finished products	60,237	61,961	62,136	63,123	62,861	133,118	133,063	133,072	133,062	133,018
Outbound frequency	Number of outbounds of finished products	19,963	21,121	20,901	20,605	20,336	28,166	33,513	32,929	33,761	33,881
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	35,7592	23,128	24,6661	24,0209	23,5855	65,1346	63,3755	60,9114	59,4041	60,502
Max orders	Maximum order quantity	80,504	76,112	72,284	69,238	68,224	141,34	143,38	127,1	128,18	131,9
Order frequency	Number of orders	10,166	15,513	14,929	15,761	15,881	14,175	14,217	15,262	15,716	15,225
FAD KPI's											
Forecast deviation	Average forecast deviation		6,54623	4,68246	4,27304	4,08033					
	Av forecast deviation as a perc of av demand		0,96146	0,68492	0,6223	0,59212					
Discount percentage	Average discount percentage		0,00471	0,00896	0,01075	0,01084					
	Av disc perc as a perc of the max possible discount		0,2355	0,44778	0,5377	0,54196					

3407384		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,52989	0,52772	0,56302	0,58505	0,63665	1	1	1	1	1
	By percentage of days without any backlogs	0,55528	0,55111	0,57799	0,59309	0,64581	1	1	1	1	1
Inventory turnover	Times per year for finished products	19,7574	19,4972	16,9206	15,3192	12,2801	4,76293	5,02618	4,93555	4,98088	4,98426
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,93574	0,9518	0,89438	0,85023	0,77281	1,12091	1,1256	1,10451	1,10944	1,12795
Inventory KPI's											
Average inventory	Average of finished products	18,2526	18,4996	21,3763	24,1102	30,033	199,723	189,432	193,728	192,86	194,474
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	75,939	76,626	74,012	75,399	83,284	326,737	316,122	318,478	318,503	322,962
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	22,1007	21,9113	20,4857	18,9579	16,9585	62,5165	63,7404	60,9545	60,2276	59,2836
Max inbound	Maximum inbound of materials/products	75,903	76,587	73,768	71,757	67,982	139,82	142,86	130,7	131,48	130,78
Inbound frequency	Number of inbounds of materials/products	16,116	16,35	17,639	19,312	22,069	14,62	14,132	14,961	15,215	15,62
Average outbound	Average outbound of finished products	16,7807	16,6479	16,8051	16,8246	17,1405	27,9409	27,7954	26,8965	25,823	24,2674
Max outbound	Maximum outbound of finished products	62,881	62,615	60,957	61,976	62,097	133,09	133,069	133,073	133,059	133,023
Outbound frequency	Number of outbounds of finished products	21,149	21,324	21,137	21,136	20,766	34,116	34,35	35,639	37,312	40,069
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	22,1007	21,9113	20,4857	18,9579	16,9585	62,5165	63,7404	60,9545	60,2276	59,2836
Max orders	Maximum order quantity	75,903	76,587	73,768	71,757	67,982	139,82	142,86	130,7	131,48	130,78
Order frequency	Number of orders	16,116	16,35	17,639	19,312	22,069	14,62	14,132	14,961	15,215	15,62
FAD KPI's											
Forecast deviation	Average forecast deviation		6,68142	5,04392	4,93556	3,83817					
	Av forecast deviation as a perc of av demand		0,9817	0,73741	0,71848	0,55805					
Discount percentage	Average discount percentage		0,00444	0,00747	0,00843	0,01115					
	Av disc perc as a perc of the max possible discount		0,2219	0,37364	0,42173	0,55771					

3407384		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,49504	0,53405	0,54984	0,59167	0,61923	1	1	1	1	1
	By percentage of days without any backlogs	0,51923	0,55989	0,56993	0,60365	0,62935	1	1	1	1	1
Inventory turnover	Times per year for finished products	22,2595	18,9876	17,9368	15,4381	13,5259	4,76903	5,03676	5,01393	5,02175	5,04571
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,87045	0,93534	0,89783	0,81614	0,75994	1,13646	1,1437	1,13833	1,13313	1,15889
Inventory KPI's											
Average inventory	Average of finished products	16,1985	18,9823	20,1042	23,556	27,1204	199,123	189,235	190,378	191,121	191,332
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	72,573	76,104	74,533	72,002	75,455	326,149	315,487	316,63	316,823	320,826
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	15,0024	19,739	17,0574	14,1476	12,762	62,4097	64,3896	63,1336	60,802	60,8572
Max inbound	Maximum inbound of materials/products	72,564	76,063	74,482	70,803	68,61	140,32	143,12	138,8	134,98	137,66
Inbound frequency	Number of inbounds of materials/products	23,57	18,182	21,074	25,755	28,973	14,589	13,993	14,307	14,988	15,08
Average outbound	Average outbound of finished products	16,0593	16,6675	16,5921	16,7142	16,6898	22,9162	26,425	24,5067	22,017	20,627
Max outbound	Maximum outbound of finished products	63,883	62,279	61,138	60,344	60,92	133,031	133,046	133,039	133,034	133,017
Outbound frequency	Number of outbounds of finished products	22,093	21,307	21,407	21,285	21,322	41,57	36,182	39,074	43,755	46,973
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	15,0024	19,739	17,0574	14,1476	12,762	62,4097	64,3896	63,1336	60,802	60,8572
Max orders	Maximum order quantity	72,564	76,063	74,482	70,803	68,61	140,32	143,12	138,8	134,98	137,66
Order frequency	Number of orders	23,57	18,182	21,074	25,755	28,973	14,589	13,993	14,307	14,988	15,08
FAD KPI's											
Forecast deviation	Average forecast deviation		6,68683	5,70538	4,73948	4,16338					
	Av forecast deviation as a perc of av demand		0,98257	0,83556	0,69233	0,60595					
Discount percentage	Average discount percentage		0,00477	0,00642	0,00871	0,01029					
	Av disc perc as a perc of the max possible discount		0,23874	0,32118	0,4353	0,51436					

3407384		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,44046	0,514	0,56549	0,60486	0,62846	1	1	1	1	1
	By percentage of days without any backlogs	0,45109	0,54136	0,58158	0,61673	0,63882	1	1	1	1	1
Inventory turnover	Times per year for finished products	27,4055	20,6285	16,8747	14,4037	12,8408	4,73561	4,98958	5,02066	5,04544	5,07584
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,96837	0,97126	0,87737	0,80673	0,7633	1,12656	1,11657	1,13808	1,15093	1,16521
Inventory KPI's											
Average inventory	Average of finished products	13,1496	17,4286	21,4599	25,3426	28,6324	199,591	190,571	190,581	190,753	190,735
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	77,862	78,406	74,823	74,849	80,86	326,637	316,27	318,084	319,505	321,838
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	19,2257	19,8185	15,352	13,2715	12,3432	64,1726	64,5097	63,2673	61,7961	61,6192
Max inbound	Maximum inbound of materials/products	77,862	78,406	74,582	71,814	70,348	142,82	139,54	139,6	137,92	142
Inbound frequency	Number of inbounds of materials/products	18,171	17,994	23,542	27,653	30,234	14,154	13,992	14,375	14,783	14,933
Average outbound	Average outbound of finished products	15,9093	16,4579	16,5369	16,6796	16,7703	26,1873	26,4923	23,1117	21,162	20,1615
Max outbound	Maximum outbound of finished products	67,45	63,603	61,131	61,209	62,133	133,075	133,061	133,088	133,059	133,037
Outbound frequency	Number of outbounds of finished products	22,301	21,549	21,482	21,321	21,228	36,171	35,994	41,542	45,653	48,234
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	19,2257	19,8185	15,352	13,2715	12,3432	64,1726	64,5097	63,2673	61,7961	61,6192
Max orders	Maximum order quantity	77,862	78,406	74,582	71,814	70,348	142,82	139,54	139,6	137,92	142
Order frequency	Number of orders	18,171	17,994	23,542	27,653	30,234	14,154	13,992	14,375	14,783	14,933
FAD KPI's											
Forecast deviation	Average forecast deviation		5,76798	4,74938	4,13996	3,79898					
	Av forecast deviation as a perc of av demand		0,84477	0,69396	0,60288	0,55194					
Discount percentage	Average discount percentage		0,00521	0,00778	0,00958	0,01077					
	Av disc perc as a perc of the max possible discount		0,26052	0,38919	0,47912	0,53863					

4256632		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,95339	0,93193	0,94471	0,94938	0,95425	1	1	1	1	1
	By percentage of days without any backlogs	0,95345	0,93256	0,94396	0,94916	0,95386	0,91354	0,91358	0,91401	0,91582	0,91711
Inventory turnover	Times per year for finished products	5,63319	6,24577	5,55167	4,62581	4,20103	15,5567	15,6975	15,7358	16,7246	17,4112
	Times per year for materials						9E-05	9E-05	9,1E-05	9,4E-05	9,5E-05
Bullwhip Effect	Amplification on weekly level	1,87853	1,87583	1,86289	1,80818	1,77212	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	7,53788	6,80002	7,74728	9,63007	11,1822	5,83373	5,7747	5,80364	5,63698	5,54606
	Average of materials						999933	999934	999933	999931	999929
Max inventory	Maximum of finished products	13,208	12,484	14,654	20,442	24,462	39	39	39	39	39
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	10,0542	10,0158	10,0218	10,009	10,0095	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	10,23	10,06	10,09	10,04	10,04	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	4,618	4,624	4,686	4,947	5,142	0	0	0	0	0
Average outbound	Average outbound of finished products	1,73334	1,72451	1,73108	1,73421	1,73583	7,77246	7,75863	7,77241	7,81472	7,84836
Max outbound	Maximum outbound of finished products	5,511	5,423	5,517	5,619	5,647	32	32	32	32	32
Outbound frequency	Number of outbounds of finished products	24,18	24,311	24,212	24,172	24,161	11,618	11,624	11,686	11,947	12,142
Production KPI's											
Average production	Average production quantity						16,0304	15,772	15,8542	15,5791	15,3866
Max production	Maximum production quantity						32	32	32	32	32
Production frequency	Number of production runs						6,011	6,101	6,113	6,377	6,562
Ordering KPI's											
Average orders	Average order quantity	10,0542	10,0158	10,0218	10,009	10,0095	0	0	0	0	0
Max orders	Maximum order quantity	10,23	10,06	10,09	10,04	10,04	0	0	0	0	0
Order frequency	Number of orders	4,618	4,624	4,686	4,947	5,142	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		0,66192	0,34077	0,31327	0,27981					
	Av forecast deviation as a perc of av demand		0,8281	0,41335	0,37918	0,34					
Discount percentage	Average discount percentage		0,01204	0,01423	0,01622	0,01804					
	Av disc perc as a perc of the max possible discount		0,60213	0,71154	0,81115	0,90182					

4256632		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,91633	0,76	0,74946	0,7719	0,90106	1	1	1	1	1
	By percentage of days without any backlogs	0,91703	0,76769	0,75638	0,77836	0,90376	0,93543	0,95464	0,95546	0,95408	0,9443
Inventory turnover	Times per year for finished products	8,59405	14,475	16,3741	14,9915	6,68198	56,4127	57,2231	55,5536	55,2345	55,6863
	Times per year for materials						8,8E-05	8,8E-05	8,5E-05	8,5E-05	8,8E-05
Bullwhip Effect	Amplification on weekly level	1,34965	1,12596	1,15956	1,178	1,25882	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	4,93114	3,05694	2,87779	3,47132	6,70943	1,55992	1,53659	1,53108	1,54227	1,57638
	Average of materials						999940	999942	999942	999941	999938
Max inventory	Maximum of finished products	8,872	8,016	8,512	10,308	15,294	33	33	33	33	33
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	5,11239	2,89276	2,63969	2,78686	3,95958	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	7,476	6,724	6,97	6,866	6,642	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	8,629	15,614	16,212	15,635	11,288	0	0	0	0	0
Average outbound	Average outbound of finished products	1,71647	1,6573	1,65109	1,66283	1,70261	5,63893	3,94932	3,74613	3,86937	4,84585
Max outbound	Maximum outbound of finished products	5,135	5,145	5,127	5,243	5,45	32	32	32	32	32
Outbound frequency	Number of outbounds of finished products	24,419	25,313	25,358	25,18	24,607	15,629	22,614	23,212	22,635	18,288
Production KPI's											
Average production	Average production quantity						6,0292	4,20888	3,98282	4,11361	5,16592
Max production	Maximum production quantity						32	32	32	32	32
Production frequency	Number of production runs						14,629	21,253	21,875	21,334	17,179
Ordering KPI's											
Average orders	Average order quantity	5,11239	2,89276	2,63969	2,78686	3,95958	0	0	0	0	0
Max orders	Maximum order quantity	7,476	6,724	6,97	6,866	6,642	0	0	0	0	0
Order frequency	Number of orders	8,629	15,614	16,212	15,635	11,288	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		0,56125	0,5661	0,52052	0,17275					
	Av forecast deviation as a perc of av demand		0,69975	0,69063	0,63436	0,2081					
Discount percentage	Average discount percentage		0,0172	0,01508	0,01553	0,0195					
	Av disc perc as a perc of the max possible discount		0,85996	0,75386	0,77629	0,97489					

4256632		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,87381	0,71809	0,83332	0,86809	0,87674	1	1	1	1	1
	By percentage of days without any backlogs	0,87474	0,729	0,83655	0,87017	0,87926	0,95266	0,96051	0,95613	0,95899	0,95828
Inventory turnover	Times per year for finished products	11,1946	18,1175	11,9611	9,84092	8,91286	56,4111	56,6152	55,8812	56,5868	56,5445
	Times per year for materials						8,7E-05	8,6E-05	8,5E-05	8,8E-05	8,7E-05
Bullwhip Effect	Amplification on weekly level	1,0441	0,97653	1,00871	0,91375	0,92576	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	3,79231	2,39123	3,59876	4,4346	4,99896	1,5353	1,52557	1,52913	1,5539	1,54523
	Average of materials						999941	999942	999941	999940	999940
Max inventory	Maximum of finished products	7,068	6,558	7,498	9,378	11,051	33	33	33	33	33
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	2,96875	2,27775	2,58323	2,48664	2,51698	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	6,242	6,301	5,855	5,391	5,339	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	14,41	18,722	16,176	17,748	17,329	0	0	0	0	0
Average outbound	Average outbound of finished products	1,69015	1,63892	1,66936	1,68192	1,69237	4,06511	3,38267	3,71562	3,57474	3,61445
Max outbound	Maximum outbound of finished products	4,822	4,978	4,964	5,078	5,23	32	32	32	32	32
Outbound frequency	Number of outbounds of finished products	24,794	25,584	25,068	24,933	24,781	21,41	25,722	23,176	24,748	24,329
Production KPI's											
Average production	Average production quantity						4,26843	3,58149	3,91172	3,75751	3,78776
Max production	Maximum production quantity						32	32	32	32	32
Production frequency	Number of production runs						20,41	24,324	22,044	23,564	23,236
Ordering KPI's											
Average orders	Average order quantity	2,96875	2,27775	2,58323	2,48664	2,51698	0	0	0	0	0
Max orders	Maximum order quantity	6,242	6,301	5,855	5,391	5,339	0	0	0	0	0
Order frequency	Number of orders	14,41	18,722	16,176	17,748	17,329	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		0,63306	0,301	0,22165	0,2031					
	Av forecast deviation as a perc of av demand		0,78783	0,3656	0,26774	0,24393					
Discount percentage	Average discount percentage		0,01555	0,01705	0,01898	0,0189					
	Av disc perc as a perc of the max possible discount		0,77761	0,85255	0,94919	0,94487					

4256632		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,85224	0,77412	0,83384	0,86941	0,88914	1	1	1	1	1
	By percentage of days without any backlogs	0,85598	0,7805	0,83576	0,8723	0,89057	0,96134	0,96144	0,96242	0,96485	0,96676
Inventory turnover	Times per year for finished products	12,3487	15,7121	12,2841	10,1338	8,72642	56,3829	56,153	56,5607	56,378	56,9111
	Times per year for materials						8,6E-05	8,6E-05	8,7E-05	8,7E-05	8,8E-05
Bullwhip Effect	Amplification on weekly level	0,91011	0,93929	0,88745	0,81893	0,7661	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	3,43992	2,72065	3,48435	4,27458	4,99921	1,52795	1,52934	1,5305	1,54392	1,54039
	Average of materials						999941	999942	999941	999940	999940
Max inventory	Maximum of finished products	6,442	6,323	6,786	8,593	9,992	33	33	33	33	33
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	2,19596	2,17881	2,13656	1,97286	1,86045	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	5,819	6,084	5,534	5,094	4,808	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	19,242	19,3	19,977	21,897	23,489	0	0	0	0	0
Average outbound	Average outbound of finished products	1,67294	1,64529	1,66498	1,67698	1,68639	3,30149	3,2857	3,22704	3,03258	2,88958
Max outbound	Maximum outbound of finished products	4,679	4,776	4,864	5,081	5,157	32	32	32	32	32
Outbound frequency	Number of outbounds of finished products	25,053	25,47	25,191	25,005	24,869	26,242	26,3	26,977	28,897	30,489
Production KPI's											
Average production	Average production quantity						3,48304	3,48331	3,38172	3,18036	3,04111
Max production	Maximum production quantity						32	32	32	32	32
Production frequency	Number of production runs						24,903	24,839	25,768	27,586	28,985
Ordering KPI's											
Average orders	Average order quantity	2,19596	2,17881	2,13656	1,97286	1,86045	0	0	0	0	0
Max orders	Maximum order quantity	5,819	6,084	5,534	5,094	4,808	0	0	0	0	0
Order frequency	Number of orders	19,242	19,3	19,977	21,897	23,489	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		0,55102	0,29756	0,23415	0,18642					
	Av forecast deviation as a perc of av demand		0,68523	0,36152	0,2821	0,22329					
Discount percentage	Average discount percentage		0,01621	0,01762	0,01849	0,01922					
	Av disc perc as a perc of the max possible discount		0,81033	0,88077	0,92449	0,96099					

4256632		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,81879	0,78789	0,86567	0,88735	0,89939	1	1	1	1	1
	By percentage of days without any backlogs	0,82395	0,79461	0,8673	0,88885	0,90258	0,95786	0,96222	0,9651	0,96627	0,96776
Inventory turnover	Times per year for finished products	14,1007	14,7713	10,6997	9,02092	8,2992	56,3665	56,0694	56,9362	56,444	57,1832
	Times per year for materials						8,6E-05	8,6E-05	8,8E-05	8,8E-05	8,8E-05
Bullwhip Effect	Amplification on weekly level	1,0007	0,90538	0,80979	0,76885	0,73523	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	3,00136	2,9046	4,01348	4,8006	5,26745	1,53206	1,53169	1,53996	1,55388	1,54422
	Average of materials						999942	999942	999941	999940	999939
Max inventory	Maximum of finished products	6,583	6,435	8,026	9,662	10,759	33	33	33	33	33
	Maximum of materials						1000000	1000000	1000000	1000000	1000000
Average inbound	Average inbound of materials/products	2,49219	2,11594	1,98142	1,89458	1,81398	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	6,47	5,86	5,333	4,946	4,759	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	17,065	19,88	22,095	23,146	24,452	0	0	0	0	0
Average outbound	Average outbound of finished products	1,66761	1,647	1,66775	1,68083	1,68582	3,6092	3,21689	3,03212	2,92999	2,82246
Max outbound	Maximum outbound of finished products	4,614	4,82	4,969	5,142	5,165	32	32	32	32	32
Outbound frequency	Number of outbounds of finished products	25,14	25,46	25,156	24,953	24,892	24,065	26,88	29,095	30,146	31,452
Production KPI's											
Average production	Average production quantity						3,78254	3,40626	3,17202	3,06415	2,97093
Max production	Maximum production quantity						32	32	32	32	32
Production frequency	Number of production runs						22,99	25,418	27,842	28,86	29,899
Ordering KPI's											
Average orders	Average order quantity	2,49219	2,11594	1,98142	1,89458	1,81398	0	0	0	0	0
Max orders	Maximum order quantity	6,47	5,86	5,333	4,946	4,759	0	0	0	0	0
Order frequency	Number of orders	17,065	19,88	22,095	23,146	24,452	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		0,39463	0,22973	0,187	0,16258					
	Av forecast deviation as a perc of av demand		0,48198	0,27825	0,22489	0,19392					
Discount percentage	Average discount percentage		0,01655	0,01872	0,01918	0,01971					
	Av disc perc as a perc of the max possible discount		0,82772	0,93622	0,95912	0,98555					

Annex XVIII: Normative deviations of FAD KPI values in percentages of their null situation

4536827 and 4536835		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0561	-0,0178	0,02792	0,01299		-8E-05	0,00063	0,00039	0,0009
	By percentage of days without any backlogs		-0,0648	-0,0207	0,03114	0,01418		-0,0005	0,00094	0,00099	0,00174
Inventory turnover	Times per year for finished products		0,3041	0,09744	-0,1541	-0,1037		0,0332	0,01861	0,00751	0,01293
	Times per year for materials							0,01468	0,00474	0,00439	0,00147
Bullwhip Effect	Amplification on weekly level		0,42792	0,18307	0,11563	0,1481		-0,4899	-0,1912	-0,1183	-0,1716
Inventory KPI's											
Average inventory	Average of finished products		0,23209	0,08578	-0,1895	-0,1412		0,03379	0,01786	0,0011	0,00885
	Average of materials							0,01649	0,00479	-0,0026	-0,0021
Max inventory	Maximum of finished products		0,20191	-0,0032	-0,4303	-0,3518		0,06376	0,01366	0,00586	0,01845
	Maximum of materials							-0,0048	0,00431	0,00569	0,00406
Average inbound	Average inbound of materials/products		0,26935	0,16389	0,10426	0,12461		-0,0081	-0,0209	-0,0205	-0,0222
Max inbound	Maximum inbound of materials/products		0,14175	0,01219	-0,0093	0,03143		0,01862	0,00482	-0,0044	0,00068
Inbound frequency	Number of inbounds of materials/products		0,36596	0,19849	0,13003	0,15303		-0,0159	-0,0171	-0,0106	-0,0165
Average outbound	Average outbound of finished products		-0,0326	-0,0085	0,01914	0,00967		0,12849	0,07212	0,04243	0,05219
Max outbound	Maximum outbound of finished products		0,03808	0,02361	0,09546	0,07653		0,11147	0,01207	-0,0093	0,03107
Outbound frequency	Number of outbounds of finished products		-0,0305	-0,0077	0,0198	0,01052		0,14602	0,07859	0,0514	0,0599
Production KPI's											
Average production	Average production quantity							0,04002	0,00364	0,003	0,0103
Max production	Maximum production quantity							0,0643	0,01888	0,01772	0,02779
Production frequency	Number of production runs							0,03731	0,00211	0,01006	0,01345
Ordering KPI's											
Average orders	Average order quantity		0,26991	0,16466	0,10503	0,12549		-0,0081	-0,0209	-0,0205	-0,0222
Max orders	Maximum order quantity		0,14168	0,01239	-0,0089	0,03115		0,01862	0,00482	-0,0044	0,00068
Order frequency	Number of orders		0,36706	0,19966	0,13106	0,15424		-0,0159	-0,0171	-0,0106	-0,0165
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0644	-0,0292	0,01696	0,00233		0,00239	0,02624	0,03381	0,03262
	By percentage of days without any backlogs		-0,0736	-0,0324	0,01948	0,00285		0,00998	0,03897	0,06327	0,05062
Inventory turnover	Times per year for finished products		0,3247	0,12198	-0,137	-0,0891		0,03891	0,01782	0,0135	0,01582
	Times per year for materials							0,11226	0,07316	0,02239	0,04022
Bullwhip Effect	Amplification on weekly level		0,41873	0,18211	0,11444	0,14701		-0,1628	-0,0197	-0,0755	-0,0637
Inventory KPI's											
Average inventory	Average of finished products		0,24457	0,10648	-0,1653	-0,1219		0,03963	0,01769	0,00747	0,01222
	Average of materials							0,10515	0,07092	0,01866	0,03818
Max inventory	Maximum of finished products		0,23727	0,05114	-0,3645	-0,3042		0,17415	-0,0071	-0,0116	0,06588
	Maximum of materials							0,24906	0,26469	0,25159	0,27313
Average inbound	Average inbound of materials/products		0,21954	0,10179	0,03217	0,05726		0,09057	0,06971	0,03557	0,06106
Max inbound	Maximum inbound of materials/products		0,14529	0,00759	-0,0218	0,01899		0,28849	0,2655	0,24977	0,28417
Inbound frequency	Number of inbounds of materials/products		0,27475	0,11176	0,04287	0,06725		0,09132	0,07231	0,04406	0,06763
Average outbound	Average outbound of finished products		-0,0383	-0,0157	0,01229	0,00289		0,14515	0,08023	0,04114	0,05904
Max outbound	Maximum outbound of finished products		0,01906	0,00248	0,07811	0,05987		0,15217	0,00851	-0,0224	0,03067
Outbound frequency	Number of outbounds of finished products		-0,0359	-0,0149	0,01263	0,00352		0,16804	0,08804	0,04984	0,06754
Production KPI's											
Average production	Average production quantity							0,16082	0,09817	0,059	0,079
Max production	Maximum production quantity							0,18084	-0,0053	-0,0049	0,07766
Production frequency	Number of production runs							0,1889	0,10912	0,06929	0,09057
Ordering KPI's											
Average orders	Average order quantity		0,2674	0,16402	0,10423	0,12502		0,09057	0,06971	0,03557	0,06106
Max orders	Maximum order quantity		0,12988	0,01135	-0,0133	0,02876		0,28849	0,2655	0,24977	0,28417
Order frequency	Number of orders		0,36181	0,19849	0,12988	0,15339		0,09132	0,07231	0,04406	0,06763
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0533	-0,0209	0,03169	0,01881		0,00036	0,01809	0,02465	0,02761
	By percentage of days without any backlogs		-0,0615	-0,0252	0,03523	0,02065		-0,0026	0,02387	0,04208	0,04238
Inventory turnover	Times per year for finished products		0,25579	0,10172	-0,173	-0,1296		0,0378	0,02061	0,01958	0,01588
	Times per year for materials							0,08942	0,06635	0,01704	0,0377
Bullwhip Effect	Amplification on weekly level		0,36629	0,17993	0,10443	0,12398		-0,1261	-0,0352	-0,0618	-0,0388
Inventory KPI's											
Average inventory	Average of finished products		0,20325	0,09016	-0,2156	-0,169		0,0382	0,02034	0,01295	0,01158
	Average of materials							0,08537	0,06444	0,01253	0,03448
Max inventory	Maximum of finished products		0,20228	0,05233	-0,3974	-0,3225		0,16125	0,00019	0,03598	0,08368
	Maximum of materials							0,23947	0,26928	0,27012	0,26444
Average inbound	Average inbound of materials/products		0,17538	0,08399	0,01338	0,02956		0,07608	0,05763	0,03336	0,05537
Max inbound	Maximum inbound of materials/products		0,10289	0,01552	-0,0094	0,02047		0,25376	0,24309	0,25844	0,26878
Inbound frequency	Number of inbounds of materials/products		0,2087	0,09108	0,0246	0,03854		0,07684	0,05986	0,04421	0,06368
Average outbound	Average outbound of finished products		-0,0316	-0,011	0,02026	0,0124		0,12543	0,07409	0,04193	0,04531
Max outbound	Maximum outbound of finished products		0,01753	0,02121	0,09074	0,06552		0,12267	0,02466	0,00653	0,04304
Outbound frequency	Number of outbounds of finished products		-0,0299	-0,0103	0,02075	0,01289		0,14224	0,08078	0,05118	0,05268
Production KPI's											
Average production	Average production quantity							0,14313	0,09292	0,06242	0,06597
Max production	Maximum production quantity							0,16937	0,00012	0,04644	0,09678
Production frequency	Number of production runs							0,16478	0,10248	0,07352	0,07568
Ordering KPI's											
Average orders	Average order quantity		0,21749	0,13842	0,07855	0,08983		0,07608	0,05763	0,03336	0,05537
Max orders	Maximum order quantity		0,1034	0,03339	0,01727	0,04006		0,25376	0,24309	0,25844	0,26878
Order frequency	Number of orders		0,27582	0,1624	0,09905	0,10917		0,07684	0,05986	0,04421	0,06368
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,06584	0,06743	0,08272	0,08618		0,04015	0,04317	0,04574	0,04299
	By percentage of days without any backlogs		0,07305	0,0755	0,09693	0,10225		0,04954	0,05435	0,05943	0,06764
Inventory turnover	Times per year for finished products		-0,1313	-0,1371	-0,2422	-0,2609		-0,0134	-0,0135	-0,0095	-0,0064
	Times per year for materials							-0,0136	-0,0125	0,0011	0,00722
Bullwhip Effect	Amplification on weekly level		0,00875	0,03556	0,23219	0,30379		0,11976	0,11635	0,06309	0,05401
Inventory KPI's											
Average inventory	Average of finished products		-0,1506	-0,1586	-0,3232	-0,3604		-0,0151	-0,0152	-0,0146	-0,011
	Average of materials							-0,0145	-0,0132	-0,0028	0,00383
Max inventory	Maximum of finished products		0,0067	0,00597	-0,1935	-0,1821		0,10786	0,12001	0,15833	0,17307
	Maximum of materials							0,15054	0,17501	0,16642	0,17188
Average inbound	Average inbound of materials/products		-0,1398	-0,1351	-0,0741	-0,0505		0,03845	0,04529	0,0564	0,0588
Max inbound	Maximum inbound of materials/products		0,07302	0,07808	0,09417	0,10051		0,12519	0,16803	0,16764	0,17212
Inbound frequency	Number of inbounds of materials/products		-0,1199	-0,1165	-0,0608	-0,0405		0,04151	0,0499	0,06498	0,0662
Average outbound	Average outbound of finished products		0,03818	0,03927	0,04847	0,05025		-0,0011	0,00488	0,03678	0,0457
Max outbound	Maximum outbound of finished products		0,10139	0,10304	0,11274	0,10996		0,0885	0,09625	0,10796	0,1191
Outbound frequency	Number of outbounds of finished products		0,03997	0,04117	0,05114	0,05313		0,00072	0,00676	0,04369	0,05293
Production KPI's											
Average production	Average production quantity							0,01004	0,01757	0,0543	0,06479
Max production	Maximum production quantity							0,11836	0,13036	0,17933	0,19745
Production frequency	Number of production runs							0,01203	0,01984	0,06384	0,07451
Ordering KPI's											
Average orders	Average order quantity		-0,0688	-0,0573	0,00379	0,02756		0,03845	0,04529	0,0564	0,0588
Max orders	Maximum order quantity		0,06687	0,06821	0,07964	0,08461		0,12519	0,16803	0,16764	0,17212
Order frequency	Number of orders		-0,0612	-0,051	0,01317	0,03714		0,04151	0,0499	0,06498	0,0662
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,09525	0,11285	0,11867	0,12166		0,04938	0,07309	0,07794	0,08063
	By percentage of days without any backlogs		0,10446	0,12674	0,13438	0,13885		0,02367	0,06148	0,07254	0,07347
Inventory turnover	Times per year for finished products		-0,1807	-0,2585	-0,278	-0,3057		-0,0552	-0,0509	-0,0486	-0,0437
	Times per year for materials							0,27322	0,41917	0,46857	0,47939
Bullwhip Effect	Amplification on weekly level		0,03425	0,24892	0,33341	0,36239		0,09811	0,06355	0,03456	0,03578
Inventory KPI's											
Average inventory	Average of finished products		-0,2192	-0,3511	-0,3908	-0,4491		-0,0605	-0,0582	-0,0562	-0,0501
	Average of materials							0,22421	0,30438	0,32863	0,334
Max inventory	Maximum of finished products		0,00827	-0,0505	-0,0506	-0,0996		-0,0597	-0,0295	-0,007	0,00423
	Maximum of materials							0,27417	0,34194	0,36819	0,37564
Average inbound	Average inbound of materials/products		-0,1087	-0,0643	-0,0467	-0,0409		0,04272	0,06871	0,07967	0,0815
Max inbound	Maximum inbound of materials/products		0,03676	0,10423	0,1386	0,14713		0,12696	0,21516	0,25716	0,26113
Inbound frequency	Number of inbounds of materials/products		-0,0942	-0,0527	-0,0361	-0,0317		0,04254	0,07035	0,08144	0,08388
Average outbound	Average outbound of finished products		0,05353	0,0631	0,06634	0,06785		-0,0238	0,00024	0,01075	0,0149
Max outbound	Maximum outbound of finished products		0,17626	0,22387	0,23287	0,23638		-0,0297	0,0257	0,05147	0,06048
Outbound frequency	Number of outbounds of finished products		0,05621	0,06698	0,07067	0,07234		-0,0213	0,00493	0,01613	0,01983
Production KPI's											
Average production	Average production quantity							-0,0427	-0,0103	0,00192	0,00785
Max production	Maximum production quantity							-0,0606	-0,0304	-0,0077	0,00342
Production frequency	Number of production runs							-0,0369	-0,0037	0,00819	0,0139
Ordering KPI's											
Average orders	Average order quantity		-0,0638	0,01394	0,03921	0,04661		0,04272	0,06871	0,07967	0,0815
Max orders	Maximum order quantity		0,06307	0,10991	0,13426	0,13781		0,12696	0,21516	0,25716	0,26113
Order frequency	Number of orders		-0,0571	0,02199	0,04993	0,05697		0,04254	0,07035	0,08144	0,08388
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0027	-0,0022	0,00234	0,00529		0	0	0	0
	By percentage of days without any backlogs		-0,0021	-0,0015	0,00239	0,00526		0,00018	0,00014	0,00021	0,00022
Inventory turnover	Times per year for finished products		0,09568	-0,0368	-0,2012	-0,2691		0,02749	0,02192	0,03237	0,03827
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,0596	0,03752	0,05244	0,0558		-0,0042	-0,008	-0,0083	-0,0046
Inventory KPI's											
Average inventory	Average of finished products		0,09069	-0,0431	-0,2688	-0,3966		0,0273	0,02013	0,02811	0,03324
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,15575	-0,0385	-0,3251	-0,5067		0,00181	0,00332	0,01165	0,01656
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,06532	0,03284	0,03975	0,04307		0,01621	0,01722	0,01757	0,01823
Max inbound	Maximum inbound of materials/products		0,31217	0,14572	0,18516	0,19452		0	0,01175	0,01775	0,029
Inbound frequency	Number of inbounds of materials/products		0,05836	0,04405	0,06732	0,07168		0,00362	0,00313	0,00675	0,00725
Average outbound	Average outbound of finished products		0,00025	-0,0006	0,00016	0,00125		0,00966	0,00593	0,00823	0,00879
Max outbound	Maximum outbound of finished products		0,00494	0,0015	-0,003	-0,0001		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00022	-0,0006	0,00013	0,00112		0,00919	0,00694	0,0106	0,01129
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,06532	0,03284	0,03975	0,04307		0,01621	0,01722	0,01757	0,01823
Max orders	Maximum order quantity		0,31217	0,14572	0,18516	0,19452		0	0,01175	0,01775	0,029
Order frequency	Number of orders		0,05836	0,04405	0,06732	0,07168		0,00362	0,00313	0,00675	0,00725
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0429	-0,0498	-0,0378	-0,0233		0	0	0	0
	By percentage of days without any backlogs		-0,038	-0,0453	-0,0349	-0,022		0,0025	0,00225	0,00187	0,00116
Inventory turnover	Times per year for finished products		0,28493	0,12181	-0,0889	-0,2798		0,0114	-0,0136	-0,0104	-0,0164
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,15659	0,08831	0,07371	0,03298		0,00506	-0,0165	-0,0098	-0,0037
Inventory KPI's											
Average inventory	Average of finished products		0,2163	0,10101	-0,1276	-0,4247		0,01349	-0,0114	-0,0088	-0,0173
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,11748	-0,0765	-0,4459	-0,7482		0,0151	-0,0005	0,00163	0,00566
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,42607	0,39674	0,34018	0,22452		0,01339	0,00134	-0,0007	0,00981
Max inbound	Maximum inbound of materials/products		0,15544	0,0283	0,04825	0,01174		0,00343	0,01451	0,01759	0,02034
Inbound frequency	Number of inbounds of materials/products		0,74883	0,66814	0,54742	0,32282		0,01286	-0,001	-0,0024	0,01053
Average outbound	Average outbound of finished products		-0,0077	-0,0117	-0,0097	-0,0072		0,13556	0,12264	0,10172	0,06184
Max outbound	Maximum outbound of finished products		-0,0092	-0,0248	-0,0226	-0,0237		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0076	-0,0113	-0,0094	-0,007		0,15816	0,14112	0,11562	0,06818
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,42607	0,39674	0,34018	0,22452		0,01339	0,00134	-0,0007	0,00981
Max orders	Maximum order quantity		0,15544	0,0283	0,04825	0,01174		0,00343	0,01451	0,01759	0,02034
Order frequency	Number of orders		0,74883	0,66814	0,54742	0,32282		0,01286	-0,001	-0,0024	0,01053
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0263	-0,0162	-0,0197	-0,0009		0	0	0	0
	By percentage of days without any backlogs		-0,0228	-0,0132	-0,0181	1,7E-05		0,00024	-0,0003	0,00021	7,8E-05
Inventory turnover	Times per year for finished products		0,03854	-0,0762	-0,1532	-0,3266		0,0153	-0,0011	-0,0005	-0,001
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,1876	-0,16	-0,1108	-0,0762		0,00758	-0,0034	0,00252	0,00829
Inventory KPI's											
Average inventory	Average of finished products		0,03516	-0,0839	-0,1915	-0,5023		0,01666	-0,0024	2,4E-06	-0,0021
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,1407	-0,1558	-0,3856	-0,7602		0,01086	-0,0033	0,00225	0,00368
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,05786	-0,0792	0,03692	-0,0024		0,02356	0,01844	0,0168	0,01814
Max inbound	Maximum inbound of materials/products		-0,209	-0,2208	-0,1738	-0,1174		-0,0011	-0,011	0,00103	0,02053
Inbound frequency	Number of inbounds of materials/products		0,05025	-0,0545	0,04403	0,01622		0,02267	0,02301	0,01686	0,02007
Average outbound	Average outbound of finished products		-0,003	-0,0053	-0,006	-0,0011		0,01692	-0,0201	0,01367	0,00378
Max outbound	Maximum outbound of finished products		-0,0186	-0,0375	-0,0353	-0,0332		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0031	-0,0052	-0,006	-0,0013		0,01669	-0,0181	0,01463	0,00539
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,05786	-0,0792	0,03692	-0,0024		0,02356	0,01844	0,0168	0,01814
Max orders	Maximum order quantity		-0,209	-0,2208	-0,1738	-0,1174		-0,0011	-0,011	0,00103	0,02053
Order frequency	Number of orders		0,05025	-0,0545	0,04403	0,01622		0,02267	0,02301	0,01686	0,02007
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,01767	0,0035	0,01491	0,02211		0	0	0	0
	By percentage of days without any backlogs		0,01591	0,00337	0,01244	0,01883		-0,0019	-0,0013	-0,0005	-0,0003
Inventory turnover	Times per year for finished products		-0,139	-0,1364	-0,2399	-0,3418		0,00983	0,00762	0,00467	0,00378
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,5127	-0,4103	-0,2207	-0,1685		0,01241	0,00491	0,01185	0,01281
Inventory KPI's											
Average inventory	Average of finished products		-0,1597	-0,1584	-0,3182	-0,5256		0,01027	0,00639	0,00326	0,00229
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,2872	-0,2694	-0,4027	-0,6733		0,00991	-0,0018	0,0037	0,00557
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,4172	-0,2912	-0,1183	-0,0752		0,02478	0,00701	0,01481	0,01261
Max inbound	Maximum inbound of materials/products		-0,382	-0,382	-0,3095	-0,2797		-0,0025	-0,0098	-0,0062	0,02411
Inbound frequency	Number of inbounds of materials/products		-0,2954	-0,2105	-0,0873	-0,0509		0,02599	0,01252	0,01965	0,01527
Average outbound	Average outbound of finished products		0,00396	-0,0016	0,00017	0,00185		-0,1391	-0,0971	-0,0392	-0,0232
Max outbound	Maximum outbound of finished products		-0,0047	-0,0303	-0,0208	-0,021		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00396	-0,0015	0,00027	0,00194		-0,1224	-0,0872	-0,0362	-0,0211
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,4172	-0,2912	-0,1183	-0,0752		0,02478	0,00701	0,01481	0,01261
Max orders	Maximum order quantity		-0,382	-0,382	-0,3095	-0,2797		-0,0025	-0,0098	-0,0062	0,02411
Order frequency	Number of orders		-0,2954	-0,2105	-0,0873	-0,0509		0,02599	0,01252	0,01965	0,01527
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00865	0,01284	0,0207	0,02754		0	0	0	0
	By percentage of days without any backlogs		0,00837	0,01155	0,01808	0,02372		-0,0009	-2E-06	5,1E-05	0,00039
Inventory turnover	Times per year for finished products		-0,1298	-0,2426	-0,3616	-0,4254		0,0037	0,0037	0,00348	0,0058
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,2628	-0,0913	-0,0546	0,01444		0,01103	0,01083	0,01462	0,01747
Inventory KPI's											
Average inventory	Average of finished products		-0,1496	-0,3247	-0,5759	-0,7555		0,00316	0,0018	0,00118	0,0033
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,2378	-0,4445	-0,7851	-0,9845		0,00563	0,00214	0,0037	0,0019
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,186	-0,0258	-0,0208	0,03614		0,02164	0,01367	0,01518	0,01529
Max inbound	Maximum inbound of materials/products		-0,2094	-0,1517	-0,1159	-0,0457		0,00195	-0,0104	0,02463	0,03632
Inbound frequency	Number of inbounds of materials/products		-0,1488	-0,0005	0,0085	0,06998		0,0238	0,01904	0,0207	0,01862
Average outbound	Average outbound of finished products		0,00033	0,00175	0,00246	0,00404		-0,0646	-0,0021	0,00126	0,02523
Max outbound	Maximum outbound of finished products		-0,0025	-0,0026	-0,0025	-0,0085		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00027	0,00162	0,00247	0,00403		-0,0602	-0,0002	0,00344	0,02829
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,186	-0,0258	-0,0208	0,03614		0,02164	0,01367	0,01518	0,01529
Max orders	Maximum order quantity		-0,2094	-0,1517	-0,1159	-0,0457		0,00195	-0,0104	0,02463	0,03632
Order frequency	Number of orders		-0,1488	-0,0005	0,0085	0,06998		0,0238	0,01904	0,0207	0,01862
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00512	0,00795	0,01213	0,01477		3,8E-06	6,8E-06	1,3E-05	6,8E-06
	By percentage of days without any backlogs		0,00522	0,00764	0,01173	0,01443		9,6E-06	1E-05	2,1E-05	1,1E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0953	-0,2072	-0,2799		-0,0069	-0,0117	-0,0024	0,00268
	Times per year for materials							0,0006	0,00202	0,00607	0,00808
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08586	0,10776		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,0499	-0,1052	-0,2652	-0,4052		-0,0076	-0,0138	-0,0084	-0,0055
	Average of materials							1,8E-05	3,8E-05	8,2E-05	0,00012
Max inventory	Maximum of finished products		-0,0025	-0,087	-0,4653	-0,654		-0,0165	-0,014	-0,0126	-0,0099
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1553	-0,1534	-0,1034	-0,1057		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0416	-0,0309	-0,0201	-0,0059		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,1331	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00145	0,00299	0,00527	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0004	0,02552	0,05311	0,06586		-0,0041	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00146	0,00295	0,00524	0,00616		-0,0665	-0,0647	-0,0416	-0,0406
Production KPI's											
Average production	Average production quantity							-0,0132	-0,0111	-0,005	-0,0006
Max production	Maximum production quantity							-0,0119	-0,0087	-0,0063	-0,0067
Production frequency	Number of production runs							-0,013	-0,0093	-8E-05	0,00578
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1533	-0,1033	-0,1057		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0416	-0,0309	-0,0201	-0,006		#######	#######	#######	#######
Order frequency	Number of orders		-0,1331	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00515	0,00795	0,01216	0,01477		1E-05	3,1E-05	2,1E-05	3,1E-05
	By percentage of days without any backlogs		0,00524	0,00764	0,01175	0,01443		7E-06	4E-05	3E-05	4E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0953	-0,2072	-0,2798		0,0094	0,01017	0,01257	0,01374
	Times per year for materials							0,0006	0,00202	0,00606	0,00808
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08596	0,10776		########	########	########	########
Inventory KPI's											
Average inventory	Average of finished products		-0,05	-0,1051	-0,2652	-0,4052		0,00872	0,0081	0,00651	0,00571
	Average of materials							1,4E-05	3E-05	7,8E-05	0,00012
Max inventory	Maximum of finished products		-0,0026	-0,087	-0,4652	-0,654		-0,0011	-3E-05	-0,0007	6,7E-05
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1553	-0,1534	-0,1034	-0,1058		########	########	########	########
Max inbound	Maximum inbound of materials/products		-0,0417	-0,0309	-0,02	-0,0059		########	########	########	########
Inbound frequency	Number of inbounds of materials/products		-0,1331	-0,1296	-0,0832	-0,0814		########	########	########	########
Average outbound	Average outbound of finished products		0,00147	0,00299	0,00528	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0002	0,02552	0,0532	0,06586		-0,0043	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00147	0,00295	0,00525	0,00615		-0,0665	-0,0647	-0,0416	-0,0407
Production KPI's											
Average production	Average production quantity							-0,0779	-0,0771	-0,0524	-0,0535
Max production	Maximum production quantity							-0,0037	0,00033	-0,001	-0,0002
Production frequency	Number of production runs							-0,0717	-0,0697	-0,0439	-0,0429
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1534	-0,1033	-0,1057		########	########	########	########
Max orders	Maximum order quantity		-0,0418	-0,0309	-0,0201	-0,006		########	########	########	########
Order frequency	Number of orders		-0,1331	-0,1295	-0,0832	-0,0813		########	########	########	########
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0092	-0,0006	-0,0011	0,00589		1,4E-06	2E-05	6,6E-06	1,5E-05
	By percentage of days without any backlogs		-0,0083	-0,0006	-0,0007	0,00576		-2E-05	6,2E-07	-1E-05	2,8E-07
Inventory turnover	Times per year for finished products		0,16887	-0,0137	-0,0849	-0,2668		-0,0052	0,00075	0,00254	0,00255
	Times per year for materials							-0,0021	0,00285	0,0066	0,00597
Bullwhip Effect	Amplification on weekly level		0,3395	0,05077	0,10138	0,03814		########	########	########	########
Inventory KPI's											
Average inventory	Average of finished products		0,14422	-0,0147	-0,1015	-0,3779		-0,0031	-0,0021	-0,004	-0,0032
	Average of materials							-5E-05	5,6E-06	3,7E-05	0,00014
Max inventory	Maximum of finished products		0,20363	-0,0622	-0,2416	-0,6515		0,06578	-0,0241	-0,0096	-0,0144
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,31251	0,09399	0,13859	0,07766		########	########	########	########
Max inbound	Maximum inbound of materials/products		0,27008	-0,0421	-0,0071	-0,0262		########	########	########	########
Inbound frequency	Number of inbounds of materials/products		0,45	0,11126	0,17994	0,09925		########	########	########	########
Average outbound	Average outbound of finished products		-0,0032	5,3E-05	-0,0002	0,00291		0,14412	0,03657	0,05563	0,02939
Max outbound	Maximum outbound of finished products		-0,0271	0,0045	0,0054	0,05214		0,15924	-0,0421	-0,0148	-0,0284
Outbound frequency	Number of outbounds of finished products		-0,003	7,3E-05	-0,0001	0,00287		0,1663	0,04112	0,0665	0,03668
Production KPI's											
Average production	Average production quantity							0,15531	0,0417	0,06286	0,03471
Max production	Maximum production quantity							0,15568	-0,0419	-0,0152	-0,0308
Production frequency	Number of production runs							0,18169	0,04684	0,07509	0,04265
Ordering KPI's											
Average orders	Average order quantity		0,31248	0,09398	0,13855	0,07763		########	########	########	########
Max orders	Maximum order quantity		0,27008	-0,0421	-0,0071	-0,0262		########	########	########	########
Order frequency	Number of orders		0,44995	0,11127	0,17988	0,09922		########	########	########	########
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00515	0,00795	0,01216	0,01477		1E-05	3,1E-05	2,1E-05	3,1E-05
	By percentage of days without any backlogs		0,00524	0,00764	0,01175	0,01443		7E-06	4E-05	3E-05	4E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0953	-0,2072	-0,2798		0,0094	0,01017	0,01257	0,01374
	Times per year for materials							0,0006	0,00202	0,00606	0,00808
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08596	0,10776		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,05	-0,1051	-0,2652	-0,4052		0,00872	0,0081	0,00651	0,00571
	Average of materials							1,4E-05	3E-05	7,8E-05	0,00012
Max inventory	Maximum of finished products		-0,0026	-0,087	-0,4652	-0,654		-0,0011	-3E-05	-0,0007	6,7E-05
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1553	-0,1534	-0,1034	-0,1058		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0417	-0,0309	-0,02	-0,0059		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,1331	-0,1296	-0,0832	-0,0814		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00147	0,00299	0,00528	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0002	0,02552	0,0532	0,06586		-0,0043	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00147	0,00295	0,00525	0,00615		-0,0665	-0,0647	-0,0416	-0,0407
Production KPI's											
Average production	Average production quantity							-0,0779	-0,0771	-0,0524	-0,0535
Max production	Maximum production quantity							-0,0037	0,00033	-0,001	-0,0002
Production frequency	Number of production runs							-0,0717	-0,0697	-0,0439	-0,0429
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1534	-0,1033	-0,1057		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0418	-0,0309	-0,0201	-0,006		#######	#######	#######	#######
Order frequency	Number of orders		-0,1331	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00266	0,004	0,0044	0,00518		0,0122	0,01525	0,01652	0,01811
	By percentage of days without any backlogs		0,00236	0,00383	0,00418	0,0051		0,01623	0,02107	0,02237	0,02448
Inventory turnover	Times per year for finished products		-0,0767	-0,1919	-0,2758	-0,2955		0,00865	0,01117	0,01229	0,01203
	Times per year for materials							0,00214	0,00785	0,01009	0,00992
Bullwhip Effect	Amplification on weekly level		-0,0121	0,10925	0,12756	0,18124		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,0832	-0,2415	-0,3953	-0,4415		0,0065	0,00338	0,00233	0,00225
	Average of materials							2,5E-05	7,3E-05	0,00012	0,00013
Max inventory	Maximum of finished products		-0,0975	-0,5007	-0,7851	-0,7632		-0,0004	0,00333	0,00424	0,00382
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1685	-0,1326	-0,1369	-0,1295		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,1165	-0,0938	-0,0941	-0,0622		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,1407	-0,1039	-0,1036	-0,0983		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00085	0,00139	0,0013	0,00157		-0,0799	-0,0643	-0,0665	-0,0631
Max outbound	Maximum outbound of finished products		0,02169	0,02802	0,02943	0,03188		-0,0048	-0,002	-0,0031	-0,0026
Outbound frequency	Number of outbounds of finished products		0,00084	0,00136	0,00127	0,00154		-0,0721	-0,0533	-0,0531	-0,0504
Production KPI's											
Average production	Average production quantity							-0,065	-0,0392	-0,0395	-0,0326
Max production	Maximum production quantity							0,00627	0,02014	0,02206	0,0225
Production frequency	Number of production runs							-0,059	-0,0301	-0,0281	-0,0219
Ordering KPI's											
Average orders	Average order quantity		-0,1369	-0,0913	-0,0928	-0,0814		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0889	-0,0662	-0,0655	-0,0311		#######	#######	#######	#######
Order frequency	Number of orders		-0,1167	-0,0697	-0,067	-0,0577		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		0,00667	0,01742	0,016	0,01861
	By percentage of days without any backlogs		0	0	0	0		0,00168	0,01346	0,01222	0,01308
Inventory turnover	Times per year for finished products		0,00136	-0,0547	-0,1715	-0,2159		0,0201	-0,1186	-0,0893	-0,0658
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0012	0,00669	0,02687	0,03214		0,00122	-0,0038	-0,0063	0,00195
Inventory KPI's											
Average inventory	Average of finished products		0,00122	-0,061	-0,214	-0,2908		0,02056	-0,1426	-0,1181	-0,0935
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,0047	-0,14	-0,4051	-0,538		0,02534	-0,0547	-0,0377	-0,034
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,04568	0,01209	-0,0028	-0,004		0,02266	0,01826	0,0211	0,02259
Max inbound	Maximum inbound of materials/products		0	0	0	0		0,04501	0,04488	0,04896	0,05172
Inbound frequency	Number of inbounds of materials/products		0,04757	0,02716	0,04916	0,05764		0	0	0,00275	0,00575
Average outbound	Average outbound of finished products		0	0	0	0		-0,0012	-0,0126	-0,0157	-0,0177
Max outbound	Maximum outbound of finished products		0	0	0	0		-0,0338	-0,0458	-0,0477	-0,0477
Outbound frequency	Number of outbounds of finished products		0	0	0	0		-0,0017	-0,0095	-0,0035	-0,0029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0	0	0	0		0,02266	0,01826	0,0211	0,02259
Max orders	Maximum order quantity		0	0	0	0		0,04501	0,04488	0,04896	0,05172
Order frequency	Number of orders		-0,0022	0,01213	0,05038	0,06135		0	0	0,00275	0,00575
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,0441	-0,0207	-0,0269	-0,0223
	By percentage of days without any backlogs		0	0	0	0		-0,0426	-0,0229	-0,0206	-0,021
Inventory turnover	Times per year for finished products		-0,0119	-0,0527	-0,1144	-0,1763		0,07954	0,02646	0,0343	0,02467
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0397	-0,0472	0,02597	0,04389		0,01347	0,01499	-0,0109	-0,003
Inventory KPI's											
Average inventory	Average of finished products		-0,0119	-0,056	-0,1314	-0,2181		0,07384	0,0234	0,02678	0,01474
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0	-0,0008	-0,0487	-0,0549		0	0	0	0
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,1546	-0,1681	-0,1054	-0,1268		-0,0348	-0,0537	-0,0698	-0,0763
Max inbound	Maximum inbound of materials/products		-0,0004	-0,0284	-0,0241	-0,0249		-0,0191	-0,0375	-0,041	-0,0341
Inbound frequency	Number of inbounds of materials/products		-0,1337	-0,134	-0,0687	-0,0746		-0,0392	-0,0513	-0,0624	-0,0636
Average outbound	Average outbound of finished products		0	0	0	0		-0,0274	-0,0459	-0,0212	-0,0267
Max outbound	Maximum outbound of finished products		0	0	0	0		0,04656	0,05977	0,08203	0,0742
Outbound frequency	Number of outbounds of finished products		0	0	0	0		-0,0268	-0,0416	-0,0143	-0,0167
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,1552	-0,1686	-0,1057	-0,127		-0,0348	-0,0537	-0,0698	-0,0763
Max orders	Maximum order quantity		-0,0008	-0,0287	-0,0244	-0,025		-0,0191	-0,0375	-0,041	-0,0341
Order frequency	Number of orders		-0,1341	-0,1344	-0,0689	-0,0748		-0,0392	-0,0513	-0,0624	-0,0636
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,0508	-0,0138	-0,0287	-0,0195
	By percentage of days without any backlogs		0	0	0	0		-0,0152	-0,0123	-0,0138	-0,0125
Inventory turnover	Times per year for finished products		0,05958	-0,0272	-0,0824	-0,1745		0,09253	0,0118	0,03239	0,02037
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,24842	0,01303	0,03919	0,00914		-0,0098	-0,0141	-0,0389	-0,0381
Inventory KPI's											
Average inventory	Average of finished products		0,05623	-0,0285	-0,0936	-0,2172		0,08554	0,00926	0,0244	0,00981
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,00636	-0,0139	-0,1189	-0,1686		0	0	0	0
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,29021	0,04572	0,07991	-0,0158		-0,0276	-0,0634	-0,0633	-0,0664
Max inbound	Maximum inbound of materials/products		0,32579	-0,0205	-0,0042	-0,0017		-0,0325	-0,0737	-0,0709	-0,0621
Inbound frequency	Number of inbounds of materials/products		0,40302	0,06017	0,12619	0,0335		-0,0327	-0,0596	-0,0563	-0,0538
Average outbound	Average outbound of finished products		0	0	0	0		0,12395	0,02437	0,04058	0,00895
Max outbound	Maximum outbound of finished products		0	0	0	0		0,00347	-0,0127	0,00196	0,0016
Outbound frequency	Number of outbounds of finished products		0	0	0	0		0,14072	0,02762	0,0504	0,01989
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,28853	0,04283	0,07784	-0,0167		-0,0276	-0,0634	-0,0633	-0,0664
Max orders	Maximum order quantity		0,3212	-0,0205	-0,0044	-0,0017		-0,0325	-0,0737	-0,0709	-0,0621
Order frequency	Number of orders		0,39965	0,05684	0,12365	0,03258		-0,0327	-0,0596	-0,0563	-0,0538
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,0441	-0,0207	-0,0269	-0,0223
	By percentage of days without any backlogs		0	0	0	0		-0,0426	-0,0229	-0,0206	-0,021
Inventory turnover	Times per year for finished products		-0,0119	-0,0527	-0,1144	-0,1763		0,07954	0,02646	0,0343	0,02467
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0397	-0,0472	0,02597	0,04389		0,01347	0,01499	-0,0109	-0,003
Inventory KPI's											
Average inventory	Average of finished products		-0,0119	-0,056	-0,1314	-0,2181		0,07384	0,0234	0,02678	0,01474
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0	-0,0008	-0,0487	-0,0549		0	0	0	0
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,1546	-0,1681	-0,1054	-0,1268		-0,0348	-0,0537	-0,0698	-0,0763
Max inbound	Maximum inbound of materials/products		-0,0004	-0,0284	-0,0241	-0,0249		-0,0191	-0,0375	-0,041	-0,0341
Inbound frequency	Number of inbounds of materials/products		-0,1337	-0,134	-0,0687	-0,0746		-0,0392	-0,0513	-0,0624	-0,0636
Average outbound	Average outbound of finished products		0	0	0	0		-0,0274	-0,0459	-0,0212	-0,0267
Max outbound	Maximum outbound of finished products		0	0	0	0		0,04656	0,05977	0,08203	0,0742
Outbound frequency	Number of outbounds of finished products		0	0	0	0		-0,0268	-0,0416	-0,0143	-0,0167
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,1552	-0,1686	-0,1057	-0,127		-0,0348	-0,0537	-0,0698	-0,0763
Max orders	Maximum order quantity		-0,0008	-0,0287	-0,0244	-0,025		-0,0191	-0,0375	-0,041	-0,0341
Order frequency	Number of orders		-0,1341	-0,1344	-0,0689	-0,0748		-0,0392	-0,0513	-0,0624	-0,0636
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,015	-0,0127	-0,0143	-0,0111
	By percentage of days without any backlogs		0	0	0	0		-0,0192	-0,0167	-0,0181	-0,0183
Inventory turnover	Times per year for finished products		-0,0441	-0,1178	-0,1853	-0,2241		0,02554	0,035	0,03113	0,03126
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0434	0,01458	0,02865	0,03525		0,0293	0,02418	0,00634	0,00196
Inventory KPI's											
Average inventory	Average of finished products		-0,0464	-0,1353	-0,2311	-0,2967		0,02361	0,02827	0,02069	0,01699
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0	-0,0301	-0,048	-0,0777		0	0	0	0
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,1557	-0,1246	-0,1415	-0,1611		-0,0465	-0,0562	-0,0697	-0,0702
Max inbound	Maximum inbound of materials/products		-0,1578	-0,153	-0,1595	-0,1736		-0,0428	-0,029	-0,0434	-0,0423
Inbound frequency	Number of inbounds of materials/products		-0,1289	-0,0876	-0,0855	-0,0851		-0,0471	-0,051	-0,0587	-0,055
Average outbound	Average outbound of finished products		0	0	0	0		-0,0464	-0,0329	-0,035	-0,0388
Max outbound	Maximum outbound of finished products		0	0	0	0		0,00854	0,04342	0,02364	0,02586
Outbound frequency	Number of outbounds of finished products		0	0	0	0		-0,0431	-0,0263	-0,0243	-0,024
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,1563	-0,1248	-0,1418	-0,1612		-0,0465	-0,0562	-0,0697	-0,0702
Max orders	Maximum order quantity		-0,1576	-0,153	-0,1597	-0,1734		-0,0428	-0,029	-0,0434	-0,0423
Order frequency	Number of orders		-0,1294	-0,0878	-0,0857	-0,0852		-0,0471	-0,051	-0,0587	-0,055
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,121	-0,0374	0,03132	0,06874		0	0	0	0
	By percentage of days without any backlogs		-0,119	-0,075	-0,0133	0,04026		0	0	0	0
Inventory turnover	Times per year for finished products		0,30088	-0,0203	-0,1746	-0,1946		0,04942	0,01681	0,03544	0,0385
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,08977	0,1211	0,16756	0,18376		-0,033	0,0006	-0,0211	-0,0445
Inventory KPI's											
Average inventory	Average of finished products		0,22971	-0,0317	-0,271	-0,3674		0,05299	0,01255	0,02079	0,02668
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,05998	0,06729	-0,1228	-0,2108		0,02944	0,03622	0,02703	0,00946
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,35323	0,31022	0,32826	0,34043		-0,0077	0,03943	0,0318	0,01585
Max inbound	Maximum inbound of materials/products		0,05456	0,10211	0,13994	0,15254		-0,0108	0,08588	0,06962	0,04065
Inbound frequency	Number of inbounds of materials/products		0,52597	0,46852	0,55036	0,56217		-0,0334	0,04463	0,04022	0,0121
Average outbound	Average outbound of finished products		0,05351	0,04219	0,028	0,01459		0,16273	0,13977	0,15201	0,15801
Max outbound	Maximum outbound of finished products		-0,0286	-0,0315	-0,0479	-0,0436		0,00041	0,00035	0,00042	0,00075
Outbound frequency	Number of outbounds of finished products		0,05801	0,04699	0,03216	0,01868		0,18984	0,1691	0,19864	0,2029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,35323	0,31022	0,32826	0,34043		-0,0077	0,03943	0,0318	0,01585
Max orders	Maximum order quantity		0,05456	0,10211	0,13994	0,15254		-0,0108	0,08588	0,06962	0,04065
Order frequency	Number of orders		0,52597	0,46852	0,55036	0,56217		-0,0334	0,04463	0,04022	0,0121
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,121	-0,0374	0,03132	0,06874		0	0	0	0
	By percentage of days without any backlogs		-0,119	-0,075	-0,0133	0,04026		0	0	0	0
Inventory turnover	Times per year for finished products		0,30088	-0,0203	-0,1746	-0,1946		0,04606	0,01199	0,03202	0,03424
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,08977	0,1211	0,16756	0,18376		-0,0135	-0,0071	-0,0084	-0,0351
Inventory KPI's											
Average inventory	Average of finished products		0,22971	-0,0317	-0,271	-0,3674		0,04992	0,0081	0,01762	0,02267
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,05998	0,06729	-0,1228	-0,2108		0,03239	0,01756	0,01551	0,00128
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,35323	0,31022	0,32826	0,34043		0,02701	0,06484	0,08798	0,07112
Max inbound	Maximum inbound of materials/products		0,05456	0,10211	0,13994	0,15254		-0,0144	0,10075	0,09311	0,06679
Inbound frequency	Number of inbounds of materials/products		0,52597	0,46852	0,55036	0,56217		0,00296	0,07668	0,10871	0,07407
Average outbound	Average outbound of finished products		0,05351	0,04219	0,028	0,01459		0,16273	0,13977	0,15201	0,15801
Max outbound	Maximum outbound of finished products		-0,0286	-0,0315	-0,0479	-0,0436		0,00041	0,00035	0,00042	0,00075
Outbound frequency	Number of outbounds of finished products		0,05801	0,04699	0,03216	0,01868		0,18984	0,1691	0,19864	0,2029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,35323	0,31022	0,32826	0,34043		0,02701	0,06484	0,08798	0,07112
Max orders	Maximum order quantity		0,05456	0,10211	0,13994	0,15254		-0,0144	0,10075	0,09311	0,06679
Order frequency	Number of orders		0,52597	0,46852	0,55036	0,56217		0,00296	0,07668	0,10871	0,07407
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0041	0,06251	0,10409	0,20148		0	0	0	0
	By percentage of days without any backlogs		-0,0075	0,04088	0,06809	0,16302		0	0	0	0
Inventory turnover	Times per year for finished products		-0,0132	-0,1436	-0,2246	-0,3785		0,05527	0,03624	0,04576	0,04647
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0172	0,0442	0,09139	0,17412		-0,0042	0,01463	0,01023	-0,0063
Inventory KPI's											
Average inventory	Average of finished products		-0,0135	-0,1711	-0,3209	-0,6454		0,05153	0,03001	0,03436	0,02628
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,009	0,02538	0,00711	-0,0967		0,03249	0,02528	0,0252	0,01155
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,00857	0,07308	0,14221	0,23267		-0,0196	0,02499	0,03661	0,05171
Max inbound	Maximum inbound of materials/products		-0,009	0,02813	0,05462	0,10436		-0,0217	0,06523	0,05965	0,06465
Inbound frequency	Number of inbounds of materials/products		0,01452	0,0945	0,19831	0,36938		-0,0334	0,02332	0,0407	0,0684
Average outbound	Average outbound of finished products		0,00791	-0,0015	-0,0026	-0,0214		0,00521	0,03738	0,0758	0,13147
Max outbound	Maximum outbound of finished products		0,00423	0,0306	0,01439	0,01247		0,00016	0,00013	0,00023	0,0005
Outbound frequency	Number of outbounds of finished products		0,00827	-0,0006	-0,0006	-0,0181		0,00686	0,04464	0,09368	0,17449
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,00857	0,07308	0,14221	0,23267		-0,0196	0,02499	0,03661	0,05171
Max orders	Maximum order quantity		-0,009	0,02813	0,05462	0,10436		-0,0217	0,06523	0,05965	0,06465
Order frequency	Number of orders		0,01452	0,0945	0,19831	0,36938		-0,0334	0,02332	0,0407	0,0684
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,0788	0,11069	0,19519	0,25087		0	0	0	0
	By percentage of days without any backlogs		0,07833	0,09766	0,16259	0,2121		0	0	0	0
Inventory turnover	Times per year for finished products		-0,147	-0,1942	-0,3064	-0,3924		0,05614	0,05135	0,05299	0,05802
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0745	-0,0315	0,06239	0,12695		-0,0064	-0,0016	0,00293	-0,0197
Inventory KPI's											
Average inventory	Average of finished products		-0,1719	-0,2411	-0,4542	-0,6743		0,04966	0,04392	0,04019	0,03913
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,0487	-0,027	0,00787	-0,0397		0,03269	0,02919	0,02859	0,01632
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,3157	-0,137	0,05698	0,14933		-0,0317	-0,0116	0,02576	0,02488
Max inbound	Maximum inbound of materials/products		-0,0482	-0,0264	0,02427	0,05449		-0,02	0,01083	0,03806	0,01896
Inbound frequency	Number of inbounds of materials/products		-0,2286	-0,1059	0,0927	0,22923		-0,0409	-0,0193	0,02735	0,03366
Average outbound	Average outbound of finished products		-0,0379	-0,0332	-0,0408	-0,0393		-0,1531	-0,0694	0,03924	0,09989
Max outbound	Maximum outbound of finished products		0,02511	0,04297	0,0554	0,04638		-0,0001	-6E-05	-2E-05	0,00011
Outbound frequency	Number of outbounds of finished products		-0,0356	-0,0311	-0,0366	-0,0349		-0,1296	-0,06	0,05256	0,12997
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,3157	-0,137	0,05698	0,14933		-0,0317	-0,0116	0,02576	0,02488
Max orders	Maximum order quantity		-0,0482	-0,0264	0,02427	0,05449		-0,02	0,01083	0,03806	0,01896
Order frequency	Number of orders		-0,2286	-0,1059	0,0927	0,22923		-0,0409	-0,0193	0,02735	0,03366
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,16697	0,28386	0,37326	0,42685		0	0	0	0
	By percentage of days without any backlogs		0,20012	0,28928	0,36722	0,41619		0	0	0	0
Inventory turnover	Times per year for finished products		-0,2473	-0,3843	-0,4744	-0,5315		0,05363	0,06019	0,06543	0,07185
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,003	0,09397	0,16693	0,21177		0,00888	-0,0102	-0,0216	-0,0343
Inventory KPI's											
Average inventory	Average of finished products		-0,3254	-0,632	-0,9273	-1,1774		0,04519	0,04514	0,04428	0,04437
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,007	0,03903	0,0387	-0,0385		0,03174	0,02619	0,02183	0,01469
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		-0,0308	0,20148	0,3097	0,35798		-0,0053	0,01411	0,03703	0,03979
Max inbound	Maximum inbound of materials/products		-0,007	0,04213	0,07768	0,0965		0,02297	0,02255	0,03431	0,00574
Inbound frequency	Number of inbounds of materials/products		-0,0097	0,29558	0,52182	0,66386		-0,0114	0,01561	0,04444	0,05504
Average outbound	Average outbound of finished products		-0,0345	-0,0395	-0,0484	-0,0541		-0,0116	0,11745	0,1919	0,2301
Max outbound	Maximum outbound of finished products		0,05703	0,09368	0,09253	0,07883		0,00011	-1E-04	0,00012	0,00029
Outbound frequency	Number of outbounds of finished products		-0,0337	-0,0367	-0,0439	-0,0481		-0,0049	0,14849	0,26214	0,3335
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		-0,0308	0,20148	0,3097	0,35798		-0,0053	0,01411	0,03703	0,03979
Max orders	Maximum order quantity		-0,007	0,04213	0,07768	0,0965		0,02297	0,02255	0,03431	0,00574
Order frequency	Number of orders		-0,0097	0,29558	0,52182	0,66386		-0,0114	0,01561	0,04444	0,05504
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0225	-0,0091	-0,0042	0,0009		0	0	0	0
	By percentage of days without any backlogs		-0,0219	-0,01	-0,0045	0,00042		4E-05	0,00052	0,00249	0,0039
Inventory turnover	Times per year for finished products		0,10874	-0,0145	-0,1788	-0,2542		0,00905	0,01151	0,07507	0,11921
	Times per year for materials							-0,0012	0,00597	0,03429	0,05586
Bullwhip Effect	Amplification on weekly level		0,00144	0,00833	0,03745	0,05664		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,09789	-0,0278	-0,2776	-0,4835		0,01012	0,00516	0,03373	0,04931
	Average of materials							-8E-07	1,7E-07	1,9E-06	3,4E-06
Max inventory	Maximum of finished products		0,05482	-0,1095	-0,5477	-0,8521		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,00381	0,00322	0,00449	0,00444		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,01662	0,01369	0,01857	0,01857		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,0013	0,01472	0,07124	0,11347		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00509	0,0013	-0,0005	-0,0014		0,00178	7,1E-06	-0,0054	-0,0098
Max outbound	Maximum outbound of finished products		0,01597	-0,0011	-0,0196	-0,0247		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00542	0,00132	-0,0003	-0,0008		0,00052	0,00585	0,02832	0,0451
Production KPI's											
Average production	Average production quantity							0,01612	0,01099	0,02815	0,04016
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							0,01497	0,01697	0,06089	0,09167
Ordering KPI's											
Average orders	Average order quantity		0,00381	0,00322	0,00449	0,00444		#######	#######	#######	#######
Max orders	Maximum order quantity		0,01662	0,01369	0,01857	0,01857		#######	#######	#######	#######
Order frequency	Number of orders		0,0013	0,01472	0,07124	0,11347		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1706	-0,1821	-0,1576	-0,0167		0	0	0	0
	By percentage of days without any backlogs		-0,1629	-0,1752	-0,1512	-0,0145		0,02054	0,02142	0,01994	0,00949
Inventory turnover	Times per year for finished products		0,68431	0,90528	0,74441	-0,2225		0,01436	-0,0152	-0,0209	-0,0129
	Times per year for materials							-0,0007	-0,0335	-0,0323	-0,0024
Bullwhip Effect	Amplification on weekly level		0,16574	0,14084	0,12718	0,0673		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,38007	0,41641	0,29604	-0,3606		0,01495	0,01849	0,01131	-0,0106
	Average of materials							-2E-06	-2E-06	-2E-06	1,8E-06
Max inventory	Maximum of finished products		0,09648	0,04058	-0,1619	-0,7239		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,43417	0,48367	0,45488	0,22549		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,10059	0,06768	0,08159	0,11156		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,80948	0,87878	0,81191	0,30815		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,03447	0,03809	0,03125	0,00808		0,29963	0,33567	0,31381	0,14064
Max outbound	Maximum outbound of finished products		-0,0019	0,00156	-0,021	-0,0613		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,03661	0,03845	0,03116	0,0077		0,44693	0,48519	0,44827	0,17013
Production KPI's											
Average production	Average production quantity							0,30192	0,33941	0,31772	0,14318
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							0,4528	0,49532	0,45834	0,17431
Ordering KPI's											
Average orders	Average order quantity		0,43417	0,48367	0,45488	0,22549		#######	#######	#######	#######
Max orders	Maximum order quantity		0,10059	0,06768	0,08159	0,11156		#######	#######	#######	#######
Order frequency	Number of orders		0,80948	0,87878	0,81191	0,30815		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1782	-0,0463	-0,0066	0,00334		0	0	0	0
	By percentage of days without any backlogs		-0,1666	-0,0437	-0,0052	0,00517		0,00825	0,00364	0,00664	0,0059
Inventory turnover	Times per year for finished products		0,61841	0,06847	-0,1209	-0,2038		0,00362	-0,0094	0,00311	0,00236
	Times per year for materials							-0,0026	-0,0135	0,01506	0,0086
Bullwhip Effect	Amplification on weekly level		0,06471	0,0339	0,12485	0,11334		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,36945	0,05104	-0,1694	-0,3182		0,00634	0,00402	-0,0121	-0,0065
	Average of materials							-2E-06	-2E-07	6,5E-07	1,2E-06
Max inventory	Maximum of finished products		0,07216	-0,0608	-0,3268	-0,5635		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,23276	0,12986	0,16239	0,15218		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0095	0,062	0,13633	0,14467		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,29924	0,12255	0,23164	0,20257		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,03032	0,0123	0,00487	-0,0013		0,16788	0,08597	0,12063	0,11086
Max outbound	Maximum outbound of finished products		-0,0324	-0,0294	-0,0531	-0,0846		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,03186	0,01105	0,00561	-0,0005		0,2014	0,08248	0,15591	0,13634
Production KPI's											
Average production	Average production quantity							0,16094	0,08357	0,1197	0,11261
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							0,19177	0,08006	0,15453	0,13846
Ordering KPI's											
Average orders	Average order quantity		0,23276	0,12986	0,16239	0,15218		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0095	0,062	0,13633	0,14467		#######	#######	#######	#######
Order frequency	Number of orders		0,29924	0,12255	0,23164	0,20257		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0917	-0,0216	0,02015	0,04329		0	0	0	0
	By percentage of days without any backlogs		-0,0882	-0,0236	0,01907	0,04041		9,6E-05	0,00112	0,00365	0,00563
Inventory turnover	Times per year for finished products		0,27237	-0,0052	-0,1794	-0,2933		-0,0041	0,00315	-9E-05	0,00937
	Times per year for materials							-0,0031	0,00492	0,01024	0,01717
Bullwhip Effect	Amplification on weekly level		-0,0321	0,0249	0,10019	0,15823		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,20909	-0,0129	-0,2426	-0,4533		-0,0009	-0,0017	-0,0105	-0,0081
	Average of materials							-8E-07	2,8E-08	8,6E-07	1,6E-06
Max inventory	Maximum of finished products		0,01847	-0,0534	-0,3339	-0,5511		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,00781	0,02705	0,1016	0,15279		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0455	0,04898	0,12459	0,17374		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,00301	0,0382	0,13798	0,22072		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,01653	0,00476	-0,0024	-0,008		0,00478	0,02255	0,08145	0,12477
Max outbound	Maximum outbound of finished products		-0,0207	-0,0395	-0,0859	-0,1022		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,01664	0,00551	-0,0019	-0,0073		0,00221	0,02801	0,10117	0,16184
Production KPI's											
Average production	Average production quantity							-8E-05	0,02909	0,0869	0,12688
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							-0,0026	0,03473	0,10774	0,16392
Ordering KPI's											
Average orders	Average order quantity		0,00781	0,02705	0,1016	0,15279		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0455	0,04898	0,12459	0,17374		#######	#######	#######	#######
Order frequency	Number of orders		0,00301	0,0382	0,13798	0,22072		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0377	0,05725	0,08372	0,09843		0	0	0	0
	By percentage of days without any backlogs		-0,0356	0,05261	0,07876	0,09542		0,00456	0,00756	0,00878	0,01034
Inventory turnover	Times per year for finished products		0,04756	-0,2412	-0,3603	-0,4114		-0,0053	0,01011	0,00138	0,01449
	Times per year for materials							-0,0055	0,01509	0,01528	0,02203
Bullwhip Effect	Amplification on weekly level		0,09525	0,19077	0,23169	0,26528		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,03224	-0,3372	-0,5995	-0,755		0,00024	-0,0052	-0,0142	-0,0079
	Average of materials							-1E-07	1E-06	1,9E-06	2,3E-06
Max inventory	Maximum of finished products		0,02248	-0,2192	-0,4677	-0,6344		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,15097	0,20495	0,23979	0,27213		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,09428	0,17573	0,23555	0,26445		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,16496	0,29476	0,35634	0,43287		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,01236	-8E-05	-0,0079	-0,0109		0,1087	0,15989	0,18819	0,21798
Max outbound	Maximum outbound of finished products		-0,0446	-0,0769	-0,1144	-0,1194		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,01273	0,00064	-0,0074	-0,0099		0,11697	0,20902	0,25269	0,30696
Production KPI's											
Average production	Average production quantity							0,09948	0,16141	0,18992	0,21457
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							0,10561	0,21105	0,25533	0,30052
Ordering KPI's											
Average orders	Average order quantity		0,15097	0,20495	0,23979	0,27213		#######	#######	#######	#######
Max orders	Maximum order quantity		0,09428	0,17573	0,23555	0,26445		#######	#######	#######	#######
Order frequency	Number of orders		0,16496	0,29476	0,35634	0,43287		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

Annex XIX: Normative deviations of FAD KPI values as percentage of the empirical nullcase

4536827 and 4536835		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0561	-0,0178	0,02792	0,01299		-8E-05	0,00063	0,00039	0,0009
	By percentage of days without any backlogs		-0,0648	-0,0207	0,03114	0,01418		-0,0005	0,00094	0,00099	0,00174
Inventory turnover	Times per year for finished products		0,3041	0,09744	-0,1541	-0,1037		0,0332	0,01861	0,00751	0,01293
	Times per year for materials							0,01468	0,00474	0,00439	0,00147
Bullwhip Effect	Amplification on weekly level		0,42792	0,18307	0,11563	0,1481		-0,4899	-0,1912	-0,1183	-0,1716
Inventory KPI's											
Average inventory	Average of finished products		0,23209	0,08578	-0,1895	-0,1412		0,03379	0,01786	0,0011	0,00885
	Average of materials							0,01649	0,00479	-0,0026	-0,0021
Max inventory	Maximum of finished products		0,20191	-0,0032	-0,4303	-0,3518		0,06376	0,01366	0,00586	0,01845
	Maximum of materials							-0,0048	0,00431	0,00569	0,00406
Average inbound	Average inbound of materials/products		0,26935	0,16389	0,10426	0,12461		-0,0081	-0,0209	-0,0205	-0,0222
Max inbound	Maximum inbound of materials/products		0,14175	0,01219	-0,0093	0,03143		0,01862	0,00482	-0,0044	0,00068
Inbound frequency	Number of inbounds of materials/products		0,36596	0,19849	0,13003	0,15303		-0,0159	-0,0171	-0,0106	-0,0165
Average outbound	Average outbound of finished products		-0,0326	-0,0085	0,01914	0,00967		0,12849	0,07212	0,04243	0,05219
Max outbound	Maximum outbound of finished products		0,03808	0,02361	0,09546	0,07653		0,11147	0,01207	-0,0093	0,03107
Outbound frequency	Number of outbounds of finished products		-0,0305	-0,0077	0,0198	0,01052		0,14602	0,07859	0,0514	0,0599
Production KPI's											
Average production	Average production quantity							0,04002	0,00364	0,003	0,0103
Max production	Maximum production quantity							0,0643	0,01888	0,01772	0,02779
Production frequency	Number of production runs							0,03731	0,00211	0,01006	0,01345
Ordering KPI's											
Average orders	Average order quantity		0,26991	0,16466	0,10503	0,12549		-0,0081	-0,0209	-0,0205	-0,0222
Max orders	Maximum order quantity		0,14168	0,01239	-0,0089	0,03115		0,01862	0,00482	-0,0044	0,00068
Order frequency	Number of orders		0,36706	0,19966	0,13106	0,15424		-0,0159	-0,0171	-0,0106	-0,0165
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0537	-0,018	0,02868	0,01388		-0,1082	-0,0869	-0,0802	-0,0813
	By percentage of days without any backlogs		-0,0624	-0,0207	0,03181	0,01498		-0,2268	-0,2046	-0,186	-0,1957
Inventory turnover	Times per year for finished products		0,2951	0,09692	-0,1562	-0,1095		2,69202	2,61704	2,60172	2,60994
	Times per year for materials							1,86578	1,76505	1,63423	1,68018
Bullwhip Effect	Amplification on weekly level		0,41864	0,18199	0,1143	0,14688		0,48472	0,54813	0,52339	0,52862
Inventory KPI's											
Average inventory	Average of finished products		0,22666	0,0853	-0,1929	-0,1485		0,7297	0,72352	0,72064	0,72198
	Average of materials							0,65197	0,63865	0,61833	0,62592
Max inventory	Maximum of finished products		0,20012	0,00493	-0,431	-0,3677		0,55094	0,45238	0,44995	0,49207
	Maximum of materials							0,61667	0,62464	0,61796	0,62895
Average inbound	Average inbound of materials/products		0,28672	0,17911	0,11548	0,13841		0,7654	0,76002	0,75121	0,75778
Max inbound	Maximum inbound of materials/products		0,16427	0,02963	0,00088	0,04078		0,65234	0,64111	0,63342	0,65023
Inbound frequency	Number of inbounds of materials/products		0,39998	0,22097	0,14531	0,1721		3,05656	2,98588	2,8809	2,9685
Average outbound	Average outbound of finished products		-0,0303	-0,0079	0,0199	0,01058		0,26767	0,21206	0,17857	0,1939
Max outbound	Maximum outbound of finished products		0,04391	0,02775	0,10147	0,08369		0,15216	0,0085	-0,0224	0,03066
Outbound frequency	Number of outbounds of finished products		-0,0283	-0,0071	0,02059	0,0114		0,36462	0,27116	0,22653	0,24721
Production KPI's											
Average production	Average production quantity							0,7207	0,69985	0,68681	0,69347
Max production	Maximum production quantity							0,51862	0,40922	0,4095	0,45799
Production frequency	Number of production runs							2,51103	2,27541	2,15779	2,22063
Ordering KPI's											
Average orders	Average order quantity		0,26695	0,1635	0,10367	0,12448		0,7654	0,76002	0,75121	0,75778
Max orders	Maximum order quantity		0,13146	0,01315	-0,0115	0,03053		0,65234	0,64111	0,63342	0,65023
Order frequency	Number of orders		0,36156	0,19827	0,12968	0,15318		3,05656	2,98588	2,8809	2,9685
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0534	-0,021	0,03155	0,01867		-0,1086	-0,0928	-0,087	-0,0843
	By percentage of days without any backlogs		-0,062	-0,0257	0,03465	0,02008		-0,2283	-0,2078	-0,1937	-0,1935
Inventory turnover	Times per year for finished products		0,29546	0,13651	-0,1469	-0,1021		2,69334	2,63215	2,6285	2,61535
	Times per year for materials							1,87494	1,81405	1,68393	1,73847
Bullwhip Effect	Amplification on weekly level		0,42214	0,2522	0,18335	0,20118		0,48237	0,52411	0,51189	0,52248
Inventory KPI's											
Average inventory	Average of finished products		0,22691	0,11718	-0,1795	-0,1343		0,7298	0,72478	0,7227	0,72232
	Average of materials							0,65309	0,64515	0,62546	0,63379
Max inventory	Maximum of finished products		0,20076	0,05053	-0,4	-0,3251		0,55084	0,4646	0,48376	0,5093
	Maximum of materials							0,61584	0,6309	0,63132	0,62845
Average inbound	Average inbound of materials/products		0,28823	0,20935	0,1484	0,16236		0,76517	0,76048	0,75431	0,75991
Max inbound	Maximum inbound of materials/products		0,1643	0,08291	0,05968	0,08752		0,65174	0,64677	0,65393	0,65875
Inbound frequency	Number of inbounds of materials/products		0,40289	0,26637	0,18921	0,20539		3,05259	2,98866	2,92977	3,00305
Average outbound	Average outbound of finished products		-0,03	-0,0095	0,0217	0,01386		0,26925	0,22636	0,19948	0,20231
Max outbound	Maximum outbound of finished products		0,04373	0,04732	0,11499	0,09045		0,15241	0,05772	0,04021	0,07548
Outbound frequency	Number of outbounds of finished products		-0,0282	-0,0086	0,02252	0,01465		0,36758	0,29399	0,25855	0,26034
Production KPI's											
Average production	Average production quantity							0,72009	0,70369	0,69372	0,69488
Max production	Maximum production quantity							0,51851	0,4204	0,44725	0,47643
Production frequency	Number of production runs							2,50339	2,31599	2,22889	2,2354
Ordering KPI's											
Average orders	Average order quantity		0,26853	0,19461	0,13865	0,1492		0,76517	0,76048	0,75431	0,75991
Max orders	Maximum order quantity		0,13162	0,06382	0,0482	0,07027		0,65174	0,64677	0,65393	0,65875
Order frequency	Number of orders		0,36445	0,24315	0,1754	0,18622		3,05259	2,98866	2,92977	3,00305
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0541	-0,0527	-0,0391	-0,036		-0,1073	-0,1047	-0,1025	-0,1049
	By percentage of days without any backlogs		-0,0625	-0,0604	-0,0416	-0,037		-0,2263	-0,2227	-0,219	-0,2129
Inventory turnover	Times per year for finished products		0,29744	0,28876	0,13179	0,1038		2,68802	2,68778	2,70275	2,71431
	Times per year for materials							1,88073	1,88384	1,92354	1,94141
Bullwhip Effect	Amplification on weekly level		0,4278	0,44328	0,55679	0,59812		0,48038	0,47837	0,44693	0,44157
Inventory KPI's											
Average inventory	Average of finished products		0,22808	0,2227	0,11223	0,08728		0,72939	0,72936	0,72953	0,73047
	Average of materials							0,65385	0,65431	0,65786	0,66011
Max inventory	Maximum of finished products		0,20685	0,20626	0,047	0,05606		0,55321	0,55929	0,57848	0,58586
	Maximum of materials							0,62417	0,635	0,6312	0,63361
Average inbound	Average inbound of materials/products		0,28918	0,2921	0,33015	0,34486		0,76568	0,76735	0,77006	0,77064
Max inbound	Maximum inbound of materials/products		0,16808	0,17262	0,18707	0,19275		0,66131	0,6779	0,67775	0,67948
Inbound frequency	Number of inbounds of materials/products		0,40496	0,41036	0,49926	0,53172		3,06127	3,09397	3,15279	3,15756
Average outbound	Average outbound of finished products		-0,0305	-0,0293	-0,0194	-0,0175		0,27074	0,27508	0,29832	0,30482
Max outbound	Maximum outbound of finished products		0,04249	0,04425	0,05458	0,05162		0,15922	0,16636	0,17716	0,18744
Outbound frequency	Number of outbounds of finished products		-0,0285	-0,0274	-0,0181	-0,0162		0,37044	0,37872	0,4293	0,44195
Production KPI's											
Average production	Average production quantity							0,72074	0,72287	0,73323	0,73619
Max production	Maximum production quantity							0,52102	0,52753	0,55414	0,56398
Production frequency	Number of production runs							2,51179	2,53888	2,69158	2,72861
Ordering KPI's											
Average orders	Average order quantity		0,2721	0,27989	0,32151	0,3377		0,76568	0,76735	0,77006	0,77064
Max orders	Maximum order quantity		0,13474	0,13599	0,14659	0,1512		0,66131	0,6779	0,67775	0,67948
Order frequency	Number of orders		0,37133	0,3863	0,48003	0,51504		3,06127	3,09397	3,15279	3,15756
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536827 and 4536835		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,03872	0,05541	0,06094	0,06377		-0,1656	-0,1468	-0,1429	-0,1408
	By percentage of days without any backlogs		0,03482	0,0557	0,06285	0,06704		-0,3078	-0,2823	-0,2748	-0,2742
Inventory turnover	Times per year for finished products		0,10739	0,00227	-0,0242	-0,0615		2,43801	2,45359	2,46207	2,47993
	Times per year for materials							2,46367	2,86071	2,99509	3,02453
Bullwhip Effect	Amplification on weekly level		0,37762	0,51597	0,57042	0,58909		0,33877	0,31343	0,29218	0,29307
Inventory KPI's											
Average inventory	Average of finished products		0,09789	0,00029	-0,0291	-0,0722		0,70912	0,70975	0,7103	0,71198
	Average of materials							0,70851	0,73864	0,74775	0,74977
Max inventory	Maximum of finished products		0,10748	0,05455	0,05453	0,01042		0,28811	0,3084	0,32357	0,33108
	Maximum of materials							0,45707	0,50776	0,52739	0,53297
Average inbound	Average inbound of materials/products		0,35463	0,38048	0,39071	0,3941		0,7138	0,72157	0,72485	0,7254
Max inbound	Maximum inbound of materials/products		0,06805	0,13333	0,16658	0,17483		0,45311	0,50837	0,53468	0,53716
Inbound frequency	Number of inbounds of materials/products		0,55094	0,62206	0,65043	0,658		2,33621	2,4252	2,46068	2,4685
Average outbound	Average outbound of finished products		0,03444	0,0442	0,04751	0,04905		0,18189	0,20109	0,20948	0,2128
Max outbound	Maximum outbound of finished products		0,21241	0,25793	0,26653	0,26989		-0,1091	-0,0494	-0,0216	-0,0119
Outbound frequency	Number of outbounds of finished products		0,03544	0,046	0,04961	0,05126		0,22199	0,25473	0,26872	0,27335
Production KPI's											
Average production	Average production quantity							0,65211	0,66292	0,667	0,66898
Max production	Maximum production quantity							0,21594	0,23829	0,25503	0,26326
Production frequency	Number of production runs							1,82219	1,91947	1,95442	1,97114
Ordering KPI's											
Average orders	Average order quantity		0,25734	0,31158	0,32922	0,33439		0,7138	0,72157	0,72485	0,7254
Max orders	Maximum order quantity		0,05799	0,10508	0,12956	0,13314		0,45311	0,50837	0,53468	0,53716
Order frequency	Number of orders		0,34545	0,45823	0,49809	0,50813		2,33621	2,4252	2,46068	2,4685
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0027	-0,0022	0,00234	0,00529		0	0	0	0
	By percentage of days without any backlogs		-0,0021	-0,0015	0,00239	0,00526		0,00018	0,00014	0,00021	0,00022
Inventory turnover	Times per year for finished products		0,09568	-0,0368	-0,2012	-0,2691		0,02749	0,02192	0,03237	0,03827
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,0596	0,03752	0,05244	0,0558		-0,0042	-0,008	-0,0083	-0,0046
Inventory KPI's											
Average inventory	Average of finished products		0,09069	-0,0431	-0,2688	-0,3966		0,0273	0,02013	0,02811	0,03324
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,15575	-0,0385	-0,3251	-0,5067		0,00181	0,00332	0,01165	0,01656
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,06532	0,03284	0,03975	0,04307		0,01621	0,01722	0,01757	0,01823
Max inbound	Maximum inbound of materials/products		0,31217	0,14572	0,18516	0,19452		0	0,01175	0,01775	0,029
Inbound frequency	Number of inbounds of materials/products		0,05836	0,04405	0,06732	0,07168		0,00362	0,00313	0,00675	0,00725
Average outbound	Average outbound of finished products		0,00025	-0,0006	0,00016	0,00125		0,00966	0,00593	0,00823	0,00879
Max outbound	Maximum outbound of finished products		0,00494	0,0015	-0,003	-0,0001		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00022	-0,0006	0,00013	0,00112		0,00919	0,00694	0,0106	0,01129
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,06532	0,03284	0,03975	0,04307		0,01621	0,01722	0,01757	0,01823
Max orders	Maximum order quantity		0,31217	0,14572	0,18516	0,19452		0	0,01175	0,01775	0,029
Order frequency	Number of orders		0,05836	0,04405	0,06732	0,07168		0,00362	0,00313	0,00675	0,00725
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0614	-0,0682	-0,0565	-0,0422		0	0	0	0
	By percentage of days without any backlogs		-0,055	-0,0621	-0,052	-0,0392		0,00377	0,00352	0,00314	0,00244
Inventory turnover	Times per year for finished products		0,55877	0,36088	0,10532	-0,1264		0,62445	0,58424	0,58937	0,57986
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,31547	0,26005	0,2482	0,21514		0,4372	0,42502	0,42879	0,43227
Inventory KPI's											
Average inventory	Average of finished products		0,35583	0,26106	0,07315	-0,1711		0,38721	0,37175	0,37334	0,36811
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,29136	0,13563	-0,161	-0,4038		0,33791	0,32743	0,32884	0,33156
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,61016	0,59024	0,55183	0,47327		0,72401	0,72064	0,72007	0,72301
Max inbound	Maximum inbound of materials/products		0,40856	0,31952	0,33349	0,30792		0,45481	0,46088	0,46256	0,46406
Inbound frequency	Number of inbounds of materials/products		1,50572	1,39012	1,21715	0,89535		2,42725	2,3805	2,3755	2,41938
Average outbound	Average outbound of finished products		-0,0131	-0,0171	-0,0151	-0,0125		0,19215	0,18008	0,16053	0,12326
Max outbound	Maximum outbound of finished products		-0,0098	-0,0254	-0,0231	-0,0243		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0128	-0,0165	-0,0146	-0,0121		0,23709	0,21888	0,19165	0,14098
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,61016	0,59024	0,55183	0,47327		0,72401	0,72064	0,72007	0,72301
Max orders	Maximum order quantity		0,40856	0,31952	0,33349	0,30792		0,45481	0,46088	0,46256	0,46406
Order frequency	Number of orders		1,50572	1,39012	1,21715	0,89535		2,42725	2,3805	2,3755	2,41938
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0719	-0,0622	-0,0656	-0,0477		0	0	0	0
	By percentage of days without any backlogs		-0,0647	-0,0555	-0,0602	-0,0428		0,00437	0,00383	0,00434	0,00421
Inventory turnover	Times per year for finished products		0,63668	0,45586	0,33447	0,06118		0,63757	0,61107	0,61213	0,61133
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,36129	0,3761	0,40256	0,42119		0,43634	0,43011	0,43346	0,43674
Inventory KPI's											
Average inventory	Average of finished products		0,38881	0,31337	0,24526	0,04835		0,39256	0,38076	0,38227	0,38095
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,29164	0,28224	0,13958	-0,0931		0,33779	0,32831	0,33202	0,33298
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,66132	0,61206	0,65379	0,63965		0,72145	0,71999	0,71953	0,71991
Max inbound	Maximum inbound of materials/products		0,41928	0,41364	0,43623	0,4633		0,45431	0,44894	0,4555	0,46613
Inbound frequency	Number of inbounds of materials/products		1,79617	1,51717	1,77962	1,70557		2,38838	2,3895	2,36913	2,37975
Average outbound	Average outbound of finished products		-0,0149	-0,0173	-0,018	-0,0131		0,22275	0,19349	0,22017	0,21236
Max outbound	Maximum outbound of finished products		-0,0091	-0,0279	-0,0257	-0,0236		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0146	-0,0167	-0,0175	-0,0127		0,28282	0,23889	0,28021	0,26856
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,66132	0,61206	0,65379	0,63965		0,72145	0,71999	0,71953	0,71991
Max orders	Maximum order quantity		0,41928	0,41364	0,43623	0,4633		0,45431	0,44894	0,4555	0,46613
Order frequency	Number of orders		1,79617	1,51717	1,77962	1,70557		2,38838	2,3895	2,36913	2,37975
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0526	-0,0658	-0,0551	-0,0484		0	0	0	0
	By percentage of days without any backlogs		-0,0468	-0,0585	-0,05	-0,044		0,00413	0,00474	0,00555	0,00578
Inventory turnover	Times per year for finished products		0,53941	0,54414	0,35907	0,17678		0,62908	0,62551	0,62075	0,61931
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,36637	0,4093	0,48871	0,51056		0,4378	0,43354	0,43749	0,43803
Inventory KPI's											
Average inventory	Average of finished products		0,35161	0,35235	0,26299	0,14703		0,38913	0,38674	0,38481	0,38421
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,29201	0,30179	0,22848	0,07965		0,33765	0,32983	0,3335	0,33475
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,64493	0,67649	0,71982	0,73062		0,72212	0,71705	0,71928	0,71865
Max inbound	Maximum inbound of materials/products		0,42059	0,42059	0,451	0,4635		0,45419	0,45025	0,45219	0,46869
Inbound frequency	Number of inbounds of materials/products		1,66625	1,98756	2,45358	2,59121		2,4005	2,35588	2,3795	2,365
Average outbound	Average outbound of finished products		-0,0109	-0,0166	-0,0148	-0,0131		0,2104	0,23947	0,2796	0,2907
Max outbound	Maximum outbound of finished products		0,0072	-0,0182	-0,0087	-0,0089		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0107	-0,016	-0,0143	-0,0126		0,26236	0,31296	0,38634	0,40801
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,64493	0,67649	0,71982	0,73062		0,72212	0,71705	0,71928	0,71865
Max orders	Maximum order quantity		0,42059	0,42059	0,451	0,4635		0,45419	0,45025	0,45219	0,46869
Order frequency	Number of orders		1,66625	1,98756	2,45358	2,59121		2,4005	2,35588	2,3795	2,365
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4255030		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0525	-0,0486	-0,0412	-0,0348		0	0	0	0
	By percentage of days without any backlogs		-0,0464	-0,0434	-0,0372	-0,0319		0,00493	0,00584	0,00589	0,00623
Inventory turnover	Times per year for finished products		0,68893	0,47004	0,23914	0,11521		0,61843	0,61843	0,61807	0,62182
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,43884	0,51508	0,53138	0,56205		0,43648	0,43637	0,43853	0,44015
Inventory KPI's											
Average inventory	Average of finished products		0,40971	0,31977	0,19082	0,09859		0,38484	0,384	0,38362	0,38493
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,39198	0,29044	0,12309	0,02517		0,3366	0,33427	0,33531	0,33411
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,69249	0,73405	0,73534	0,7501		0,72103	0,71876	0,71918	0,71922
Max inbound	Maximum inbound of materials/products		0,4493	0,47557	0,49188	0,52383		0,4555	0,44875	0,46788	0,47425
Inbound frequency	Number of inbounds of materials/products		2,09072	2,62929	2,66202	2,88527		2,3875	2,37175	2,37725	2,37038
Average outbound	Average outbound of finished products		-0,0087	-0,0072	-0,0065	-0,0049		0,2498	0,29384	0,29622	0,31311
Max outbound	Maximum outbound of finished products		0,02268	0,02257	0,02268	0,01687		0	0	0	0
Outbound frequency	Number of outbounds of finished products		-0,0086	-0,0072	-0,0064	-0,0049		0,3292	0,414	0,41916	0,45431
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,69249	0,73405	0,73534	0,7501		0,72103	0,71876	0,71918	0,71922
Max orders	Maximum order quantity		0,4493	0,47557	0,49188	0,52383		0,4555	0,44875	0,46788	0,47425
Order frequency	Number of orders		2,09072	2,62929	2,66202	2,88527		2,3875	2,37175	2,37725	2,37038
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00512	0,00795	0,01213	0,01477		3,8E-06	6,8E-06	1,3E-05	6,8E-06
	By percentage of days without any backlogs		0,00522	0,00764	0,01173	0,01443		9,6E-06	1E-05	2,1E-05	1,1E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0953	-0,2072	-0,2799		-0,0069	-0,0117	-0,0024	0,00268
	Times per year for materials							0,0006	0,00202	0,00607	0,00808
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08586	0,10776		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,0499	-0,1052	-0,2652	-0,4052		-0,0076	-0,0138	-0,0084	-0,0055
	Average of materials							1,8E-05	3,8E-05	8,2E-05	0,00012
Max inventory	Maximum of finished products		-0,0025	-0,087	-0,4653	-0,654		-0,0165	-0,014	-0,0126	-0,0099
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1553	-0,1534	-0,1034	-0,1057		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0416	-0,0309	-0,0201	-0,0059		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,1331	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00145	0,00299	0,00527	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0004	0,02552	0,05311	0,06586		-0,0041	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00146	0,00295	0,00524	0,00616		-0,0665	-0,0647	-0,0416	-0,0406
Production KPI's											
Average production	Average production quantity							-0,0132	-0,0111	-0,005	-0,0006
Max production	Maximum production quantity							-0,0119	-0,0087	-0,0063	-0,0067
Production frequency	Number of production runs							-0,013	-0,0093	-8E-05	0,00578
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1533	-0,1033	-0,1057		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0416	-0,0309	-0,0201	-0,006		#######	#######	#######	#######
Order frequency	Number of orders		-0,1331	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00515	0,00795	0,01216	0,01477		-2E-05	5,2E-06	-5E-06	5,2E-06
	By percentage of days without any backlogs		0,00524	0,00764	0,01175	0,01443		-2E-05	1E-05	9,7E-08	1,1E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0954	-0,2072	-0,2799		2,02821	2,03053	2,03775	2,04124
	Times per year for materials							0,0003	0,00172	0,00576	0,00778
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08595	0,10776		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,05	-0,1052	-0,2653	-0,4052		0,66987	0,66966	0,66913	0,66886
	Average of materials							-0,0003	-0,0003	-0,0002	-0,0002
Max inventory	Maximum of finished products		-0,0026	-0,087	-0,4653	-0,654		0,47231	0,47289	0,47253	0,47294
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1552	-0,1534	-0,1033	-0,1057		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0417	-0,0309	-0,02	-0,0059		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,133	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00147	0,003	0,00528	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0002	0,02552	0,0532	0,06586		-0,0043	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00147	0,00296	0,00526	0,00616		-0,0665	-0,0647	-0,0415	-0,0406
Production KPI's											
Average production	Average production quantity							0,71943	0,71965	0,72608	0,7258
Max production	Maximum production quantity							0,50603	0,50803	0,50737	0,50777
Production frequency	Number of production runs							2,49481	2,5023	2,59919	2,60312
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1533	-0,1033	-0,1057		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0418	-0,0309	-0,0201	-0,006		#######	#######	#######	#######
Order frequency	Number of orders		-0,133	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00528	0,01402	0,01351	0,02061		-2E-05	3,7E-06	-1E-05	-2E-06
	By percentage of days without any backlogs		0,00534	0,01309	0,01301	0,01958		-2E-05	-3E-06	-1E-05	-4E-06
Inventory turnover	Times per year for finished products		-0,0496	-0,198	-0,2559	-0,4039		2,0373	2,05536	2,06082	2,06085
	Times per year for materials							0,0003	0,00524	0,00901	0,00837
Bullwhip Effect	Amplification on weekly level		-0,0656	-0,5314	-0,4498	-0,5518		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,0515	-0,2468	-0,3535	-0,6931		0,67086	0,67121	0,67058	0,67082
	Average of materials							-0,0003	-0,0002	-0,0002	-1E-04
Max inventory	Maximum of finished products		-0,0025	-0,3371	-0,563	-1,0789		0,47231	0,42154	0,42972	0,42703
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1769	-0,5509	-0,4746	-0,5789		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0451	-0,4921	-0,4419	-0,4693		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,1489	-0,3477	-0,3074	-0,3548		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00151	0,00471	0,0045	0,00755		-0,0811	-0,2169	-0,1928	-0,226
Max outbound	Maximum outbound of finished products		0,00136	0,03205	0,03293	0,07837		-0,0052	-0,2459	-0,2132	-0,2295
Outbound frequency	Number of outbounds of finished products		0,00152	0,00463	0,00442	0,00744		-0,0744	-0,1737	-0,1536	-0,1773
Production KPI's											
Average production	Average production quantity							0,71952	0,6818	0,68883	0,67948
Max production	Maximum production quantity							0,50561	0,3899	0,40553	0,3964
Production frequency	Number of production runs							2,49586	2,09693	2,18051	2,08454
Ordering KPI's											
Average orders	Average order quantity		-0,1769	-0,5509	-0,4746	-0,5789		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0451	-0,4921	-0,4419	-0,4693		#######	#######	#######	#######
Order frequency	Number of orders		-0,1489	-0,3477	-0,3074	-0,3548		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,00515	0,00795	0,01216	0,01477		-2E-05	5,2E-06	-5E-06	5,2E-06
	By percentage of days without any backlogs		0,00524	0,00764	0,01175	0,01443		-2E-05	1E-05	9,7E-08	1,1E-05
Inventory turnover	Times per year for finished products		-0,0482	-0,0954	-0,2072	-0,2799		2,02821	2,03053	2,03775	2,04124
	Times per year for materials							0,0003	0,00172	0,00576	0,00778
Bullwhip Effect	Amplification on weekly level		-0,0441	-0,0253	0,08595	0,10776		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,05	-0,1052	-0,2653	-0,4052		0,66987	0,66966	0,66913	0,66886
	Average of materials							-0,0003	-0,0003	-0,0002	-0,0002
Max inventory	Maximum of finished products		-0,0026	-0,087	-0,4653	-0,654		0,47231	0,47289	0,47253	0,47294
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1552	-0,1534	-0,1033	-0,1057		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0417	-0,0309	-0,02	-0,0059		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,133	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00147	0,003	0,00528	0,00622		-0,0719	-0,0713	-0,0496	-0,0507
Max outbound	Maximum outbound of finished products		-0,0002	0,02552	0,0532	0,06586		-0,0043	-0,0002	-0,0015	-0,0007
Outbound frequency	Number of outbounds of finished products		0,00147	0,00296	0,00526	0,00616		-0,0665	-0,0647	-0,0415	-0,0406
Production KPI's											
Average production	Average production quantity							0,71943	0,71965	0,72608	0,7258
Max production	Maximum production quantity							0,50603	0,50803	0,50737	0,50777
Production frequency	Number of production runs							2,49481	2,5023	2,59919	2,60312
Ordering KPI's											
Average orders	Average order quantity		-0,1553	-0,1533	-0,1033	-0,1057		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0418	-0,0309	-0,0201	-0,006		#######	#######	#######	#######
Order frequency	Number of orders		-0,133	-0,1295	-0,0832	-0,0813		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4536553		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0,02795	0,02933	0,02973	0,03054		-0,0116	-0,0086	-0,0073	-0,0058
	By percentage of days without any backlogs		0,02603	0,02755	0,0279	0,02884		-0,0159	-0,0112	-0,01	-0,0079
Inventory turnover	Times per year for finished products		-0,1134	-0,224	-0,3046	-0,3235		2,04059	2,04817	2,05155	2,05075
	Times per year for materials							0,00027	0,00597	0,00821	0,00803
Bullwhip Effect	Amplification on weekly level		-0,0281	0,09516	0,11376	0,1683		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		-0,1253	-0,2897	-0,4494	-0,4974		0,67122	0,67019	0,66984	0,66982
	Average of materials							-0,0003	-0,0002	-0,0002	-0,0002
Max inventory	Maximum of finished products		0,01048	-0,353	-0,6094	-0,5897		0,46896	0,47095	0,47143	0,47121
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		-0,1081	-0,074	-0,0781	-0,071		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		-0,0162	0,00449	0,00421	0,03323		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		-0,0959	-0,0572	-0,0568	-0,0513		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,01102	0,01155	0,01146	0,01172		-0,051	-0,0359	-0,038	-0,0347
Max outbound	Maximum outbound of finished products		0,15849	0,16394	0,16515	0,16726		-0,0035	-0,0006	-0,0018	-0,0012
Outbound frequency	Number of outbounds of finished products		0,01083	0,01135	0,01126	0,01153		-0,0479	-0,0286	-0,0284	-0,0256
Production KPI's											
Average production	Average production quantity							0,71916	0,72594	0,72587	0,72769
Max production	Maximum production quantity							0,49181	0,4989	0,49989	0,50011
Production frequency	Number of production runs							2,49096	2,59814	2,60547	2,62857
Ordering KPI's											
Average orders	Average order quantity		-0,1434	-0,0975	-0,099	-0,0876		#######	#######	#######	#######
Max orders	Maximum order quantity		-0,0292	-0,0078	-0,007	0,02543		#######	#######	#######	#######
Order frequency	Number of orders		-0,1244	-0,0778	-0,0752	-0,0659		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		0,00667	0,01742	0,016	0,01861
	By percentage of days without any backlogs		0	0	0	0		0,00168	0,01346	0,01222	0,01308
Inventory turnover	Times per year for finished products		0,00136	-0,0547	-0,1715	-0,2159		0,0201	-0,1186	-0,0893	-0,0658
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		-0,0012	0,00669	0,02687	0,03214		0,00122	-0,0038	-0,0063	0,00195
Inventory KPI's											
Average inventory	Average of finished products		0,00122	-0,061	-0,214	-0,2908		0,02056	-0,1426	-0,1181	-0,0935
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		-0,0047	-0,14	-0,4051	-0,538		0,02534	-0,0547	-0,0377	-0,034
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,04568	0,01209	-0,0028	-0,004		0,02266	0,01826	0,0211	0,02259
Max inbound	Maximum inbound of materials/products		0	0	0	0		0,04501	0,04488	0,04896	0,05172
Inbound frequency	Number of inbounds of materials/products		0,04757	0,02716	0,04916	0,05764		0	0	0,00275	0,00575
Average outbound	Average outbound of finished products		0	0	0	0		-0,0012	-0,0126	-0,0157	-0,0177
Max outbound	Maximum outbound of finished products		0	0	0	0		-0,0338	-0,0458	-0,0477	-0,0477
Outbound frequency	Number of outbounds of finished products		0	0	0	0		-0,0017	-0,0095	-0,0035	-0,0029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0	0	0	0		0,02266	0,01826	0,0211	0,02259
Max orders	Maximum order quantity		0	0	0	0		0,04501	0,04488	0,04896	0,05172
Order frequency	Number of orders		-0,0022	0,01213	0,05038	0,06135		0	0	0,00275	0,00575
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,14	-0,119	-0,1246	-0,1204
	By percentage of days without any backlogs		0	0	0	0		-0,0774	-0,0584	-0,0562	-0,0566
Inventory turnover	Times per year for finished products		0,47585	0,41489	0,32274	0,23039		2,71376	2,53117	2,55815	2,52501
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,6234	0,62071	0,6472	0,6537		0,64333	0,64388	0,63453	0,63739
Inventory KPI's											
Average inventory	Average of finished products		0,32281	0,29333	0,2429	0,18487		0,73507	0,72064	0,72161	0,71817
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,19226	0,19158	0,15293	0,14795		0,53231	0,53231	0,53231	0,53231
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,77738	0,77478	0,78687	0,78274		0,90315	0,90138	0,89988	0,89927
Max inbound	Maximum inbound of materials/products		0,62069	0,61007	0,61168	0,6114		0,78185	0,7779	0,77715	0,77863
Inbound frequency	Number of inbounds of materials/products		3,20458	3,20313	3,51994	3,49106		8,03175	7,9175	7,81375	7,80175
Average outbound	Average outbound of finished products		0	0	0	0		0,36472	0,35325	0,36854	0,36516
Max outbound	Maximum outbound of finished products		0	0	0	0		0,28492	0,29482	0,31152	0,30565
Outbound frequency	Number of outbounds of finished products		0	0	0	0		0,55264	0,52906	0,57246	0,56875
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,79407	0,79168	0,8029	0,7991		0,90315	0,90138	0,89988	0,89927
Max orders	Maximum order quantity		0,6205	0,6099	0,61154	0,6113		0,78185	0,7779	0,77715	0,77863
Order frequency	Number of orders		3,57846	3,57716	3,92305	3,89216		8,03175	7,9175	7,81375	7,80175
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,1365	-0,1028	-0,1163	-0,108
	By percentage of days without any backlogs		0	0	0	0		-0,0748	-0,0721	-0,0735	-0,0723
Inventory turnover	Times per year for finished products		0,46203	0,34229	0,26618	0,13907		2,70286	2,42924	2,49902	2,45831
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,6165	0,49639	0,50974	0,4944		0,64424	0,64269	0,63396	0,63425
Inventory KPI's											
Average inventory	Average of finished products		0,31642	0,25502	0,20792	0,11836		0,73401	0,71182	0,71622	0,71198
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,19226	0,17579	0,09048	0,05008		0,53231	0,53231	0,53231	0,53231
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,77401	0,69616	0,70705	0,67656		0,90329	0,89992	0,89993	0,89964
Max inbound	Maximum inbound of materials/products		0,61283	0,41398	0,42331	0,42478		0,78017	0,77139	0,77198	0,77385
Inbound frequency	Number of inbounds of materials/products		3,16165	2,14469	2,34053	2,06559		8,06025	7,80775	7,8385	7,8625
Average outbound	Average outbound of finished products		0	0	0	0		0,3595	0,28669	0,29855	0,27542
Max outbound	Maximum outbound of finished products		0	0	0	0		0,27273	0,26093	0,27163	0,27137
Outbound frequency	Number of outbounds of finished products		0	0	0	0		0,54167	0,38883	0,41962	0,37837
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,79048	0,71813	0,72844	0,7006		0,90329	0,89992	0,89993	0,89964
Max orders	Maximum order quantity		0,61015	0,41389	0,42314	0,4247		0,78017	0,77139	0,77198	0,77385
Order frequency	Number of orders		3,52144	2,41403	2,62985	2,33564		8,06025	7,80775	7,8385	7,8625
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,14	-0,119	-0,1246	-0,1204
	By percentage of days without any backlogs		0	0	0	0		-0,0774	-0,0584	-0,0562	-0,0566
Inventory turnover	Times per year for finished products		0,47585	0,41489	0,32274	0,23039		2,71376	2,53117	2,55815	2,52501
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,6234	0,62071	0,6472	0,6537		0,64333	0,64388	0,63453	0,63739
Inventory KPI's											
Average inventory	Average of finished products		0,32281	0,29333	0,2429	0,18487		0,73507	0,72064	0,72161	0,71817
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,19226	0,19158	0,15293	0,14795		0,53231	0,53231	0,53231	0,53231
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,77738	0,77478	0,78687	0,78274		0,90315	0,90138	0,89988	0,89927
Max inbound	Maximum inbound of materials/products		0,62069	0,61007	0,61168	0,6114		0,78185	0,7779	0,77715	0,77863
Inbound frequency	Number of inbounds of materials/products		3,20458	3,20313	3,51994	3,49106		8,03175	7,9175	7,81375	7,80175
Average outbound	Average outbound of finished products		0	0	0	0		0,36472	0,35325	0,36854	0,36516
Max outbound	Maximum outbound of finished products		0	0	0	0		0,28492	0,29482	0,31152	0,30565
Outbound frequency	Number of outbounds of finished products		0	0	0	0		0,55264	0,52906	0,57246	0,56875
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,79407	0,79168	0,8029	0,7991		0,90315	0,90138	0,89988	0,89927
Max orders	Maximum order quantity		0,6205	0,6099	0,61154	0,6113		0,78185	0,7779	0,77715	0,77863
Order frequency	Number of orders		3,57846	3,57716	3,92305	3,89216		8,03175	7,9175	7,81375	7,80175
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4531430		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		0	0	0	0		-0,1233	-0,1213	-0,1228	-0,1199
	By percentage of days without any backlogs		0	0	0	0		-0,0567	-0,0543	-0,0557	-0,0558
Inventory turnover	Times per year for finished products		0,4547	0,34255	0,23973	0,18078		2,51331	2,54571	2,53247	2,5329
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,63787	0,65799	0,66287	0,66516		0,64446	0,64258	0,63605	0,63445
Inventory KPI's											
Average inventory	Average of finished products		0,31329	0,25489	0,19206	0,14897		0,71992	0,72125	0,71908	0,71802
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,19226	0,16794	0,15347	0,1295		0,53231	0,53231	0,53231	0,53231
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,78494	0,79073	0,78758	0,78394		0,90135	0,90043	0,89916	0,89911
Max inbound	Maximum inbound of materials/products		0,62115	0,62272	0,62057	0,61598		0,77626	0,77922	0,77613	0,77636
Inbound frequency	Number of inbounds of materials/products		3,35272	3,55903	3,56976	3,57162		7,8875	7,85175	7,77925	7,814
Average outbound	Average outbound of finished products		0	0	0	0		0,36303	0,37126	0,37001	0,36767
Max outbound	Maximum outbound of finished products		0	0	0	0		0,28747	0,31253	0,29831	0,29991
Outbound frequency	Number of outbounds of finished products		0	0	0	0		0,54863	0,57576	0,57897	0,57947
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,80105	0,80648	0,80355	0,80021		0,90135	0,90043	0,89916	0,89911
Max orders	Maximum order quantity		0,62115	0,62266	0,62049	0,61598		0,77626	0,77922	0,77613	0,77636
Order frequency	Number of orders		3,73928	3,96564	3,97719	3,97993		7,8875	7,85175	7,77925	7,814
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,121	-0,0374	0,03132	0,06874		0	0	0	0
	By percentage of days without any backlogs		-0,119	-0,075	-0,0133	0,04026		0	0	0	0
Inventory turnover	Times per year for finished products		0,30088	-0,0203	-0,1746	-0,1946		0,04942	0,01681	0,03544	0,0385
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,08977	0,1211	0,16756	0,18376		-0,033	0,0006	-0,0211	-0,0445
Inventory KPI's											
Average inventory	Average of finished products		0,22971	-0,0317	-0,271	-0,3674		0,05299	0,01255	0,02079	0,02668
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,05998	0,06729	-0,1228	-0,2108		0,02944	0,03622	0,02703	0,00946
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,35323	0,31022	0,32826	0,34043		-0,0077	0,03943	0,0318	0,01585
Max inbound	Maximum inbound of materials/products		0,05456	0,10211	0,13994	0,15254		-0,0108	0,08588	0,06962	0,04065
Inbound frequency	Number of inbounds of materials/products		0,52597	0,46852	0,55036	0,56217		-0,0334	0,04463	0,04022	0,0121
Average outbound	Average outbound of finished products		0,05351	0,04219	0,028	0,01459		0,16273	0,13977	0,15201	0,15801
Max outbound	Maximum outbound of finished products		-0,0286	-0,0315	-0,0479	-0,0436		0,00041	0,00035	0,00042	0,00075
Outbound frequency	Number of outbounds of finished products		0,05801	0,04699	0,03216	0,01868		0,18984	0,1691	0,19864	0,2029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,35323	0,31022	0,32826	0,34043		-0,0077	0,03943	0,0318	0,01585
Max orders	Maximum order quantity		0,05456	0,10211	0,13994	0,15254		-0,0108	0,08588	0,06962	0,04065
Order frequency	Number of orders		0,52597	0,46852	0,55036	0,56217		-0,0334	0,04463	0,04022	0,0121
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,121	-0,0374	0,03132	0,06874		0	0	0	0
	By percentage of days without any backlogs		-0,119	-0,075	-0,0133	0,04026		0	0	0	0
Inventory turnover	Times per year for finished products		0,30088	-0,0203	-0,1746	-0,1946		0,21349	0,17395	0,19719	0,19976
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,08977	0,1211	0,16756	0,18376		0,18225	0,18743	0,18637	0,16479
Inventory KPI's											
Average inventory	Average of finished products		0,22971	-0,0317	-0,271	-0,3674		0,1812	0,14515	0,15335	0,15771
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,05998	0,06729	-0,1228	-0,2108		0,18145	0,16891	0,16717	0,15513
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,35323	0,31022	0,32826	0,34043		0,47472	0,49514	0,50764	0,49854
Max inbound	Maximum inbound of materials/products		0,05456	0,10211	0,13994	0,15254		0,17909	0,2723	0,26612	0,24482
Inbound frequency	Number of inbounds of materials/products		0,52597	0,46852	0,55036	0,56217		0,79236	0,9241	0,98134	0,91944
Average outbound	Average outbound of finished products		0,05351	0,04219	0,028	0,01459		0,16273	0,13977	0,15201	0,15801
Max outbound	Maximum outbound of finished products		-0,0286	-0,0315	-0,0479	-0,0436		0,00041	0,00035	0,00042	0,00075
Outbound frequency	Number of outbounds of finished products		0,05801	0,04699	0,03216	0,01868		0,18984	0,1691	0,19864	0,2029
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,35323	0,31022	0,32826	0,34043		0,47472	0,49514	0,50764	0,49854
Max orders	Maximum order quantity		0,05456	0,10211	0,13994	0,15254		0,17909	0,2723	0,26612	0,24482
Order frequency	Number of orders		0,52597	0,46852	0,55036	0,56217		0,79236	0,9241	0,98134	0,91944
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1381	-0,0804	-0,0444	0,03988		0	0	0	0
	By percentage of days without any backlogs		-0,1398	-0,0979	-0,0743	0,00797		0	0	0	0
Inventory turnover	Times per year for finished products		0,32828	0,15275	0,04365	-0,1634		0,221	0,19898	0,20999	0,21081
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,08775	0,14279	0,18511	0,2593		0,1782	0,1936	0,19	0,17649
Inventory KPI's											
Average inventory	Average of finished products		0,24539	0,12805	0,01653	-0,2251		0,18611	0,16765	0,17138	0,16445
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,05414	0,08641	0,06929	-0,028		0,18414	0,17806	0,17799	0,16649
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,38725	0,42712	0,46985	0,52576		0,47169	0,49479	0,50081	0,50863
Max inbound	Maximum inbound of materials/products		0,04866	0,08367	0,10865	0,15555		0,18207	0,25169	0,24722	0,25123
Inbound frequency	Number of inbounds of materials/products		0,6083	0,7351	0,89967	1,17086		0,78164	0,88616	0,91818	0,96924
Average outbound	Average outbound of finished products		0,06188	0,05302	0,05192	0,03412		0,1831	0,20952	0,24107	0,28679
Max outbound	Maximum outbound of finished products		-0,0395	-0,012	-0,0289	-0,0309		0,00037	0,00034	0,00044	0,00071
Outbound frequency	Number of outbounds of finished products		0,06818	0,05881	0,05876	0,04022		0,21956	0,26532	0,32472	0,4226
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,38725	0,42712	0,46985	0,52576		0,47169	0,49479	0,50081	0,50863
Max orders	Maximum order quantity		0,04866	0,08367	0,10865	0,15555		0,18207	0,25169	0,24722	0,25123
Order frequency	Number of orders		0,6083	0,7351	0,89967	1,17086		0,78164	0,88616	0,91818	0,96924
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1277	-0,1019	-0,0336	0,01142		0	0	0	0
	By percentage of days without any backlogs		-0,1261	-0,1104	-0,0578	-0,0177		0	0	0	0
Inventory turnover	Times per year for finished products		0,29357	0,22198	0,05175	-0,0785		0,22357	0,21802	0,21992	0,22574
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,10353	0,13948	0,21778	0,27164		0,16498	0,16891	0,1727	0,1539
Inventory KPI's											
Average inventory	Average of finished products		0,2257	0,17994	0,03913	-0,1063		0,18696	0,18205	0,17885	0,17795
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,06058	0,07998	0,11122	0,06859		0,18578	0,18283	0,18233	0,172
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,448	0,52299	0,60436	0,64311		0,46631	0,47672	0,49605	0,49559
Max inbound	Maximum inbound of materials/products		0,05516	0,0748	0,1205	0,14774		0,18058	0,20531	0,22718	0,21184
Inbound frequency	Number of inbounds of materials/products		0,78851	1,07299	1,53344	1,84999		0,76412	0,80371	0,88956	0,90116
Average outbound	Average outbound of finished products		0,06078	0,06503	0,05814	0,05952		0,22338	0,27975	0,35293	0,39378
Max outbound	Maximum outbound of finished products		-0,0339	-0,015	-0,0018	-0,0113		0,00054	0,00059	0,00063	0,00076
Outbound frequency	Number of outbounds of finished products		0,06732	0,07233	0,06622	0,06808		0,2846	0,38728	0,55347	0,66772
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,448	0,52299	0,60436	0,64311		0,46631	0,47672	0,49605	0,49559
Max orders	Maximum order quantity		0,05516	0,0748	0,1205	0,14774		0,18058	0,20531	0,22718	0,21184
Order frequency	Number of orders		0,78851	1,07299	1,53344	1,84999		0,76412	0,80371	0,88956	0,90116
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

3407384		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1605	-0,0764	-0,012	0,02651		0	0	0	0
	By percentage of days without any backlogs		-0,155	-0,0923	-0,0374	-0,0029		0	0	0	0
Inventory turnover	Times per year for finished products		0,40536	0,14962	-0,0187	-0,1252		0,21211	0,21966	0,22567	0,23306
	Times per year for materials							#######	#######	#######	#######
Bullwhip Effect	Amplification on weekly level		0,0691	0,15909	0,2268	0,26842		0,1848	0,16909	0,15971	0,14929
Inventory KPI's											
Average inventory	Average of finished products		0,28908	0,12464	-0,0337	-0,1679		0,18122	0,18118	0,18044	0,18051
	Average of materials							#######	#######	#######	#######
Max inventory	Maximum of finished products		0,03217	0,0764	0,07608	0,00188		0,18376	0,17907	0,17541	0,16939
	Maximum of materials							#######	#######	#######	#######
Average inbound	Average inbound of materials/products		0,44578	0,57068	0,62886	0,65482		0,46532	0,47562	0,48781	0,48928
Max inbound	Maximum inbound of materials/products		0,02606	0,07356	0,10794	0,12616		0,20108	0,20073	0,21035	0,18699
Inbound frequency	Number of inbounds of materials/products		0,77002	1,31576	1,72015	1,97403		0,76399	0,81228	0,86372	0,88263
Average outbound	Average outbound of finished products		0,07259	0,06813	0,06009	0,05498		0,2214	0,32075	0,37805	0,40746
Max outbound	Maximum outbound of finished products		-0,0559	-0,0148	-0,0161	-0,0315		0,00043	0,00023	0,00044	0,00061
Outbound frequency	Number of outbounds of finished products		0,07945	0,07609	0,06803	0,06337		0,27792	0,4749	0,62085	0,71249
Production KPI's											
Average production	Average production quantity							#######	#######	#######	#######
Max production	Maximum production quantity							#######	#######	#######	#######
Production frequency	Number of production runs							#######	#######	#######	#######
Ordering KPI's											
Average orders	Average order quantity		0,44578	0,57068	0,62886	0,65482		0,46532	0,47562	0,48781	0,48928
Max orders	Maximum order quantity		0,02606	0,07356	0,10794	0,12616		0,20108	0,20073	0,21035	0,18699
Order frequency	Number of orders		0,77002	1,31576	1,72015	1,97403		0,76399	0,81228	0,86372	0,88263
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,0225	-0,0091	-0,0042	0,0009		0	0	0	0
	By percentage of days without any backlogs		-0,0219	-0,01	-0,0045	0,00042		4E-05	0,00052	0,00249	0,0039
Inventory turnover	Times per year for finished products		0,10874	-0,0145	-0,1788	-0,2542		0,00905	0,01151	0,07507	0,11921
	Times per year for materials							-0,0012	0,00597	0,03429	0,05586
Bullwhip Effect	Amplification on weekly level		0,00144	0,00833	0,03745	0,05664		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,09789	-0,0278	-0,2776	-0,4835		0,01012	0,00516	0,03373	0,04931
	Average of materials							-8E-07	1,7E-07	1,9E-06	3,4E-06
Max inventory	Maximum of finished products		0,05482	-0,1095	-0,5477	-0,8521		0	0	0	0
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,00381	0,00322	0,00449	0,00444		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,01662	0,01369	0,01857	0,01857		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		0,0013	0,01472	0,07124	0,11347		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,00509	0,0013	-0,0005	-0,0014		0,00178	7,1E-06	-0,0054	-0,0098
Max outbound	Maximum outbound of finished products		0,01597	-0,0011	-0,0196	-0,0247		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,00542	0,00132	-0,0003	-0,0008		0,00052	0,00585	0,02832	0,0451
Production KPI's											
Average production	Average production quantity							0,01612	0,01099	0,02815	0,04016
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							0,01497	0,01697	0,06089	0,09167
Ordering KPI's											
Average orders	Average order quantity		0,00381	0,00322	0,00449	0,00444		#######	#######	#######	#######
Max orders	Maximum order quantity		0,01662	0,01369	0,01857	0,01857		#######	#######	#######	#######
Order frequency	Number of orders		0,0013	0,01472	0,07124	0,11347		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,2028	-0,2139	-0,1904	-0,0549		0	0	0	0
	By percentage of days without any backlogs		-0,1948	-0,2067	-0,1836	-0,0521		0,04499	0,04589	0,04437	0,03367
Inventory turnover	Times per year for finished products		1,5696	1,90672	1,66129	0,18618		2,67836	2,57104	2,55053	2,57957
	Times per year for materials							-0,0276	-0,0595	-0,0582	-0,0292
Bullwhip Effect	Amplification on weekly level		0,40062	0,38273	0,37292	0,32989		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,59446	0,61822	0,53948	0,10991		0,7366	0,73755	0,73563	0,72978
	Average of materials							-9E-06	-9E-06	-8E-06	-5E-06
Max inventory	Maximum of finished products		0,3931	0,35554	0,21956	-0,1579		0,15385	0,15385	0,15385	0,15385
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,71228	0,73745	0,72282	0,60618		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,34272	0,31867	0,32884	0,35073		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		2,38112	2,51061	2,38566	1,44435		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,04387	0,04745	0,04068	0,01773		0,49188	0,51802	0,50217	0,37654
Max outbound	Maximum outbound of finished products		0,06641	0,06968	0,04863	0,01107		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,04686	0,04872	0,04136	0,01766		0,94646	0,99793	0,94827	0,57411
Production KPI's											
Average production	Average production quantity							0,73744	0,75155	0,74339	0,67774
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							2,53568	2,63916	2,54916	1,85793
Ordering KPI's											
Average orders	Average order quantity		0,71228	0,73745	0,72282	0,60618		#######	#######	#######	#######
Max orders	Maximum order quantity		0,34272	0,31867	0,32884	0,35073		#######	#######	#######	#######
Order frequency	Number of orders		2,38112	2,51061	2,38566	1,44435		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,2468	-0,1259	-0,0895	-0,0804		0	0	0	0
	By percentage of days without any backlogs		-0,2354	-0,1226	-0,0873	-0,0778		0,05141	0,04661	0,04974	0,04897
Inventory turnover	Times per year for finished products		2,2162	1,12332	0,74695	0,5822		2,63928	2,5921	2,63746	2,63474
	Times per year for materials							-0,0447	-0,0551	-0,0277	-0,0339
Bullwhip Effect	Amplification on weekly level		0,48016	0,46303	0,51358	0,50719		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,68277	0,52258	0,41169	0,33682		0,73849	0,73788	0,73363	0,73512
	Average of materials							-1E-05	-8E-06	-7E-06	-7E-06
Max inventory	Maximum of finished products		0,50348	0,43231	0,28998	0,16331		0,15385	0,15385	0,15385	0,15385
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,77345	0,74307	0,75268	0,74966		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,38407	0,42766	0,47302	0,4781		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		3,05414	2,50282	2,84322	2,75249		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,05447	0,03691	0,02967	0,02364		0,56479	0,52195	0,54008	0,53497
Max outbound	Maximum outbound of finished products		0,09672	0,09926	0,07857	0,05099		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,05806	0,03672	0,03114	0,02486		1,21398	0,99484	1,13014	1,09408
Production KPI's											
Average production	Average production quantity							0,77658	0,75598	0,7656	0,76371
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							3,04658	2,66728	2,92015	2,86558
Ordering KPI's											
Average orders	Average order quantity		0,77345	0,74307	0,75268	0,74966		#######	#######	#######	#######
Max orders	Maximum order quantity		0,38407	0,42766	0,47302	0,4781		#######	#######	#######	#######
Order frequency	Number of orders		3,05414	2,50282	2,84322	2,75249		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,188	-0,1254	-0,0881	-0,0674		0	0	0	0
	By percentage of days without any backlogs		-0,1814	-0,1234	-0,0851	-0,0659		0,05242	0,0535	0,05616	0,05825
Inventory turnover	Times per year for finished products		1,7892	1,18067	0,79894	0,54911		2,60957	2,63578	2,62404	2,6583
	Times per year for materials							-0,0501	-0,0425	-0,0375	-0,0309
Bullwhip Effect	Amplification on weekly level		0,49999	0,52758	0,56406	0,59218		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,63907	0,53775	0,43292	0,33679		0,73784	0,73765	0,73535	0,73595
	Average of materials							-9E-06	-8E-06	-8E-06	-7E-06
Max inventory	Maximum of finished products		0,52127	0,48622	0,34941	0,24349		0,15385	0,15385	0,15385	0,15385
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,78329	0,7875	0,80378	0,81496		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,40528	0,45904	0,50205	0,53001		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		3,1793	3,3259	3,74166	4,0864		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,0508	0,03944	0,03252	0,02708		0,57726	0,58481	0,60983	0,62823
Max outbound	Maximum outbound of finished products		0,13337	0,1174	0,07803	0,06424		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,05335	0,04181	0,03412	0,02849		1,26373	1,322	1,48726	1,62429
Production KPI's											
Average production	Average production quantity							0,78271	0,78904	0,8016	0,81029
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							3,13226	3,28681	3,58925	3,82199
Ordering KPI's											
Average orders	Average order quantity		0,78329	0,7875	0,80378	0,81496		#######	#######	#######	#######
Max orders	Maximum order quantity		0,40528	0,45904	0,50205	0,53001		#######	#######	#######	#######
Order frequency	Number of orders		3,1793	3,3259	3,74166	4,0864		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

4256632		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time		-0,1736	-0,092	-0,0693	-0,0566		0	0	0	0
	By percentage of days without any backlogs		-0,1666	-0,0904	-0,0678	-0,0534		0,05328	0,05643	0,05772	0,05935
Inventory turnover	Times per year for finished products		1,62219	0,8994	0,60139	0,47327		2,6042	2,65991	2,62828	2,6758
	Times per year for materials							-0,0501	-0,0304	-0,0303	-0,0238
Bullwhip Effect	Amplification on weekly level		0,51804	0,56892	0,59072	0,60861		#######	#######	#######	#######
Inventory KPI's											
Average inventory	Average of finished products		0,61467	0,46756	0,36314	0,3012		0,73744	0,73603	0,73364	0,73529
	Average of materials							-9E-06	-8E-06	-7E-06	-7E-06
Max inventory	Maximum of finished products		0,5128	0,39234	0,26847	0,18542		0,15385	0,15385	0,15385	0,15385
	Maximum of materials							0	0	0	0
Average inbound	Average inbound of materials/products		0,78955	0,80293	0,81156	0,81958		#######	#######	#######	#######
Max inbound	Maximum inbound of materials/products		0,42717	0,47869	0,51652	0,5348		#######	#######	#######	#######
Inbound frequency	Number of inbounds of materials/products		3,30489	3,78454	4,01213	4,29493		#######	#######	#######	#######
Average outbound	Average outbound of finished products		0,04981	0,03784	0,03029	0,02742		0,58612	0,60989	0,62303	0,63686
Max outbound	Maximum outbound of finished products		0,12539	0,09835	0,06696	0,06278		0	0	0	0
Outbound frequency	Number of outbounds of finished products		0,05294	0,04036	0,03197	0,02945		1,31365	1,5043	1,59477	1,70718
Production KPI's											
Average production	Average production quantity							0,78751	0,80212	0,80885	0,81467
Max production	Maximum production quantity							0	0	0	0
Production frequency	Number of production runs							3,22858	3,63184	3,8012	3,97405
Ordering KPI's											
Average orders	Average order quantity		0,78955	0,80293	0,81156	0,81958		#######	#######	#######	#######
Max orders	Maximum order quantity		0,42717	0,47869	0,51652	0,5348		#######	#######	#######	#######
Order frequency	Number of orders		3,30489	3,78454	4,01213	4,29493		#######	#######	#######	#######
FAD KPI's											
Forecast deviation	Average forecast deviation										
	Av forecast deviation as a perc of av demand										
Discount percentage	Average discount percentage										
	Av disc perc as a perc of the max possible discount										

Annex XX: Simulation outcomes of Stochastic series compared to Empirical showcases

4536827 and 4536835		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-4,33	-3,2	-2,81	-2,63	-2,46	-0,57	-0,65	-0,57	-0,57	-0,52
	By percentage of days without any backlogs	-4,65	-3,68	-2,93	-2,97	-2,86	-0,72	-0,85	-0,73	-0,72	-0,67
Inventory turnover	Times per year for finished products	5,615	5,195	4,627	3,822	2,556	1,986	3,872	4,412	2,65	3,777
	Times per year for materials						3,273	4,089	1,385	2,32	2,526
Bullwhip Effect	Amplification on weekly level	-0,45	-3,88	-2,1	-0,94	-1,05	0,245	1,959	2,581	1,032	1,92
Inventory KPI's											
Average inventory	Average of finished products	-6,11	-6,49	-5,31	-3,57	-2,13	1,595	-0,26	-1,02	1,082	-0,66
	Average of materials						-1,31	-2,14	1,367	-0,26	-0,33
Max inventory	Maximum of finished products	-0,39	-1,41	-1,23	-1,94	-1,11	-0,18	0,032	0,607	0,684	-0,49
	Maximum of materials						0,402	0,348	0,885	0,561	0,948
Average inbound	Average inbound of materials/products	-0,32	-2,15	-4,32	-2,35	-1,43	-0,59	-0,22	-0,63	0,302	-0,04
Max inbound	Maximum inbound of materials/products	-0,25	0,146	0,579	0,75	-0,64	0,259	-1,18	0,254	0,37	1,611
Inbound frequency	Number of inbounds of materials/products	7,128	7,698	7,259	6,281	4,433	2,919	2,858	2,602	2,733	2,528
Average outbound	Average outbound of finished products	5,486	4,42	4,495	4,794	4,452	3,663	-0,51	-1,33	0,489	0,111
Max outbound	Maximum outbound of finished products	3,278	1,301	1,973	2,415	2,477	-0,25	0,488	0,581	0,751	-0,64
Outbound frequency	Number of outbounds of finished products	-1,69	-1,63	-1,11	-0,76	-0,9	6,521	7,08	7,005	5,869	4,34
Production KPI's											
Average production	Average production quantity						-1,19	-1,21	-1,96	-1,68	-0,67
Max production	Maximum production quantity						-0,04	-0,66	0,407	0,203	0,284
Production frequency	Number of production runs						3,911	4,016	4,569	4,034	3,428
Ordering KPI's											
Average orders	Average order quantity	-0,26	-2,15	-4,3	-2,34	-1,43	-0,59	-0,22	-0,63	0,302	-0,04
Max orders	Maximum order quantity	-0,25	0,149	0,578	0,749	-0,62	0,259	-1,18	0,254	0,37	1,611
Order frequency	Number of orders	7,312	7,708	7,259	6,272	4,433	2,919	2,858	2,602	2,733	2,528
FAD KPI's											
Forecast deviation	Average forecast deviation		7,364	3,911	3,279	1,648					
	Av forecast deviation as a perc of av demand		-2,52	3,674	3,011	1,148					
Discount percentage	Average discount percentage		1,659	-3,26	-3,02	-1,42					
	Av disc perc as a perc of the max possible discount		1,659	-3,26	-3,02	-1,42					

4536827 and 4536835		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-2,76	-3,19	-2,83	-2,76	-2,47	-0,3	-1,56	-1,28	-0,75	-1,06
	By percentage of days without any backlogs	-2,74	-3,71	-2,93	-3,16	-2,88	-0,81	-2,04	-0,56	-1,72	-0,42
Inventory turnover	Times per year for finished products	4,785	5,139	4,619	3,922	2,532	2,159	3,765	3,47	4,054	3,338
	Times per year for materials						0,034	1,385	3,558	2,193	2,575
Bullwhip Effect	Amplification on weekly level	-0,38	-3,6	-2,06	-0,72	-1,03	2,372	0,183	2,083	0,934	3,423
Inventory KPI's											
Average inventory	Average of finished products	-4,13	-6,19	-5,27	-3,92	-2,09	1,327	0,707	1,617	0,636	1,299
	Average of materials						1,708	1,504	-0,2	0,941	0,61
Max inventory	Maximum of finished products	-1,47	-1,31	-1,48	-1,91	-1,04	0,73	0,325	0,914	-2,35	-0,14
	Maximum of materials						1,094	0,495	0,537	-0,24	0,094
Average inbound	Average inbound of materials/products	0,089	-2,36	-4,87	-0,1	-1,71	0,012	0,075	0,19	-0,29	1,816
Max inbound	Maximum inbound of materials/products	0,361	-0,05	0,687	0,908	-0,91	1,305	0,556	0,973	-1,26	0,78
Inbound frequency	Number of inbounds of materials/products	3,048	6,34	7,307	4,399	4,456	2,6	3,056	3,083	3,164	1,145
Average outbound	Average outbound of finished products	5,011	4,492	4,497	4,844	4,482	1,135	-0,99	-0,33	-0,91	0,365
Max outbound	Maximum outbound of finished products	1,774	1,292	1,998	2,418	2,525	0,507	0,065	0,766	-1,48	-0,66
Outbound frequency	Number of outbounds of finished products	-0,64	-1,62	-1,09	-0,87	-0,89	3,08	4,677	3,979	4,707	2,85
Production KPI's											
Average production	Average production quantity						1,419	-1,13	-0,05	-0,8	0,621
Max production	Maximum production quantity						0,821	0,419	0,894	-2,33	-0,03
Production frequency	Number of production runs						2,537	4,656	3,599	4,264	2,434
Ordering KPI's											
Average orders	Average order quantity	-1,08	-1,88	-4,21	-0,84	-1,41	0,012	0,075	0,19	-0,29	1,816
Max orders	Maximum order quantity	0,407	0,218	0,576	0,721	-0,61	1,305	0,556	0,973	-1,26	0,78
Order frequency	Number of orders	7,294	7,368	7,137	5,528	4,451	2,6	3,056	3,083	3,164	1,145
FAD KPI's											
Forecast deviation	Average forecast deviation		7,408	3,918	2,306	1,677					
	Av forecast deviation as a perc of av demand		-2,56	3,677	1,755	1,17					
Discount percentage	Average discount percentage		1,494	-3,27	-1,99	-1,45					
	Av disc perc as a perc of the max possible discount		1,494	-3,27	-1,99	-1,45					

4536827 and 4536835		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-2,95	-3,2	-2,39	-2,02	-2,45	-0,9	-1,57	0,749	-0,59	-0,65
	By percentage of days without any backlogs	-3,36	-3,74	-2,93	-2,21	-2,86	0,256	-2,09	1,924	1,022	0,85
Inventory turnover	Times per year for finished products	4,926	5,147	4,705	3,715	3,708	2,442	3,753	2,443	3,646	3,545
	Times per year for materials						1,218	1,526	3,252	2,769	2,608
Bullwhip Effect	Amplification on weekly level	-0,55	-3,63	-2,06	-0,49	-1,46	1,668	0,219	0,682	-0,04	0,382
Inventory KPI's											
Average inventory	Average of finished products	-4,54	-6,19	-5,39	-3,37	-5,51	0,784	0,726	2,56	1,292	1,304
	Average of materials						0,67	1,398	0,368	0,511	0,795
Max inventory	Maximum of finished products	-0,03	-1,32	-0,55	0,156	-1,78	0,164	0,323	-0,12	-0,47	-0,71
	Maximum of materials						0,92	0,503	0,468	-0,7	0,479
Average inbound	Average inbound of materials/products	-1,38	-2,44	-2,93	1,455	-2,42	2,087	0,1	0,826	1,563	-1,29
Max inbound	Maximum inbound of materials/products	-0,19	-0,05	0,986	0,183	-0,11	1,176	0,565	-0,45	-0,52	-0,6
Inbound frequency	Number of inbounds of materials/products	4,258	6,406	6,82	3,931	5,319	0,677	3,051	2,651	1,781	3,996
Average outbound	Average outbound of finished products	4,95	4,511	4,393	4,579	4,538	2,276	-1,06	1,987	1,471	0,641
Max outbound	Maximum outbound of finished products	2,534	1,292	1,182	1,622	2,476	0,139	0,063	1,087	0,061	0,026
Outbound frequency	Number of outbounds of finished products	-0,94	-1,63	-0,97	-0,37	-0,83	1,845	4,72	2,12	2,846	3,26
Production KPI's											
Average production	Average production quantity						2,639	-1,39	2,062	1,643	0,771
Max production	Maximum production quantity						0,054	0,417	-0,19	-0,58	-0,84
Production frequency	Number of production runs						0,823	4,839	1,708	2,413	2,89
Ordering KPI's											
Average orders	Average order quantity	-1,31	-1,98	-2,34	1,096	-2,27	2,087	0,1	0,826	1,563	-1,29
Max orders	Maximum order quantity	0,128	0,217	0,808	0,333	0,068	1,176	0,565	-0,45	-0,52	-0,6
Order frequency	Number of orders	6,918	7,54	6,866	4,983	5,769	0,677	3,051	2,651	1,781	3,996
FAD KPI's											
Forecast deviation	Average forecast deviation		7,42	3,929	1,25	3,4					
	Av forecast deviation as a perc of av demand		-2,55	3,469	0,313	3,277					
Discount percentage	Average discount percentage		1,572	-3,45	-0,93	-3,45					
	Av disc perc as a perc of the max possible discount		1,572	-3,45	-0,93	-3,45					

4536827 and 4536835		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-4,63	-2,91	-3,18	-3,59	-3,63	-0,45	-2,06	-1,14	0,383	0,215
	By percentage of days without any backlogs	-4,9	-3,53	-3,82	-4,21	-4,2	-2,13	-2,08	-1,14	-0,63	0,251
Inventory turnover	Times per year for finished products	4,873	5,169	5,316	4,901	4,9	2,412	4,863	4,475	3,033	3,206
	Times per year for materials						0,854	1,772	0,819	2,189	1,114
Bullwhip Effect	Amplification on weekly level	1,957	-3,8	-2,74	-0,71	0,138	0,24	0,029	0,33	-0,16	-0,1
Inventory KPI's											
Average inventory	Average of finished products	-5,08	-6,29	-6,98	-7,09	-8,08	1,535	-0,08	0,626	2,326	2,657
	Average of materials						1,639	1,636	2,95	1,663	3,191
Max inventory	Maximum of finished products	0,343	-1,52	-1,58	-1,22	-3,39	2,137	-1,03	-1,22	-0,05	0,792
	Maximum of materials						1,104	0,461	0,396	0,388	0,402
Average inbound	Average inbound of materials/products	3,032	-1,99	0,283	4,43	5,123	2,404	-0,46	0,514	0,566	1,801
Max inbound	Maximum inbound of materials/products	2,444	-0,09	-0,14	-0,25	0,675	1,04	0,532	0,405	0,339	1,716
Inbound frequency	Number of inbounds of materials/products	2,43	6,513	6,002	2,908	3,519	0,714	3,599	3,607	3,319	2,494
Average outbound	Average outbound of finished products	5,188	4,389	4,458	4,612	4,558	3,607	-1,2	0,302	2,877	3,948
Max outbound	Maximum outbound of finished products	3,057	1,286	1,256	3,004	2,977	2,446	1E-04	-0,07	-0,16	0,714
Outbound frequency	Number of outbounds of finished products	-2,83	-1,39	-1,59	-1,84	-1,78	0,297	5,143	4,054	1,313	0,767
Production KPI's											
Average production	Average production quantity						3,68	-1,48	-0,76	2,587	3,809
Max production	Maximum production quantity						2,144	-1,12	-1,32	0,014	0,714
Production frequency	Number of production runs						-0,42	4,929	4,68	1,373	0,549
Ordering KPI's											
Average orders	Average order quantity	5,787	-1,58	0,891	4,944	5,477	2,404	-0,46	0,514	0,566	1,801
Max orders	Maximum order quantity	1,928	0,196	0,186	0,093	0,812	1,04	0,532	0,405	0,339	1,716
Order frequency	Number of orders	1,309	7,782	6,378	3,066	4,192	0,714	3,599	3,607	3,319	2,494
FAD KPI's											
Forecast deviation	Average forecast deviation		7,879	4,722	4,229	4,505					
	Av forecast deviation as a perc of av demand		-0,35	2,813	4,058	4,35					
Discount percentage	Average discount percentage		1,507	-3,04	-4,36	-4,6					
	Av disc perc as a perc of the max possible discount		1,507	-3,04	-4,36	-4,6					

4536827 and 4536835		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-3,77	-2,82	-2,44	-2,6	-2,57	-2,17	-1,98	-0,79	-2,03	-1,94
	By percentage of days without any backlogs	-3,98	-3,44	-3,05	-3,06	-3,17	-2,6	-2,25	-1,24	-1,59	-0,89
Inventory turnover	Times per year for finished products	4,7	5,541	5,225	4,886	4,884	2,167	2,483	1,514	3,542	2,964
	Times per year for materials						0,598	1,046	0,995	0,921	0,681
Bullwhip Effect	Amplification on weekly level	1,135	-1,3	-0,4	-0,16	0,035	0,301	1,408	-1,31	0,494	1,903
Inventory KPI's											
Average inventory	Average of finished products	-3,4	-5,44	-6,63	-6,24	-7,04	0,616	0,18	1,416	-0,63	0,448
	Average of materials						0,303	0,164	0,304	0,536	0,863
Max inventory	Maximum of finished products	0,226	0,777	-2,31	-1,53	-1,75	0,961	0,458	0,309	1,34	1,274
	Maximum of materials						-0,61	0,091	1,291	-0,53	1,136
Average inbound	Average inbound of materials/products	1,551	-1,65	1,408	1,735	3,366	0,922	0,223	0,621	0,402	1,041
Max inbound	Maximum inbound of materials/products	0,673	0,809	0,518	1,509	1,943	1,331	0,146	0,908	-0,51	0,731
Inbound frequency	Number of inbounds of materials/products	2,761	4,8	3,195	3,609	2,339	1,377	2,318	2,35	2,792	2,408
Average outbound	Average outbound of finished products	5,142	5,391	5,176	5,14	5,203	2,903	2,196	4,209	3,144	4,067
Max outbound	Maximum outbound of finished products	2,545	1,997	1,83	1,802	1,697	-0,04	0,208	1,399	1,408	1,351
Outbound frequency	Number of outbounds of finished products	-1,24	-0,47	-0,02	0,144	0,229	0,861	2,16	0,115	1,969	1,235
Production KPI's											
Average production	Average production quantity						3,278	1,665	3,275	1,598	2,597
Max production	Maximum production quantity						0,954	0,458	0,309	1,339	1,274
Production frequency	Number of production runs						0,072	1,654	-0,04	2,286	1,127
Ordering KPI's											
Average orders	Average order quantity	4,457	0,801	3,733	4,71	5,777	0,922	0,223	0,621	0,402	1,041
Max orders	Maximum order quantity	0,203	1,053	0,718	0,94	1,942	1,331	0,146	0,908	-0,51	0,731
Order frequency	Number of orders	1,62	5,171	3,464	3,991	3,452	1,377	2,318	2,35	2,792	2,408
FAD KPI's											
Forecast deviation	Average forecast deviation		1,891	4,205	4,962	5,224					
	Av forecast deviation as a perc of av demand		-0,01	3,856	5,017	5,478					
Discount percentage	Average discount percentage		-0,53	-4,41	-5,35	-5,04					
	Av disc perc as a perc of the max possible discount		-0,53	-4,41	-5,35	-5,04					

4255030		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,38	-0,46	-0,43	-0,3	-0,22	0	0	0	0	0
	By percentage of days without any backlogs	-0,59	-0,66	-0,62	-0,49	-0,42	-0,85	-0,49	-0,56	-0,39	-0,36
Inventory turnover	Times per year for finished products	-0,26	0,425	0,864	0,334	0,448	-0,11	-0,36	-0,47	-0,07	0,147
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,869	0,545	0,648	0,532	0,513	-0,99	-1,29	-0,19	-0,84	-1,31
Inventory KPI's											
Average inventory	Average of finished products	0,386	-1,46	-1,66	-0,51	-0,6	-0,04	0,172	0,426	0,07	-0,16
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	1,003	0,352	-0,5	-0	0,285	0,597	0,498	0,363	0,55	0,41
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,894	0,169	0,596	0,492	0,485	-0,04	1,042	0,978	0,793	0,802
Max inbound	Maximum inbound of materials/products	0,992	0,173	0,621	0,53	0,508	0	0	-0,22	-0,22	-0,28
Inbound frequency	Number of inbounds of materials/products	-0,85	-0,48	-0,54	-0,37	-0,34	0	0,173	0,16	0,212	0,225
Average outbound	Average outbound of finished products	-0,38	-0,39	-0,37	-0,38	-0,4	1,012	0,496	0,658	0,489	0,462
Max outbound	Maximum outbound of finished products	-1,05	-1,07	-1,05	-0,98	-1,01	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	-0,77	-0,77	-0,78	-0,77	-0,76	-0,85	-0,48	-0,54	-0,37	-0,34
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,894	0,169	0,596	0,492	0,485	-0,04	1,042	0,978	0,793	0,802
Max orders	Maximum order quantity	0,992	0,173	0,621	0,53	0,508	0	0	-0,22	-0,22	-0,28
Order frequency	Number of orders	-0,85	-0,48	-0,54	-0,37	-0,34	0	0,173	0,16	0,212	0,225
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,66	-0,39	0,111	0,703					
	Av forecast deviation as a perc of av demand		-0,69	-0,42	0,126	0,787					
Discount percentage	Average discount percentage		0,963	0,289	-0,12	-0,69					
	Av disc perc as a perc of the max possible discount		0,963	0,289	-0,12	-0,69					

4255030		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,47	-0,34	0,151	0,244	-0,66	0	0	0	0	0
	By percentage of days without any backlogs	-0,31	-0,97	-0,21	-0,43	-0,68	-0,35	-1,33	-0,91	1,721	0,389
Inventory turnover	Times per year for finished products	-0,21	-0,26	-0,04	0,8	-0,47	1,039	-0,73	-0,45	1,485	0,461
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,429	0,815	0,323	-0,76	0,597	-0,77	0,304	0,05	-0,6	-0,43
Inventory KPI's											
Average inventory	Average of finished products	0,396	0,456	0,053	-1,34	0,688	-2,06	0,38	0,432	-1,94	-0,98
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-0,65	-1,85	-0,63	-0,4	1,461	0,814	1,672	-1,63	-2,24	0,72
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,254	0,897	0,808	-2,73	-1,05	-0,97	-1,19	-2,31	-0,12	1,129
Max inbound	Maximum inbound of materials/products	-0,03	0,29	0,206	-3,01	-0,14	1,518	-0,61	-1,86	-0,65	1,035
Inbound frequency	Number of inbounds of materials/products	-0,32	-1,44	-0,91	1,613	0,43	0,808	1,007	2,039	0,003	-1,2
Average outbound	Average outbound of finished products	-0,17	-0,08	-0,15	-0,3	0,036	0,358	1,314	0,933	-1,9	-0,62
Max outbound	Maximum outbound of finished products	-1,09	-0,99	0,197	-0,18	-0,89	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	-0,95	-1,05	-0,98	-0,84	-1,15	-0,32	-1,44	-0,91	1,613	0,43
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,254	0,897	0,808	-2,73	-1,05	-0,97	-1,19	-2,31	-0,12	1,129
Max orders	Maximum order quantity	-0,03	0,29	0,206	-3,01	-0,14	1,518	-0,61	-1,86	-0,65	1,035
Order frequency	Number of orders	-0,32	-1,44	-0,91	1,613	0,43	0,808	1,007	2,039	0,003	-1,2
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,66	-0,21	1,482	1,176					
	Av forecast deviation as a perc of av demand		-0,76	-0,21	1,668	1,306					
Discount percentage	Average discount percentage		-0,59	0,211	-0,79	-1,64					
	Av disc perc as a perc of the max possible discount		-0,59	0,211	-0,79	-1,64					

4255030		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,32	-0,1	-0,75	0,389	0,504	0	0	0	0	0
	By percentage of days without any backlogs	-0,31	-0,48	-0,53	-0,59	-0,28	0,119	-1,03	0,042	0,65	0,955
Inventory turnover	Times per year for finished products	0,309	-0,07	-0,02	-0,13	0,41	0,012	-0,63	-0,2	0,11	-0,39
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-0,52	0,384	0,572	-0,76	-0,63	-0,39	0,62	-0,15	0,905	0,276
Inventory KPI's											
Average inventory	Average of finished products	-1,12	0,057	-0,06	0,233	-0,74	-0,28	0,588	-0,03	-0,25	0,005
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-2,61	-1,83	0,364	0,206	-0,53	0,743	1,704	-0,66	0,817	0,448
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,65	0,827	-0,46	-0,88	-2,14	-1,51	-1,06	-0,32	0,148	-0,11
Max inbound	Maximum inbound of materials/products	-1,76	0,185	1,441	-1,54	-1,77	1,608	-0,6	-0,23	1,082	0,986
Inbound frequency	Number of inbounds of materials/products	0,159	-1,06	0,085	0,686	0,971	1,234	0,826	0,084	-0,04	0,029
Average outbound	Average outbound of finished products	-0,21	-0,18	-0,03	-0,26	-0,32	-0,23	1,072	-0,15	-0,75	-1,28
Max outbound	Maximum outbound of finished products	-1,14	-0,23	-0,9	-0,17	-0,17	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	-0,91	-0,96	-1,09	-0,88	-0,82	0,159	-1,06	0,085	0,686	0,971
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,65	0,827	-0,46	-0,88	-2,14	-1,51	-1,06	-0,32	0,148	-0,11
Max orders	Maximum order quantity	-1,76	0,185	1,441	-1,54	-1,77	1,608	-0,6	-0,23	1,082	0,986
Order frequency	Number of orders	0,159	-1,06	0,085	0,686	0,971	1,234	0,826	0,084	-0,04	0,029
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,33	0,384	-0,33	-0,47					
	Av forecast deviation as a perc of av demand		-0,4	0,555	-0,39	-0,58					
Discount percentage	Average discount percentage		-0,22	-1,02	0,963	0,709					
	Av disc perc as a perc of the max possible discount		-0,22	-1,02	0,963	0,709					

4255030		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,043	0,571	-0,3	-0,23	0,705	0	0	0	0	0
	By percentage of days without any backlogs	-0	0,078	-0,15	-0,2	-0,31	-0,24	-0,92	-0,04	-0,44	0,243
Inventory turnover	Times per year for finished products	0,034	-0,1	-0,03	-0,27	-0,11	0,95	-0,05	0,653	-0,42	0,57
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-0,18	0,561	0,336	0,659	-0,51	2,262	1,017	0,701	-0,01	0,964
Inventory KPI's											
Average inventory	Average of finished products	-0,23	0,102	-0,03	0,527	0,187	-2,08	-0,12	-1,26	0,353	-0,91
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-0,65	-1,86	-0,02	0,766	0,37	0,331	1,711	-0,89	-1,24	1,523
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,09	0,974	-0,13	0,143	-0,26	0,528	0,721	0,329	-0,29	0,242
Max inbound	Maximum inbound of materials/products	-1,24	0,646	1,568	0,99	-0,35	1,569	-0,59	-0,31	-0,43	1,002
Inbound frequency	Number of inbounds of materials/products	-0,2	-0,93	0,003	-0,41	0,286	-0,41	-0,6	-0,12	0,028	-0,07
Average outbound	Average outbound of finished products	-0,06	-0,1	-0,04	-0,06	-0,2	0,213	1,036	4E-04	0,425	-0,28
Max outbound	Maximum outbound of finished products	0,507	0,494	0,18	0,149	0,151	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	-1,08	-1,03	-1,09	-1,06	-0,92	-0,2	-0,93	0,003	-0,41	0,286
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,09	0,974	-0,13	0,143	-0,26	0,528	0,721	0,329	-0,29	0,242
Max orders	Maximum order quantity	-1,24	0,646	1,568	0,99	-0,35	1,569	-0,59	-0,31	-0,43	1,002
Order frequency	Number of orders	-0,2	-0,93	0,003	-0,41	0,286	-0,41	-0,6	-0,12	0,028	-0,07
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,14	0,056	0,04	0,139					
	Av forecast deviation as a perc of av demand		-0	0,185	0,077	0,193					
Discount percentage	Average discount percentage		0,062	-0,4	-0,73	0,552					
	Av disc perc as a perc of the max possible discount		0,062	-0,4	-0,73	0,552					

4255030		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,093	0,704	0,649	0,012	0,25	0	0	0	0	0
	By percentage of days without any backlogs	-0,08	0,092	0,155	-0,19	0,167	-0,3	-0,76	0,012	-0,56	-0,62
Inventory turnover	Times per year for finished products	-0	-0,23	-0,14	0,093	-0,36	0,606	0,069	-0,8	-0,55	-0,06
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,375	0,526	-0,02	0,55	0,415	2,338	0,261	0,214	0,032	0,492
Inventory KPI's											
Average inventory	Average of finished products	-0,21	0,482	0,215	-0,26	0,624	-1,4	-0,2	1,174	0,876	0,225
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,92	0,143	2	-0,53	0,629	-0,11	0,328	-0,88	1,03	-0,75
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,083	0,772	-0,14	0,509	0,727	0,537	0,775	-0,63	1,05	0,206
Max inbound	Maximum inbound of materials/products	-0,12	0,168	0,233	0,067	0,741	-0,59	1,022	-2,07	1,02	-1,19
Inbound frequency	Number of inbounds of materials/products	-0,27	-0,76	0,055	-0,54	-0,6	-0,44	-0,67	0,75	-0,84	-0,03
Average outbound	Average outbound of finished products	-0,13	-0,26	-0,28	-0,29	-0,18	0,306	0,863	-0,05	0,636	0,742
Max outbound	Maximum outbound of finished products	0,03	0,451	1,282	0,453	0,458	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	-1	-0,88	-0,87	-0,85	-0,96	-0,27	-0,76	0,055	-0,54	-0,6
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,083	0,772	-0,14	0,509	0,727	0,537	0,775	-0,63	1,05	0,206
Max orders	Maximum order quantity	-0,12	0,168	0,233	0,067	0,741	-0,59	1,022	-2,07	1,02	-1,19
Order frequency	Number of orders	-0,27	-0,76	0,055	-0,54	-0,6	-0,44	-0,67	0,75	-0,84	-0,03
FAD KPI's											
Forecast deviation	Average forecast deviation		0,487	-0,09	0,573	-0,01					
	Av forecast deviation as a perc of av demand		0,872	-0,11	0,742	-0,03					
Discount percentage	Average discount percentage		-0,26	0,336	-0,27	0,13					
	Av disc perc as a perc of the max possible discount		-0,26	0,336	-0,27	0,13					

4536553		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,17	-0,81	-0,24	-0,27	-0,65	-0,04	-0,03	-0,03	0	-0,03
	By percentage of days without any backlogs	0,377	-0,63	-0,07	-0,08	-0,9	-0,04	-0,03	-0,03	0	-0,03
Inventory turnover	Times per year for finished products	0,071	0,071	0,148	0,059	0,025	1,031	-1,65	-1,1	0,83	-0,23
	Times per year for materials						-0,27	-0,24	-0,25	-0,23	-0,07
Bullwhip Effect	Amplification on weekly level	0,369	1,095	0,333	0,009	1,364	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,04	-0,05	-0,19	0,016	0,11	-1,42	1,672	1,115	-1,19	0,263
	Average of materials						0,112	-0,08	-0,03	0,097	-0,02
Max inventory	Maximum of finished products	-0,24	-1,54	-0,44	0,73	-0,16	-0,49	-0,2	-0,27	-0,27	-0,28
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,38	0,899	0,047	-0,86	1,211	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,466	0,017	-0,1	-2,07	-0,35	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,03	-0,74	-0,25	0,391	-0,95	0	0	0	0	0
Average outbound	Average outbound of finished products	-0,73	-0,34	-0,55	-0,51	-0,37	-0,4	0,844	-0,01	-0,84	1,185
Max outbound	Maximum outbound of finished products	0,215	0,205	0,137	0,039	-0	0,123	0,185	0,129	0,002	0,15
Outbound frequency	Number of outbounds of finished products	2,219	0,897	1,677	1,567	1,064	-0,03	-0,74	-0,25	0,391	-0,95
Production KPI's											
Average production	Average production quantity						-1,47	-0,06	0,08	-1,29	1,398
Max production	Maximum production quantity						0,683	-0,02	0,44	-0,12	1,404
Production frequency	Number of production runs						1,151	-0,53	-0,43	1,157	-1,26
Ordering KPI's											
Average orders	Average order quantity	-0,38	0,899	0,048	-0,86	1,212	0	0	0	0	0
Max orders	Maximum order quantity	0,466	0,017	-0,1	-2,07	-0,35	0	0	0	0	0
Order frequency	Number of orders	-0,03	-0,74	-0,26	0,391	-0,95	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,27	-0,01	0,961	0,664					
	Av forecast deviation as a perc of av demand		-1,26	-0,03	1,016	0,7					
Discount percentage	Average discount percentage		-1,13	-0,26	-0,56	-0,85					
	Av disc perc as a perc of the max possible discount		-1,13	-0,26	-0,56	-0,85					

4536553		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,17	-0,81	-0,24	-0,27	-0,65	-0,07	-0,05	-0,03	-0,04	-0,03
	By percentage of days without any backlogs	0,377	-0,63	-0,07	-0,08	-0,9	-0,07	-0,06	-0,03	-0,04	-0,03
Inventory turnover	Times per year for finished products	0,071	0,07	0,148	0,059	0,025	0,274	0,428	0,352	0,23	0,433
	Times per year for materials						-0,27	-0,24	-0,26	-0,23	-0,07
Bullwhip Effect	Amplification on weekly level	0,368	1,096	0,333	0,009	1,364	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,04	-0,05	-0,19	0,016	0,11	-1,13	-1,3	-1,22	-0,95	-0,92
	Average of materials						0,03	0,036	0,043	0,026	0,005
Max inventory	Maximum of finished products	-0,24	-1,54	-0,44	0,73	-0,16	0,059	0,117	0,064	0,092	0,073
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,38	0,898	0,047	-0,86	1,211	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,466	0,019	-0,1	-2,07	-0,35	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,03	-0,74	-0,25	0,392	-0,95	0	0	0	0	0
Average outbound	Average outbound of finished products	-0,73	-0,34	-0,55	-0,51	-0,37	-0,41	0,843	-0,01	-0,84	1,185
Max outbound	Maximum outbound of finished products	0,215	0,204	0,137	0,039	-0	0,123	0,188	0,129	0,002	0,15
Outbound frequency	Number of outbounds of finished products	2,218	0,897	1,676	1,566	1,064	-0,03	-0,74	-0,25	0,392	-0,95
Production KPI's											
Average production	Average production quantity						-0,39	0,705	-0,13	-0,98	1,073
Max production	Maximum production quantity						0,139	0,179	0,129	0,129	0,148
Production frequency	Number of production runs						-0,02	-0,63	-0,15	0,484	-0,83
Ordering KPI's											
Average orders	Average order quantity	-0,38	0,899	0,048	-0,86	1,212	0	0	0	0	0
Max orders	Maximum order quantity	0,466	0,019	-0,1	-2,07	-0,35	0	0	0	0	0
Order frequency	Number of orders	-0,03	-0,74	-0,26	0,391	-0,95	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,28	-0,01	0,961	0,664					
	Av forecast deviation as a perc of av demand		-1,27	-0,03	1,016	0,7					
Discount percentage	Average discount percentage		-1,12	-0,26	-0,56	-0,85					
	Av disc perc as a perc of the max possible discount		-1,12	-0,26	-0,56	-0,85					

4536553		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,47	-0,8	-0,36	-0,57	-0,34	-0,04	-0,05	-0,04	-0,05	-0,04
	By percentage of days without any backlogs	0,315	-0,62	-0,01	-0,75	-0,14	-0,04	-0,06	-0,04	-0,05	-0,04
Inventory turnover	Times per year for finished products	0,101	0,042	-0,02	0,363	0,049	0,139	0,392	0,016	0,482	0,217
	Times per year for materials						-0,08	-0,24	-0,18	0,122	-0,19
Bullwhip Effect	Amplification on weekly level	-0,07	1,027	1,039	0,893	0,606	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,11	0,005	0,133	-0,39	0,067	-0,41	-1,26	-0,47	-0,54	-0,85
	Average of materials						0,031	0,032	0,013	0,096	0,01
Max inventory	Maximum of finished products	0,514	-1,54	0,2	-0,41	-0,36	-0,56	0,117	-0,15	1,535	-0,34
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,94	0,746	1,015	0,373	0,36	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	-0,69	0,046	-0,29	1,058	-0,41	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	0,223	-0,65	-0,71	-0,15	-0,34	0	0	0	0	0
Average outbound	Average outbound of finished products	-0,68	-0,34	-0,34	-0,25	-0,49	-0,67	0,688	0,927	0,365	0,267
Max outbound	Maximum outbound of finished products	0,118	0,2	0,105	0,102	-0,49	-0,69	0,208	-0,29	1,374	-0,42
Outbound frequency	Number of outbounds of finished products	2,244	0,9	0,969	0,592	1,631	0,223	-0,65	-0,71	-0,15	-0,34
Production KPI's											
Average production	Average production quantity						-1,09	0,698	0,561	0,148	-0,01
Max production	Maximum production quantity						-0,68	0,198	-0,29	1,392	-0,41
Production frequency	Number of production runs						0,468	-0,63	-0,49	-0	-0,13
Ordering KPI's											
Average orders	Average order quantity	-0,95	0,747	1,014	0,374	0,362	0	0	0	0	0
Max orders	Maximum order quantity	-0,69	0,046	-0,29	1,058	-0,41	0	0	0	0	0
Order frequency	Number of orders	0,223	-0,65	-0,71	-0,15	-0,34	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,27	-1,49	0,267	0,622					
	Av forecast deviation as a perc of av demand		-1,06	-1,6	0,266	0,637					
Discount percentage	Average discount percentage		-0,71	1,142	-0,29	-0,76					
	Av disc perc as a perc of the max possible discount		-0,71	1,142	-0,29	-0,76					

4536553		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,17	-0,81	-0,24	-0,27	-0,65	-0,07	-0,05	-0,03	-0,04	-0,03
	By percentage of days without any backlogs	0,377	-0,63	-0,07	-0,08	-0,9	-0,07	-0,06	-0,03	-0,04	-0,03
Inventory turnover	Times per year for finished products	0,071	0,07	0,148	0,059	0,025	0,274	0,428	0,352	0,23	0,433
	Times per year for materials						-0,27	-0,24	-0,26	-0,23	-0,07
Bullwhip Effect	Amplification on weekly level	0,368	1,096	0,333	0,009	1,364	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,04	-0,05	-0,19	0,016	0,11	-1,13	-1,3	-1,22	-0,95	-0,92
	Average of materials						0,03	0,036	0,043	0,026	0,005
Max inventory	Maximum of finished products	-0,24	-1,54	-0,44	0,73	-0,16	0,059	0,117	0,064	0,092	0,073
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,38	0,898	0,047	-0,86	1,211	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,466	0,019	-0,1	-2,07	-0,35	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,03	-0,74	-0,25	0,392	-0,95	0	0	0	0	0
Average outbound	Average outbound of finished products	-0,73	-0,34	-0,55	-0,51	-0,37	-0,41	0,843	-0,01	-0,84	1,185
Max outbound	Maximum outbound of finished products	0,215	0,204	0,137	0,039	-0	0,123	0,188	0,129	0,002	0,15
Outbound frequency	Number of outbounds of finished products	2,218	0,897	1,676	1,566	1,064	-0,03	-0,74	-0,25	0,392	-0,95
Production KPI's											
Average production	Average production quantity						-0,39	0,705	-0,13	-0,98	1,073
Max production	Maximum production quantity						0,139	0,179	0,129	0,129	0,148
Production frequency	Number of production runs						-0,02	-0,63	-0,15	0,484	-0,83
Ordering KPI's											
Average orders	Average order quantity	-0,38	0,899	0,048	-0,86	1,212	0	0	0	0	0
Max orders	Maximum order quantity	0,466	0,019	-0,1	-2,07	-0,35	0	0	0	0	0
Order frequency	Number of orders	-0,03	-0,74	-0,26	0,391	-0,95	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,28	-0,01	0,961	0,664					
	Av forecast deviation as a perc of av demand		-1,27	-0,03	1,016	0,7					
Discount percentage	Average discount percentage		-1,12	-0,26	-0,56	-0,85					
	Av disc perc as a perc of the max possible discount		-1,12	-0,26	-0,56	-0,85					

4536553		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,771	-0,47	-0,71	-0,48	0,854	-1,11	0,092	2,409	-0,17	2,63
	By percentage of days without any backlogs	-0,23	-0,5	-0,89	0,26	0,408	-1,15	0,445	2,599	0,031	2,548
Inventory turnover	Times per year for finished products	0,078	0,085	0,475	0,245	0,926	0,2	0,581	0,497	0,482	0,392
	Times per year for materials						-0,11	-0,24	-0,07	-0,13	-0,06
Bullwhip Effect	Amplification on weekly level	-0,02	0,113	0,036	0,277	-1,5	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,11	-0,12	-0,7	-0,2	-1,14	-0,6	-1,57	-1,07	-1,14	-0,84
	Average of materials						0,026	0,037	0,102	0,069	0,316
Max inventory	Maximum of finished products	0,212	0,248	0,339	-0,15	-1,34	0,264	0,249	0,182	0,164	0,16
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,92	-0,33	1,975	0,393	0,942	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	-0,35	0,547	-2,19	0,349	0,063	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	0,509	0,058	-1,63	-0,36	-0,69	0	0	0	0	0
Average outbound	Average outbound of finished products	-0,57	-0,5	-0,52	-0,61	-0,61	-0,93	-0,37	1,985	0,363	0,916
Max outbound	Maximum outbound of finished products	-1,29	-0,52	-0,56	-0,57	-0,6	0,162	0,163	-0,03	0,144	0,121
Outbound frequency	Number of outbounds of finished products	2,337	2,097	2,197	2,672	2,766	0,509	0,058	-1,63	-0,36	-0,69
Production KPI's											
Average production	Average production quantity						0,756	-2	-0,68	-0,23	-1,16
Max production	Maximum production quantity						0,438	0,377	0,294	0,289	0,272
Production frequency	Number of production runs						-0,58	1,142	0,476	0,068	0,791
Ordering KPI's											
Average orders	Average order quantity	0,203	-0,85	0,521	0,37	-0,5	0	0	0	0	0
Max orders	Maximum order quantity	-0,1	0,642	-1,84	0,409	-1,19	0	0	0	0	0
Order frequency	Number of orders	-0,21	0,344	-0,47	-0,38	0,303	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,14	-1,47	0,476	-0,46					
	Av forecast deviation as a perc of av demand		-0,17	-1,6	0,496	-0,51					
Discount percentage	Average discount percentage		-0,01	1,71	-0,62	0,882					
	Av disc perc as a perc of the max possible discount		-0,01	1,71	-0,62	0,882					

4531430		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0	0	0	0	0	1,17	2,132	0,405	1,607	2,336
	By percentage of days without any backlogs	0	0	0	0	0	1,136	1,459	0,497	0,467	1,742
Inventory turnover	Times per year for finished products	-0,16	-0,14	-0,71	0,015	-1,19	-1,2	-0,9	-0,1	-0,67	-0,56
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,799	1,812	1,738	1,525	1,45	1,029	1,008	1,092	1,148	0,916
Inventory KPI's											
Average inventory	Average of finished products	0,475	0,413	1,094	0,077	1,332	1,358	0,974	0,2	0,89	0,778
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	0,737	0,638	1,073	0,171	0,654	-0,81	-1,66	-0,08	-0,49	-0,57
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-1,03	-1,51	-1,05	-0,93	-0,97	-0,11	-1,7	-0,86	-1,15	-1,35
Max inbound	Maximum inbound of materials/products	0	0	0	0	0	-0,82	-1,7	-1,7	-1,85	-1,97
Inbound frequency	Number of inbounds of materials/products	0,612	0,907	0,717	0,833	0,897	0	0	0	0,105	0,153
Average outbound	Average outbound of finished products	-0,36	-0,36	-0,36	-0,36	-0,36	0,87	0,928	0,481	0,636	1,62
Max outbound	Maximum outbound of finished products	-9,92	-9,92	-9,92	-9,92	-9,92	1,495	2,556	0,889	-0,35	3,614
Outbound frequency	Number of outbounds of finished products	0,801	0,801	0,801	0,801	0,801	-0,9	-1,26	-0,4	-0,11	-0,94
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0	0	0	0	0	-0,11	-1,7	-0,86	-1,15	-1,35
Max orders	Maximum order quantity	0	0	0	0	0	-0,82	-1,7	-1,7	-1,85	-1,97
Order frequency	Number of orders	-0,14	-0,17	0,019	0,404	0,48	0	0	0	0,105	0,153
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,25	0,715	0,815	1,81					
	Av forecast deviation as a perc of av demand		-0,35	0,72	0,826	1,857					
Discount percentage	Average discount percentage		0,347	-0,7	-0,49	-1,31					
	Av disc perc as a perc of the max possible discount		0,347	-0,7	-0,49	-1,31					

4531430		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0	0	0	0	0	-0,57	-1,03	-0,03	-1,3	2,899
	By percentage of days without any backlogs	0	0	0	0	0	0,795	0,419	1,889	1,688	0,503
Inventory turnover	Times per year for finished products	0,14	-0,06	0,489	-0,01	0,079	0,203	0,462	-0,51	1,32	0,54
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,243	0,075	-0,26	0,436	1,677	0,767	2,56	0,318	0,089	-0,68
Inventory KPI's											
Average inventory	Average of finished products	-0,41	0,297	-1,54	0,119	-0,06	-0,45	-1,03	0,745	-1,88	-0,97
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,89	-1,89	-1,76	0,206	0,256	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,63	-0,85	-0,58	-0,49	-0,19	1,601	1,238	0,397	0,589	-1,41
Max inbound	Maximum inbound of materials/products	-12,4	-0,45	0,085	-9,93	0,048	0,927	1,176	-0,41	-0,41	-2,48
Inbound frequency	Number of inbounds of materials/products	0,236	0,282	0,306	0,419	-0,04	-1,65	-1,25	-0,19	-0,47	0,775
Average outbound	Average outbound of finished products	-0,36	-0,36	-0,36	-0,36	-0,36	0,012	-0,3	0,019	-0,13	0,259
Max outbound	Maximum outbound of finished products	-9,92	-9,92	-9,92	-9,92	-9,92	-0,11	-0,57	0,471	0,262	-3,62
Outbound frequency	Number of outbounds of finished products	0,801	0,801	0,801	0,801	0,801	-0,05	0,096	-0,05	0,167	-0,26
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,63	-0,84	-1,26	-1,12	-0,18	1,601	1,238	0,397	0,589	-1,41
Max orders	Maximum order quantity	-12,4	-0,45	0,09	-9,89	0,052	0,927	1,176	-0,41	-0,41	-2,48
Order frequency	Number of orders	0,235	0,276	0,725	0,792	-0,04	-1,65	-1,25	-0,19	-0,47	0,775
FAD KPI's											
Forecast deviation	Average forecast deviation		0,213	-0,8	0,569	1,015					
	Av forecast deviation as a perc of av demand		0,473	-0,99	0,597	1,066					
Discount percentage	Average discount percentage		1,265	2,175	0,642	-0,86					
	Av disc perc as a perc of the max possible discount		1,265	2,175	0,642	-0,86					

4531430		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0	0	0	0	0	0,651	-0,32	1,465	0,544	-0,12
	By percentage of days without any backlogs	0	0	0	0	0	1,565	0,551	0,104	-0,25	-0,97
Inventory turnover	Times per year for finished products	0,108	-0,06	0,009	-0,12	-0,53	0,522	0,464	0,211	0,531	0,477
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	0,263	-0,35	1,453	1,33	1,928	-0,25	1,281	-0,96	-0,75	0,763
Inventory KPI's											
Average inventory	Average of finished products	-0,3	0,281	0,055	0,326	0,969	-1,03	-0,92	-0,3	-0,43	-0,41
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,19	-1,89	-0,33	0,401	0,857	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,56	0,141	0,986	0,728	1,702	-0,73	0,419	-2,14	0,51	1,246
Max inbound	Maximum inbound of materials/products	-9,66	-0,25	-1,2	-0,6	-0,96	-0,99	-0,54	-0,07	-0,11	1,407
Inbound frequency	Number of inbounds of materials/products	0,205	-0,23	-0,57	-0,26	-1,08	0,309	-0,51	1,68	-0,39	-0,91
Average outbound	Average outbound of finished products	-0,36	-0,36	-0,36	-0,36	-0,36	-0,26	0,063	0,326	0,465	1,179
Max outbound	Maximum outbound of finished products	-9,92	-9,92	-9,92	-9,92	-9,92	-0,45	-0,34	-1,13	-0,01	-1,15
Outbound frequency	Number of outbounds of finished products	0,801	0,801	0,801	0,801	0,801	0,095	-0,12	-0,22	-0,19	-0,76
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-1,66	-0,43	0,323	0,755	1,723	-0,73	0,419	-2,14	0,51	1,246
Max orders	Maximum order quantity	-11,9	-2,3	-1,21	-0,61	-0,97	-0,99	-0,54	-0,07	-0,11	1,407
Order frequency	Number of orders	0,732	0,123	-0,16	-0,28	-1,09	0,309	-0,51	1,68	-0,39	-0,91
FAD KPI's											
Forecast deviation	Average forecast deviation		0,417	-0	0,598	-1,2					
	Av forecast deviation as a perc of av demand		0,657	-0,03	0,608	-1,27					
Discount percentage	Average discount percentage		1,114	-0,34	0,011	0,906					
	Av disc perc as a perc of the max possible discount		1,114	-0,34	0,011	0,906					

4531430		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0	0	0	0	0	-0,57	-1,03	-0,03	-1,3	2,899
	By percentage of days without any backlogs	0	0	0	0	0	0,795	0,419	1,889	1,688	0,503
Inventory turnover	Times per year for finished products	0,14	-0,06	0,489	-0,01	0,079	0,203	0,462	-0,51	1,32	0,54
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	1,243	0,075	-0,26	0,436	1,677	0,767	2,56	0,318	0,089	-0,68
Inventory KPI's											
Average inventory	Average of finished products	-0,41	0,297	-1,54	0,119	-0,06	-0,45	-1,03	0,745	-1,88	-0,97
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,89	-1,89	-1,76	0,206	0,256	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,63	-0,85	-0,58	-0,49	-0,19	1,601	1,238	0,397	0,589	-1,41
Max inbound	Maximum inbound of materials/products	-12,4	-0,45	0,085	-9,93	0,048	0,927	1,176	-0,41	-0,41	-2,48
Inbound frequency	Number of inbounds of materials/products	0,236	0,282	0,306	0,419	-0,04	-1,65	-1,25	-0,19	-0,47	0,775
Average outbound	Average outbound of finished products	-0,36	-0,36	-0,36	-0,36	-0,36	0,012	-0,3	0,019	-0,13	0,259
Max outbound	Maximum outbound of finished products	-9,92	-9,92	-9,92	-9,92	-9,92	-0,11	-0,57	0,471	0,262	-3,62
Outbound frequency	Number of outbounds of finished products	0,801	0,801	0,801	0,801	0,801	-0,05	0,096	-0,05	0,167	-0,26
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,63	-0,84	-1,26	-1,12	-0,18	1,601	1,238	0,397	0,589	-1,41
Max orders	Maximum order quantity	-12,4	-0,45	0,09	-9,89	0,052	0,927	1,176	-0,41	-0,41	-2,48
Order frequency	Number of orders	0,235	0,276	0,725	0,792	-0,04	-1,65	-1,25	-0,19	-0,47	0,775
FAD KPI's											
Forecast deviation	Average forecast deviation		0,213	-0,8	0,569	1,015					
	Av forecast deviation as a perc of av demand		0,473	-0,99	0,597	1,066					
Discount percentage	Average discount percentage		1,265	2,175	0,642	-0,86					
	Av disc perc as a perc of the max possible discount		1,265	2,175	0,642	-0,86					

4531430		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0	0	0	0	0	0,071	-0,72	0,264	0,165	-0,29
	By percentage of days without any backlogs	0	0	0	0	0	-0,29	-2,04	0,84	-0,16	0,26
Inventory turnover	Times per year for finished products	0,045	0,096	0,143	0,116	0,071	-0,59	0,167	0,122	1,279	1,381
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	2,036	2,045	1,389	0,953	1,587	-0,02	0,774	-1,77	0,004	-0,48
Inventory KPI's											
Average inventory	Average of finished products	-0,13	-0,31	-0,3	-0,17	-0,02	0,824	-0,58	-0,42	-2,09	-2,33
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,89	-1,89	-0,02	0,213	0,437	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-1,84	0,299	-1,39	-1,34	0,607	-0,05	1,576	-1,16	0,253	-1,07
Max inbound	Maximum inbound of materials/products	-2,15	-1,45	-3,81	-7,38	-0,19	1	1,234	-2,41	-2,25	-0,41
Inbound frequency	Number of inbounds of materials/products	0,633	-0,46	0,52	0,552	-0,52	0,199	-1,56	0,892	-0,59	0,803
Average outbound	Average outbound of finished products	-0,36	-0,36	-0,36	-0,36	-0,36	-1,36	-0,8	-0,55	-1,17	0,886
Max outbound	Maximum outbound of finished products	-9,92	-9,92	-9,92	-9,92	-9,92	0,9	0,561	-4,06	-3,41	0,17
Outbound frequency	Number of outbounds of finished products	0,801	0,801	0,801	0,801	0,801	0,736	0,373	0,229	0,65	-0,69
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-1,85	0,315	-1,39	-1,33	0,61	-0,05	1,576	-1,16	0,253	-1,07
Max orders	Maximum order quantity	-2,15	-1,45	-3,79	-7,32	-0,19	1	1,234	-2,41	-2,25	-0,41
Order frequency	Number of orders	0,632	-0,47	0,518	0,549	-0,52	0,199	-1,56	0,892	-0,59	0,803
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,66	0,859	0,032	1,58					
	Av forecast deviation as a perc of av demand		-0,82	0,918	0,008	1,647					
Discount percentage	Average discount percentage		-0,27	-0,89	0,384	-1,24					
	Av disc perc as a perc of the max possible discount		-0,27	-0,89	0,384	-1,24					

3407384		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,45	-0,39	-0,13	0,009	0,367	0	0	0	0	0
	By percentage of days without any backlogs	-1,47	-1,65	-0,17	-1,27	-0,51	0	0	0	0	0
Inventory turnover	Times per year for finished products	0,891	0,531	0,344	1,036	1,207	0,772	0,548	0,76	0,788	-0,12
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-1,2	-0,51	-0,2	0,04	0,824	-0,13	-0,11	0,523	1,659	-0,55
Inventory KPI's											
Average inventory	Average of finished products	-1,37	-0,21	0,246	-1,34	-1,65	-1,56	-0,38	-1,18	-1,57	-0,57
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,16	-0,25	0,18	-0,89	-1,42	0,065	0,007	-0,42	-0,22	-0,93
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,46	-0,07	0,408	-0,09	0,066	0,071	0,729	1,115	1,193	-0,42
Max inbound	Maximum inbound of materials/products	-1,14	-0,25	-0,04	-0,22	0,788	-0,21	-0,14	0,819	0,885	-0,49
Inbound frequency	Number of inbounds of materials/products	0,651	0,532	-0,03	0,264	-0,41	-0,08	-0,39	-0,82	-0,85	0,031
Average outbound	Average outbound of finished products	1,748	1,179	1,257	2,134	2,511	-0,46	-0,22	0,365	-0,17	0,137
Max outbound	Maximum outbound of finished products	-0,11	0,244	0,705	0,797	1,578	0,096	0,068	0,068	0,061	0,068
Outbound frequency	Number of outbounds of finished products	-0,62	-0,24	-0,31	-0,95	-1,28	0,651	0,532	-0,03	0,264	-0,41
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,46	-0,07	0,408	-0,09	0,066	0,071	0,729	1,115	1,193	-0,42
Max orders	Maximum order quantity	-1,14	-0,25	-0,04	-0,22	0,788	-0,21	-0,14	0,819	0,885	-0,49
Order frequency	Number of orders	0,651	0,532	-0,03	0,264	-0,41	-0,08	-0,39	-0,82	-0,85	0,031
FAD KPI's											
Forecast deviation	Average forecast deviation		0,403	0,417	0,692	0,187					
	Av forecast deviation as a perc of av demand		-0,24	0,018	0,537	-0,17					
Discount percentage	Average discount percentage		0,261	-0,68	-0,98	-1,02					
	Av disc perc as a perc of the max possible discount		0,261	-0,68	-0,98	-1,02					

3407384		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,45	-0,39	-0,13	0,009	0,367	0	0	0	0	0
	By percentage of days without any backlogs	-1,47	-1,65	-0,17	-1,27	-0,51	0	0	0	0	0
Inventory turnover	Times per year for finished products	0,891	0,531	0,344	1,036	1,207	0,296	0,08	0,222	0,64	-0,31
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-1,2	-0,51	-0,2	0,04	0,824	-0,89	-1,01	-0,22	0,953	-0,83
Inventory KPI's											
Average inventory	Average of finished products	-1,37	-0,21	0,246	-1,34	-1,65	0,12	1,395	0,103	-1,56	-0,2
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-1,16	-0,25	0,18	-0,89	-1,42	0,118	0,116	0,067	0,109	-0,87
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,46	-0,07	0,408	-0,09	0,066	0,165	1,128	-0,89	-1,22	0,352
Max inbound	Maximum inbound of materials/products	-1,14	-0,25	-0,04	-0,22	0,788	0,082	0,194	0,295	1,254	-0,41
Inbound frequency	Number of inbounds of materials/products	0,651	0,532	-0,03	0,264	-0,41	0,113	-0,49	0,719	0,958	-0,43
Average outbound	Average outbound of finished products	1,748	1,179	1,257	2,134	2,511	-0,46	-0,22	0,365	-0,17	0,137
Max outbound	Maximum outbound of finished products	-0,11	0,244	0,705	0,797	1,578	0,096	0,068	0,068	0,061	0,068
Outbound frequency	Number of outbounds of finished products	-0,62	-0,24	-0,31	-0,95	-1,28	0,651	0,532	-0,03	0,264	-0,41
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	-0,46	-0,07	0,408	-0,09	0,066	0,165	1,128	-0,89	-1,22	0,352
Max orders	Maximum order quantity	-1,14	-0,25	-0,04	-0,22	0,788	0,082	0,194	0,295	1,254	-0,41
Order frequency	Number of orders	0,651	0,532	-0,03	0,264	-0,41	0,113	-0,49	0,719	0,958	-0,43
FAD KPI's											
Forecast deviation	Average forecast deviation		0,403	0,417	0,692	0,187					
	Av forecast deviation as a perc of av demand		-0,24	0,018	0,537	-0,17					
Discount percentage	Average discount percentage		0,261	-0,68	-0,98	-1,02					
	Av disc perc as a perc of the max possible discount		0,261	-0,68	-0,98	-1,02					

3407384		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,065	-0,12	0,372	0,012	0,383	0	0	0	0	0
	By percentage of days without any backlogs	-1,14	-1,73	-1,51	-1,78	-0,2	0	0	0	0	0
Inventory turnover	Times per year for finished products	0,748	0,286	0,615	0,843	1,019	0,156	0,183	0,512	0,547	0,331
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-0,6	-0,74	-1,15	-0,94	-0,28	-0,87	-0,78	-0,19	-0,5	-0,93
Inventory KPI's											
Average inventory	Average of finished products	-0,94	0,484	-0,47	-0,89	-1,35	0,833	1,022	-0,31	0,031	0,44
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-0,51	-0,22	-0,77	-0,74	-0,12	0,39	0,017	0,52	-0,46	0,417
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,427	0,036	-0,07	0,649	-0,08	-1,09	1,219	0,197	-1,24	-1,85
Max inbound	Maximum inbound of materials/products	-0,51	-0,22	-0,77	-0,84	0,111	1,153	0,173	-0,49	0,609	0,62
Inbound frequency	Number of inbounds of materials/products	0,044	0,47	0,562	0,1	0,611	1,004	-0,56	-0,02	1,36	1,527
Average outbound	Average outbound of finished products	1,487	1,077	1,13	1,504	1,708	0,37	-0,12	-0,26	0,512	-0,31
Max outbound	Maximum outbound of finished products	-0,07	0,279	-0,19	-0,13	1,235	0,081	0,066	0,071	0,059	0,057
Outbound frequency	Number of outbounds of finished products	-0,51	-0,18	-0,24	-0,5	-0,6	0,044	0,47	0,562	0,1	0,611
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,427	0,036	-0,07	0,649	-0,08	-1,09	1,219	0,197	-1,24	-1,85
Max orders	Maximum order quantity	-0,51	-0,22	-0,77	-0,84	0,111	1,153	0,173	-0,49	0,609	0,62
Order frequency	Number of orders	0,044	0,47	0,562	0,1	0,611	1,004	-0,56	-0,02	1,36	1,527
FAD KPI's											
Forecast deviation	Average forecast deviation		0,186	0,508	0,714	0,395					
	Av forecast deviation as a perc of av demand		-1,2	0,157	0,631	0,054					
Discount percentage	Average discount percentage		0,407	0,142	-0,44	-0,21					
	Av disc perc as a perc of the max possible discount		0,407	0,142	-0,44	-0,21					

3407384		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	0,482	0,076	0,153	0,252	0,388	0	0	0	0	0
	By percentage of days without any backlogs	0,194	-1,08	-0,99	-0,64	-0,93	0	0	0	0	0
Inventory turnover	Times per year for finished products	0,568	0,267	0,523	0,586	0,514	0,473	0,223	0,206	0,131	0,215
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-0,36	-0,52	-0,4	0,013	-0,52	-0,58	-0,49	-0,97	-1,31	-1,75
Inventory KPI's											
Average inventory	Average of finished products	-0,36	0,536	-0,21	-0,35	-0,14	-0,38	0,934	0,642	0,563	0,514
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	-0,17	-0,26	-0,37	-0,14	-0,12	-0,39	0,524	-0,6	-0,42	0,977
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,433	1,266	0,819	0,708	0,69	-1,09	0,574	0,055	-1,42	-0,69
Max inbound	Maximum inbound of materials/products	-0,17	-0,26	-0,37	-0,2	-0,5	0,019	1,406	-0,07	-0,31	-0,14
Inbound frequency	Number of inbounds of materials/products	0,158	-0,58	-0,27	-0,32	-0,25	1,006	-0	0,201	1,209	0,665
Average outbound	Average outbound of finished products	2,062	1,762	1,388	2,061	1,495	0,292	1,309	0,806	0,734	0,694
Max outbound	Maximum outbound of finished products	0,179	0,259	0,192	0,535	0,393	0,052	0,05	0,043	0,053	0,034
Outbound frequency	Number of outbounds of finished products	-1,02	-0,72	-0,43	-0,98	-0,44	0,158	-0,58	-0,27	-0,32	-0,25
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,433	1,266	0,819	0,708	0,69	-1,09	0,574	0,055	-1,42	-0,69
Max orders	Maximum order quantity	-0,17	-0,26	-0,37	-0,2	-0,5	0,019	1,406	-0,07	-0,31	-0,14
Order frequency	Number of orders	0,158	-0,58	-0,27	-0,32	-0,25	1,006	-0	0,201	1,209	0,665
FAD KPI's											
Forecast deviation	Average forecast deviation		0,422	0,582	0,233	0,161					
	Av forecast deviation as a perc of av demand		-0,37	0,34	-0,51	-0,51					
Discount percentage	Average discount percentage		-0,58	-0,8	-0,51	-0,1					
	Av disc perc as a perc of the max possible discount		-0,58	-0,8	-0,51	-0,1					

3407384		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,3	-0,4	-0,1	0,415	0,383	0	0	0	0	0
	By percentage of days without any backlogs	-1,07	-1,32	-1,46	-1,07	-0,82	0	0	0	0	0
Inventory turnover	Times per year for finished products	0,292	0,374	0,619	0,756	0,849	0,389	0,333	0,33	0,266	0,126
	Times per year for materials						0	0	0	0	0
Bullwhip Effect	Amplification on weekly level	-0,15	-0,24	-0,7	-0,57	-0,8	-1,36	-0,83	0,142	-1,6	-0,25
Inventory KPI's											
Average inventory	Average of finished products	0,491	0,302	-0,47	-0,75	-0,93	0,284	0,292	-0,05	0,179	1,099
	Average of materials						0	0	0	0	0
Max inventory	Maximum of finished products	0,123	-0,17	-0,66	-0,29	0,517	0,207	0,034	1,593	1,341	1,6
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,985	0,558	0,298	0,513	-1,13	-0,63	-0,57	-0,19	-1,17	-1,48
Max inbound	Maximum inbound of materials/products	0,123	-0,17	-0,65	-0,43	-0,21	1,241	-0,02	1,052	1,044	1,328
Inbound frequency	Number of inbounds of materials/products	-0,29	-0	0,149	-0,09	1,428	0,712	0,632	0,238	1,12	1,186
Average outbound	Average outbound of finished products	1,336	1,012	0,663	1,471	1,173	1	0,493	0,19	0,467	-1,52
Max outbound	Maximum outbound of finished products	0,343	0,28	-0,12	0,271	0,676	0,075	0,064	0,087	0,061	0,046
Outbound frequency	Number of outbounds of finished products	-0,44	-0,12	0,129	-0,45	-0,2	-0,29	-0	0,149	-0,09	1,428
Production KPI's											
Average production	Average production quantity						0	0	0	0	0
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0	0	0	0	0
Ordering KPI's											
Average orders	Average order quantity	0,985	0,558	0,298	0,513	-1,13	-0,63	-0,57	-0,19	-1,17	-1,48
Max orders	Maximum order quantity	0,123	-0,17	-0,65	-0,43	-0,21	1,241	-0,02	1,052	1,044	1,328
Order frequency	Number of orders	-0,29	-0	0,149	-0,09	1,428	0,712	0,632	0,238	1,12	1,186
FAD KPI's											
Forecast deviation	Average forecast deviation		0,514	0,264	-0,05	-0,16					
	Av forecast deviation as a perc of av demand		0,117	-0,47	-0,98	-1,03					
Discount percentage	Average discount percentage		-0,42	-0,26	0,062	0,704					
	Av disc perc as a perc of the max possible discount		-0,42	-0,26	0,062	0,704					

4256632		Nullcase									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	-0,86	-1,09	-0,97	1,422	-0,82	0	0	0	0	0
	By percentage of days without any backlogs	-0,96	-1,23	-1,07	0,644	-0,9	-0,52	-0,51	-0,43	-0,13	0,066
Inventory turnover	Times per year for finished products	-0,63	-1,22	-0,38	-2,15	0,758	0,898	0,562	0,95	0,976	0,533
	Times per year for materials						-0,47	-0,49	-0,38	-0,06	0,15
Bullwhip Effect	Amplification on weekly level	1,016	0,989	0,93	0,681	0,576	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	0,494	1,419	0,149	1,671	-1,17	-1,7	-1,25	-1,77	-1,26	-0,43
	Average of materials						1,218	1,028	1,265	0,433	1,833
Max inventory	Maximum of finished products	0,169	-0,56	-0,13	1,136	-1,49	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	0,151	0,077	0,094	0,061	0,063	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,153	0,078	0,095	0,063	0,063	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,51	-0,5	-0,4	-0,06	0,145	0	0	0	0	0
Average outbound	Average outbound of finished products	-1,28	-1,35	-1,3	-1,87	-1,27	-0,31	-0,45	-0,35	-0,11	0,084
Max outbound	Maximum outbound of finished products	-0,37	-0,44	-0,36	-0,96	-0,25	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	0,047	0,08	0,055	0,304	0,042	-0,51	-0,5	-0,4	-0,06	0,145
Production KPI's											
Average production	Average production quantity						-0,35	-0,57	-0,48	-0,72	-0,5
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0,014	0,133	0,138	0,407	0,554
Ordering KPI's											
Average orders	Average order quantity	0,151	0,077	0,094	0,061	0,063	0	0	0	0	0
Max orders	Maximum order quantity	0,153	0,078	0,095	0,063	0,063	0	0	0	0	0
Order frequency	Number of orders	-0,51	-0,5	-0,4	-0,06	0,145	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,35	0,788	-1,22	0,41					
	Av forecast deviation as a perc of av demand		-0,11	0,918	-1,09	0,485					
Discount percentage	Average discount percentage		-0,2	-0,68	1,231	0,091					
	Av disc perc as a perc of the max possible discount		-0,2	-0,68	1,231	0,091					

4256632		Increment aleviation									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1,699	1,54	1,385	1,425	0,673	0	0	0	0	0
	By percentage of days without any backlogs	2,059	2,397	2,142	2,163	1,524	-0,32	-1,25	-0,99	-1,04	-1,8
Inventory turnover	Times per year for finished products	-0,41	-0,72	-0,89	-0,99	0,13	-0,32	-1,08	-0,96	-1,02	-2,1
	Times per year for materials						-0,68	-0,84	-0,71	-0,69	-2,86
Bullwhip Effect	Amplification on weekly level	0,953	1,827	1,588	1,529	2,03	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	0,023	0,691	0,785	0,809	-0,3	-1	0,556	0,683	0,84	-1,95
	Average of materials						1,148	1,057	1,036	0,876	1,267
Max inventory	Maximum of finished products	-0,1	0,84	0,353	0,753	-2,18	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,84	0,952	0,722	0,786	0,228	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	-0,75	0,413	0,582	0,549	0,438	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,25	-1,58	-1,23	-1,29	-2,36	0	0	0	0	0
Average outbound	Average outbound of finished products	-2,61	-0,74	-0,77	-0,69	-0,47	-0,76	1,23	0,942	0,992	0,683
Max outbound	Maximum outbound of finished products	-0,73	-0,56	-0,53	-0,47	-0,36	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	0,616	-0,17	-0,16	-0,2	-0,35	-0,25	-1,58	-1,23	-1,29	-2,36
Production KPI's											
Average production	Average production quantity						-0,64	1,116	0,837	0,902	0,85
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						-0,25	-1,42	-1,08	-1,15	-2,44
Ordering KPI's											
Average orders	Average order quantity	-0,84	0,952	0,722	0,786	0,228	0	0	0	0	0
Max orders	Maximum order quantity	-0,75	0,413	0,582	0,549	0,438	0	0	0	0	0
Order frequency	Number of orders	-0,25	-1,58	-1,23	-1,29	-2,36	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-2	-1,04	-1,11	-0,87					
	Av forecast deviation as a perc of av demand		-1,62	-0,95	-0,98	-0,78					
Discount percentage	Average discount percentage		0,23	0,215	0,365	-2,55					
	Av disc perc as a perc of the max possible discount		0,23	0,215	0,365	-2,55					

4256632		IA + MDBO=13									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1,226	1,974	1,428	1,621	-0,44	0	0	0	0	0
	By percentage of days without any backlogs	1,197	2,122	2,191	3,234	0,056	-0,33	-1,21	0,268	-1,25	-1,38
Inventory turnover	Times per year for finished products	-0,05	-0,61	0,15	-0,3	0,352	-0,74	-1	-0,98	-1,12	-0,68
	Times per year for materials						-0,62	-0,8	-0,94	-1,14	-1,53
Bullwhip Effect	Amplification on weekly level	1,279	1,598	0,511	1,954	2,157	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-1,03	0,539	-0,92	0,173	-0,8	0,251	0,466	0,037	-0,08	-2,1
	Average of materials						1,213	1,093	1,244	1,183	1,433
Max inventory	Maximum of finished products	0,05	0,34	-0,43	0,31	-2,08	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-0,57	0,698	-1,98	0,487	0,236	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,127	0,16	-1,14	0,784	0,7	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	-0,25	-1,38	0,407	-1,45	-1,62	0	0	0	0	0
Average outbound	Average outbound of finished products	-2,8	-0,82	-2,95	-1,13	-2,15	-0,28	1,156	-1,53	1,038	0,883
Max outbound	Maximum outbound of finished products	-0,14	-0,64	-0,74	0,059	-0,53	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	0,697	-0,1	0,76	-0,02	0,443	-0,25	-1,38	0,407	-1,45	-1,62
Production KPI's											
Average production	Average production quantity						-0,22	0,965	-1,37	1,171	0,979
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						-0,25	-1,19	0,362	-1,53	-1,67
Ordering KPI's											
Average orders	Average order quantity	-0,57	0,698	-1,98	0,487	0,236	0	0	0	0	0
Max orders	Maximum order quantity	0,127	0,16	-1,14	0,784	0,7	0	0	0	0	0
Order frequency	Number of orders	-0,25	-1,38	0,407	-1,45	-1,62	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-1,65	-0,41	-1,27	0,435					
	Av forecast deviation as a perc of av demand		-1,44	-0,25	-1,25	0,584					
Discount percentage	Average discount percentage		-0,1	-0,05	-0,93	-1,75					
	Av disc perc as a perc of the max possible discount		-0,1	-0,05	-0,93	-1,75					

4256632		IA + MDBO=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	2,025	1,722	1,519	1,121	0,542	0	0	0	0	0
	By percentage of days without any backlogs	2,633	2,477	2,27	3,366	2,001	0,279	-0,85	-0,41	-1,05	-0,73
Inventory turnover	Times per year for finished products	-0,55	-0,2	-0,39	-0,09	-0,56	-0,74	-0,98	-0,66	-0,57	0,055
	Times per year for materials						-0,69	-0,73	-0,77	-1,14	-0,63
Bullwhip Effect	Amplification on weekly level	0,284	1,629	0,496	2,017	0,843	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	0,495	-0,28	0,187	-0,28	0,604	0,082	0,593	-0,41	-1,5	-1,76
	Average of materials						1,111	1,153	1,141	1,257	1,146
Max inventory	Maximum of finished products	0,318	0,791	-1,06	-0,44	-1,64	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-1,87	0,168	-0,67	0,056	0,082	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	-0,1	0,563	-1,35	0,604	-0,68	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	0,412	-0,9	-0,34	-1,19	-0,74	0	0	0	0	0
Average outbound	Average outbound of finished products	-1,69	-0,85	-2,94	-1,73	-1,74	-1,49	0,592	-0,26	0,675	0,528
Max outbound	Maximum outbound of finished products	-1,05	-0,15	-0,88	0,064	-0,66	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	0,258	-0,13	0,773	0,244	0,214	0,412	-0,9	-0,34	-1,19	-0,74
Production KPI's											
Average production	Average production quantity						-1,83	0,826	-0,1	0,829	0,801
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0,631	-1,05	-0,4	-1,28	-0,91
Ordering KPI's											
Average orders	Average order quantity	-1,87	0,168	-0,67	0,056	0,082	0	0	0	0	0
Max orders	Maximum order quantity	-0,1	0,563	-1,35	0,604	-0,68	0	0	0	0	0
Order frequency	Number of orders	0,412	-0,9	-0,34	-1,19	-0,74	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-0,9	-0,88	-1,58	-0,91					
	Av forecast deviation as a perc of av demand		-0,57	-0,88	-1,71	-0,88					
Discount percentage	Average discount percentage		-0,31	0,366	-0,85	0,191					
	Av disc perc as a perc of the max possible discount		-0,31	0,366	-0,85	0,191					

4256632		IA + MDBO=7 + LT=7									
		TU					LG				
		none	hor=2	hor=3	hor=4	hor=5	none	hor=2	hor=3	hor=4	hor=5
General KPI's											
Service level	By percentage of total quantities delivered on time	1,83	1,909	1,128	0,239	0,403	0	0	0	0	0
	By percentage of days without any backlogs	2,661	2,641	2,267	2	1,618	-0,09	-0,42	-0,58	-1,3	-0,71
Inventory turnover	Times per year for finished products	-0,37	-0,12	-0,05	0,105	-0,76	-0,26	-0,99	-0,68	-0,55	0,115
	Times per year for materials						-0,65	-0,73	-0,75	-1,03	-0,54
Bullwhip Effect	Amplification on weekly level	1,083	1,155	0,978	2,337	1,601	0	0	0	0	0
Inventory KPI's											
Average inventory	Average of finished products	-0,14	-0,37	-0,52	-0,69	0,833	-1,27	0,653	-0,21	-1,18	-1,58
	Average of materials						1,14	1,175	1,227	1,338	1,086
Max inventory	Maximum of finished products	0,33	0,297	-1,01	-1,2	0,472	0	0	0	0	0
	Maximum of materials						0	0	0	0	0
Average inbound	Average inbound of materials/products	-1,03	-0,52	-0,32	0,746	0,213	0	0	0	0	0
Max inbound	Maximum inbound of materials/products	0,247	0,449	-0,34	1,032	0,898	0	0	0	0	0
Inbound frequency	Number of inbounds of materials/products	0,024	-0,35	-0,55	-1,58	-0,72	0	0	0	0	0
Average outbound	Average outbound of finished products	-1,66	-1,87	-1,8	-0,64	-2,29	-0,72	-0,13	0,152	1,326	0,606
Max outbound	Maximum outbound of finished products	-0,98	-0,13	-0,8	-0,68	-0,65	0	0	0	0	0
Outbound frequency	Number of outbounds of finished products	0,282	0,348	0,28	-0,25	0,459	0,024	-0,35	-0,55	-1,58	-0,72
Production KPI's											
Average production	Average production quantity						-1,23	0,129	0,302	1,099	0,879
Max production	Maximum production quantity						0	0	0	0	0
Production frequency	Number of production runs						0,358	-0,49	-0,63	-1,38	-0,88
Ordering KPI's											
Average orders	Average order quantity	-1,03	-0,52	-0,32	0,746	0,213	0	0	0	0	0
Max orders	Maximum order quantity	0,247	0,449	-0,34	1,032	0,898	0	0	0	0	0
Order frequency	Number of orders	0,024	-0,35	-0,55	-1,58	-0,72	0	0	0	0	0
FAD KPI's											
Forecast deviation	Average forecast deviation		-1,04	-0,44	-0,91	-0,33					
	Av forecast deviation as a perc of av demand		-1,09	-0,31	-0,88	-0,25					
Discount percentage	Average discount percentage		-0,07	-0,15	-1,14	-0,09					
	Av disc perc as a perc of the max possible discount		-0,07	-0,15	-1,14	-0,09					