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AGILE SUPPLY DEMAND NETWORKS APPROACH TO OPTIMIZE INVENTORY AND REDUCE LEAD TIME

Study by ASDN software

Master's Thesis in

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ABBREVIATIONS

ASDN	Agile Supply Demand Networks
ATO	Assembly To Order
CS	Cycle Stock
DCM	Demand Chain Management
DSCM	Demand Supply Chain Management
EOQ	Economic Order Quantity
ETO	Engineer To Order
IDD	Inventory Dollar Days
ILT	Internal Lead Time
MTO	Make To Order
MTS	Make To Stock
ODP	Order Decoupling Point
OLT	Order Lead Time
OTD	On Time Delivery
PDS	Product Delivery Strategy
SCM	Supply Chain Management
SF	Service Factor
SS	Safety Stock
TDD	Throughput Dollar Days
TOC	Theory ofConstrains
TPT	Production Throughput Time
WIP	Work In Progress

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ABSTRACT:

This thesis work is application of the ASDN (Agile Supply Demand Networks) software to improvement toy logistics network. The researcher worked as a development engineer with ASDN software and tasks were design an example of complex toy supply demand networks, improvement the toy logistics network, optimize inventory value level, through integrated retailers, distributors, manufacturers and suppliers to reduce the lead time to customers and inventory holding cost. The research problem is ***How to use ASDN software to analyze and optimize current toy industrial logistics network?*** In order to resolve this research problem, there have four objectives will be discussed in the present study.

The first objective *is study agile supply chain management, demand supply chain management, demand response strategies and inventory models in order to increase basic understanding ASDN software.* ***The second objective*** *is study the definition and function modules of ASDN software in order to understanding application of ASDN tool.* ***The third objective*** *is use ASDN tool to design a complex toy supply demand networks and explain related inventory models calculation.* ***The fourth objective*** *is use ASDN tool to create graph interface to analysis the complex toy supply demand networks, and optimize the analysis results.*

KEYWORDS: Agile supply management, supply and demand, logistics network, inventory model, lead time

1. INTRODUCTION

This thesis work is application of the ASDN (Agile Supply Demand Networks) software to improvement toy logistics network. ASDN is software for analyzing and developing agile logistics network. The researcher worked as a development engineer with ASDN software and tasks were design an example of complex toy supply demand networks and the content will described in the tutorial. At the same time, the each step calculation of ASDN tool will visualized in the text and also explains the calculate processing with equations. The main research aim is use ASDN software to improvement the toy industrial logistics network, optimize inventory value level and reduce lead time at the complex toy supply demand networks.

1.1. Background of the study

Nowadays the global market is more and more volatile and turbulent in manufacturing. The market conditions in which many companies find themselves are characterized by volatile and unpredictable demand (Martin, 2000), while produces high obsolete inventory (Christopher, 2001). Especially in toy industry, toys are extremely volatile and seasonal in nature (Chee, Jan & John, 2005). Volatility in the toy industry is caused by variable and unpredictable demands, very short and specific selling-windows and short product-life-cycles (Johnson, 2001). The toy industry has incurred relatively higher costs on obsolete inventory, lost sales and markdown as compared to other industries. These are the typical consequences of volatility in the toy supply chains, akin to the fashion clothing industry (Christopher, Lowson & Peck, 2004). So traditional supply chain management cannot effectively and efficiently support satisfying customers’ need and quickly changing market with optimize inventory level.

Many companies provide its customers with low cost and high quality products suitable in the past. Nowadays companies are striving to achieve focus on right products meet customers' needs, wishes and expectations; right manufactured without difficulties and then easily maintained in the field (Kidd, 1994); right time with fast response to customers demand. From the strategic perspective, present the theory of ASCM (agile supply chain management) to companies becomes more important. ASCM extends from the customer interface at marketing and sales through production and procurement to the building of relationships with suppliers.

Agility might therefore be defined as the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety (Martin, 2000). If implemented agile supply chain management, this will provide a new dimension to competing: quickly introducing new customized high quality products and delivering them with unprecedented lead times, swift decisions and manufacturing products with high velocity (Dekkers & van Luttervelt, 2006; Fisher, 1997). The success of an agile supply chain is the speed and flexibility with which these activities can be accomplished and the realization that customer needs and customer satisfaction are the very reasons for the network (Lee & Lau, 1999). In this thesis, we address the software of ASDN (Agile Supply Demand Networks) which provides support to the manager in making improved business strategy decisions that lead to maximizing customer service and profits by capitalizing on the added-value of the entire supply chain (Helo, 2006).

The motivation for this study is optimize the toy supply-demand networks and analyze the movement of products through the supply demand pipeline, monitor process, identify and analyze gaps, and developing process with ASDN software tool. The research results will resolve the toy industrial problems which are unpredictable demands, very short product life cycles, high costs on inventory and uncertainty of lead time.

1.2. Research problem and objectives

Toy industry as the creative business faces many challenges, variable and unpredictable demands, very short product life cycles, high costs on inventory and so on. Toy sellers and manufactures face high levels of risk and volatility. Volatility in the toy industry is caused by variable and unpredictable demands, very short and specific selling-windows and short product-life-cycles (Johnson, 2001). Therefore, some toy manufacturers offer early-order or quantity discounts to push the inventory risk to the retailers. Some retailers use their buying power to avoid risk-taking or pass some costs to the manufacturers (Chee, Jan & John, 2005). Finally both sellers and manufacturers have same problem is high levels inventory. Traditional supply chain management studies have focused on removing or reducing the uncertainty within a supply chain as far as possible, in order to facilitate amore predicable response to change in downstream demand (Naylor, 2000). So it cannot effectively and efficiently support satisfying customers' need and quickly changing market with optimize inventory level.

With the business economy has shifted from the economics of scale towards the economics of scope. Toy industries face a very unique challenge, which is how to provide the right toys at the right quantity at the right stores during the very short selling windows and to frequently provide creative and yet price competitive toys (Chee, Jan & John, 2005). In this thesis, we will address strategy tool of agile supply chain management – ASDN software, which will help toy companies to fix the gap of inventory problem, through integrated retailers, distributors, manufacturers and suppliers to reduce the lead time to customers and inventory holding cost. So the research problem present at below:

How to use ASDN software to analyze and optimize current toy industrial logistics network?

In order to resolve this research problem, there have four objectives will be discussed in the present study.

The first objective *is study agile supply chain management, demand supply chain management, demand response strategies and inventory models in order to increase basic understanding ASDN software.*

The second objective *is study the definition and function modules of ASDN software in order to understanding application of ASDN tool.*

The third objective *is use ASDN tool to design a complex toy supply demand networks and explain related inventory models calculation.*

The fourth objective *is use ASDN tool to create graph interface to analysis the complex toy supply demand networks, and optimize the analysis results.*

1.3. Structure of the thesis

In ***Chapter 1***, the background of the study, research problem, research objectives, and structure of the thesis are presented.

In ***Chapter 2***, provides theoretical perspective of previous studies. For instant, backgrounds of agility, definition of agility and agile supply chain management, characteristics of the agile supply chain, benefits of agile supply chain, demand and supply chain management, demand response strategies and inventory models are presented in this chapter.

In ***Chapter 3***, explain ASDN software. Includes definition of ASDN, the software background information and the functional modules of the ASDN tool are presented in this chapter.

In ***Chapter 4,*** practical application the ASDN software to developing a case example, analyze and optimize the result. In this chapter present the design processing of the example, the each step in calculations will visualized in the text and equation, discuss the analyze reports and optimize the analysis result.

In ***Chapter 5***, the summary and conclusions of the present study are presented in this chapter. There are two subchapters. In the first subchapter, the present study is summarized the study and answer the research problem. Conclusions are given in the second subchapter, in which the results in application of ASDN software and limitations of the study are given.

2. THEORY

In this chapter provides theoretical perspective of previous studies. For instant, backgrounds of agility, definition of agility and agile supply chain management, characteristics of the agile supply chain, benefits of agile supply chain, demand and supply chain management, demand response strategies and inventory model are presented in this chapter.

2.1. Agility

To understand agile supply chain, we need to first clarify the meaning of agility. In brief, Agile means fast moving. The concept of Agility defines as ability to respond quickly and effectively to satisfy customers (Veeramain & Joshi, 1997). To be reliable in an uncertain and changing environment, firms must be able to quickly respond to changes. The ability to do this in a useful time frame is called agility (Prater, Biehl & Smith, 2001). Agility means using market knowledge and virtual corporation to exploit profitable opportunities in a volatile market (Cai-fen, 2009). Agility is all about customer responsiveness, people and information, cooperation within and between firms and fitting a company for change (Intaher, 2010).

Agility can be seen as the capability to make a profit by keeping productivity level high in a changing environment. Volume levels and product mix may fluctuate and life cycles change. The agility of a manufacturing system is considered to be a derivative of these generic dimensions. The practical aspects, used in this model, are volume flexibility; mix flexibility and life cycle flexibility (Helo, 2004). Agility is the capability to react to change in a dimension beyond flexibility. Flexibility refers to company’s ability to adjust from one operation to another (Vokurka & Fliedner, 1998).

The key difference according to Vokurka and Fliedner is the ability to react to non-predictable changes in markets.

Companies must quickly identify, design, manufacture, and deliver products that meet customer desires, while maintaining stringent cost and quality standards. More specifically, greater importance is being placed on agility in terms of producing a broad range of low-cost, high-quality products with short lead times in varying of sizes, built to individual customer specifications (Narasimhan & Das, 1999). See Figure 1 for four strategic dimensional of agile competition: Enriching customers; Cooperating to enhance competitiveness; organizing to master change and uncertainty; Leveraging the impact of people and information (Steven,1994).

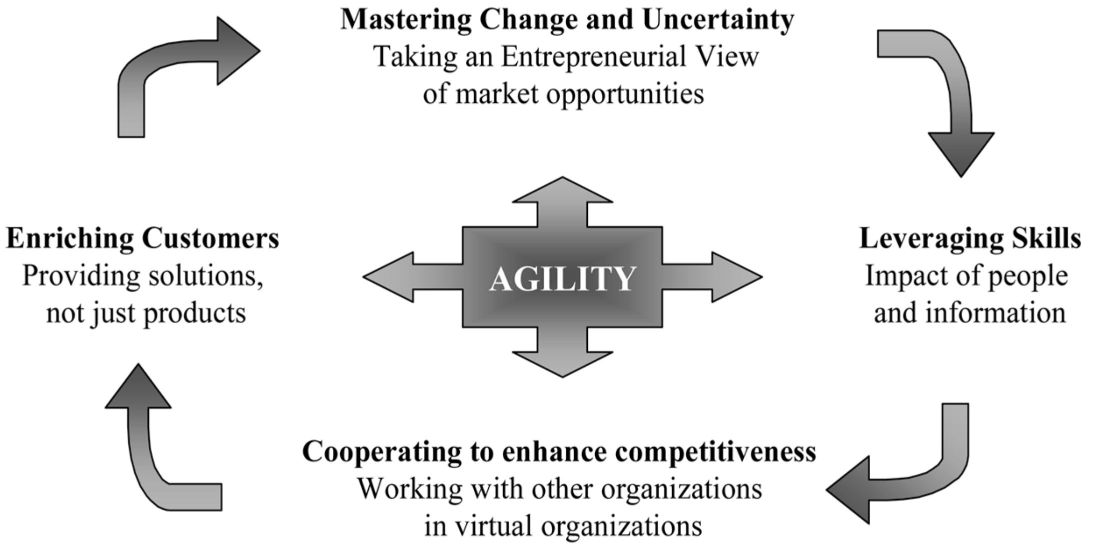


Figure 1. Four strategic dimensional of agile competition (Colin, 2000).

Enriching customer means an agile company's products perceived by its customers to be solutions to their individual problems, not only themselves of company. Cooperating to enhance competitiveness means an agile company cooperates internally or with other companies bringing agile products to markets as rapidly and as cost-effectively as possible. Organizing to master change and uncertainty means an agile company is organized in a way that allows it to thrive on change and uncertainty. Is structure is flexible enough to allow rapid reconfiguration of human and physical resources. Operation leveraging the impact of people and information by distributing authority, by providing the resources personnel need, by reinforcing a climate of mutual responsibility for joint success, and by rewarding innovation. Knowledge-based products offer the greatest potential for individualization, so continuous work force education and training are integral to agile company operations (Steven, 1994).

2.2. Agile Supply Chain Management

This subchapter will list the definition of agile supply chain management and explain why we need agile supply chain management for organizes.

2.2.1. What is ASCM

The concept of agile supply chains was introduced (Harrison et al., 1999) to transfer and apply the winning strategy of agility to that of supply chains addressing these as the newly accepted units of business. The idea of agility in the context of SCM focuses on “responsiveness” (Lee & Lau, 1999; Christopher &Towill, 2000).

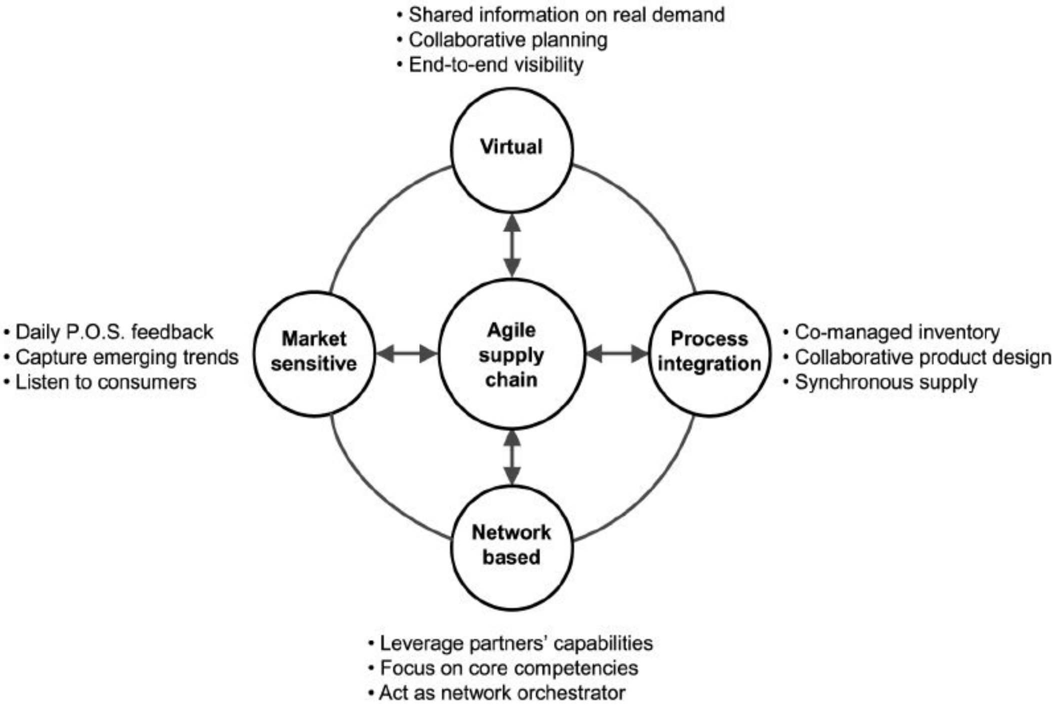
Li et al. (2008) introduce a unifying general-purpose definition of supply chain agility as follows: An organization’s supply chain agility is the result of integrating the supply chain’s alertness to changes (opportunities/challenges) – both internal and environmental – with the supply chain’s capability to use resources in responding (proactively/reactively) to such changes, all in a timely and flexible manner (Xun, Thomas & Clyde, 2009).

The concept of the agile supply chain is advocated as a new way forward for business networks to succeed in the highly changing and turbulent business environments. The main focus is in running businesses in network structures with an adequate level of agility to effectively respond to changes, as well as proactively anticipate changes and to seek emerging opportunities. Agile supply chains are, therefore, those with the ability to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network (Sharifi, Ismail & Reid, 2006).

Supply chain agility is a network‘s ability to consistently identify and capture business opportunities more quickly than its rivals do. Elements of Agile supply chain have time competitive and efficient consumer responsive. It provides ability. The ability to be able to meet the demand of customers for ever-shouter delivery times and to ensure that supply can be synchronized to meet the peaks and troughs of demand is clearly of critical importance in this era of time-base competition. To become more responsive to the needs of the market requires more than speed, it also requires a high level of maneuverability that today has come to be termed agility (Cai-fen, 2009).

In general, an agile supply chain is all about being fast and flexible. Lee (2004) specifies that the main objectives of supply chain agility are to respond to short-term changes in demand or supply quickly and to handle external disruptions smoothly. Intuitively, agile supply chain is also highly market responsive, because it is able to fast react on sudden demand peaks. Fisher (1997) states that innovative products should always require responsive supply chain that responds quickly to unpredictable demand in order to minimize stock-outs, forced markdowns and obsolete inventory (Jari & Dennis, 2006).

Christopher (2000) defines four key characteristics for agile supply chain, as show in below figure 2. First, an agile supply chain is always market sensitive with capability of reading and responding to real demand. Focus is on capturing actual customer requirements with direct feed-forward methods and not to rely much on market forecast information. It is always more demand-driven rather than forecast-driven. Second, extensive demand and supply information sharing between buyers and suppliers creates a virtual supply chains are information based rather than inventory based. The third key characteristic for agility is process integration between the partners. The extensive demand information sharing also enables truly collaborative working methods, joint product development and common systems between buyers and suppliers. Fourth, agile supply chain typically is network based with shared targets. The supply chain partners create competing networks with committed and close relationships with their final customers (Jari & Dennis, 2006).



Source: Based on the model originally developed by Harrison, Christopher & van Hoek (1999)

Figure 2. Four key characteristics for agile supply chain.

2.2.2. Why ASCM

In the 21st market environment today, proliferation of products and services are increased, demand will be increasingly difficult to forecast, product life cycles will be shorter and rates of product innovation will be increased. Simply responding quickly and at the right time in the past are not enough to meet the needs of such marketplaces (Cai-fen, 2009). This gave rise to the supply chain management concept, which integrates suppliers, manufacturers, distributors and customers to, first, reduce costs over the entire chain and, second, respond quickly to customer needs (Thomas & Griffin, 1996). So Agile supply chain emerged, which will combine needs of demand and quickly delivery.

To be competitive, companies must adapt their supply chains efficiently and build strong relationships with customers and suppliers more quickly (Tolone, 2000). A company cannot become agile unless its relationships with the supply chain are also agile. Supply chain agility is a key to inventory reduction, adapting to market variations more efficiently, enabling enterprises to respond to customer demand more quickly, and integrating with suppliers more effectively (Scott J., Michael H., Brian T. & Li, 2002). Therefore, why supply chain agility and responsiveness have already become more or less standards in the industry. Agility alone does not anymore provide a competitive advantage in supply chains, but it is rather a prerequisite for the competition (Jari & Dennis, 2006).

Supply chain management (SCM) is an integrative philosophy to manage the total flows of a distribution channel from suppliers level to production, distribution and the ultimately the end customer (Houlihan, 1987; Cooper et al., 1997; Simchi-Levi et al., 2000; Tam et al., 2002; Helo and Bulcsu, 2005). Traditional supply chain management (SCM) policies are process-driven and have used production to forecast policy.

Compare with traditional SCM, Agile supply chain management (ASCM) can effectively or efficiently support a customer-driven and dynamically changing market. ASCM is consider the integration of a business network, encompassing suppliers, manufacturers, distributors and retailers, in order to provide products and services along with the added value to end customers (Yan et al., 2003). Much work has been geared towards the management of the information, financial and physical flows throughout a supply chain network (Huang et al., 2002). Supply chain agile lends itself to be an effective means of dealing with product differentiation and customization throughout a supply demand network (Yan et al., 2003). It essentially entails the instantiation of a generic supply chain network to specific supply chains in accordance with diverse customer requirements.

The figure 3 shows the supply chain relationship between traditional SCM and ASCM. ASCM operation no longer follows a linear model, which system is a network-based operation that requires timely available of information throughout the system in order to allow cooperative and synchronized flow of material, products and information among all participants (Helo, Xiao & Jiao, 2006). At the same time, below list the compare between traditional SCM and ASCM.

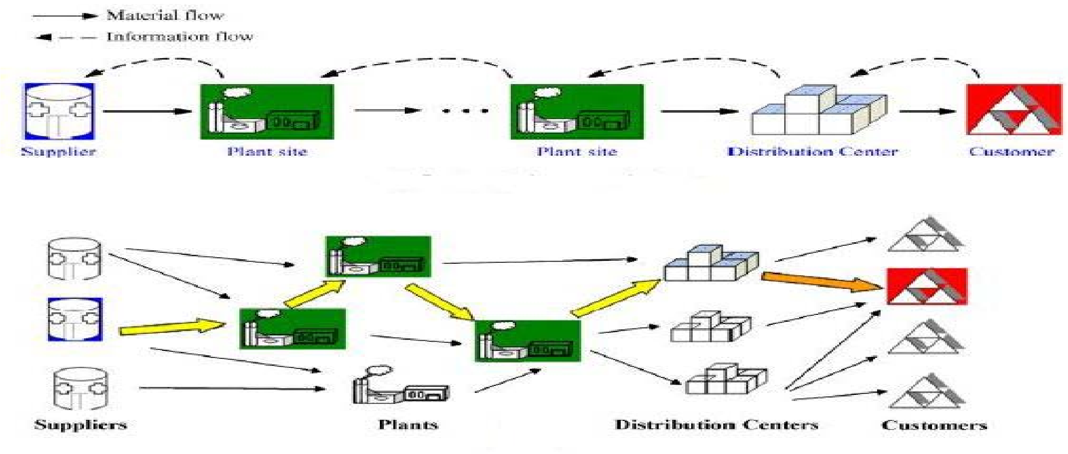


Figure 3. SCM and ASCM.

SCM	*ASCM*
Linear model	Network model
Process - driven	Customer – driven
High lead-time	Low lead-time
Focus on efficiency and cost	Focus on effectiveness and responsiveness
Stock is held at multiple echelons	Stock is held at the fewest echelons
Strategic inventory driven by forecast	Strategic inventory driven by demand
Discrete organizational units of production	Across functional boundaries

2.3. Demand Supply Chain Management

Demand supply chain management need to coordinate the demand and supply processes has been emphasized in the chain of organizations. Companies embracing the demand-led business model (demand chain masters) focus on coordinating and managing the demand processes (DCM) to obtain a competitive advantage by providing superior customer value while companies embracing the supply led business model (supply chain masters) focus on coordinating and managing the supply processes (SCM) to obtain a competitive advantage by providing comparable customer value at lower cost (Walters, 2008; Hilletofth, 2011).

In customer-centered marketing approach, the chain of organization need for DCM to be in charge of SCM, which means in environments with increasing diversity, in customer needs and requirements, companies must rapidly adjust their supply to meet demand (Sheth, Sisodia & Sharan, 2000). Moreover, the market-driven companies can gain a more sustainable competitive advantage by not only providing superior customer value propositions, but also by having a unique business system to support it (Kumar, Scheer & Kotler, 2000).

Demand supply chain management will help organization to gain a competitive advantage by providing superior customer value at lower cost. To achieve the goal, the company need understanding managing the demand chain the supply chain, and the processes and management directions can be coordinated (Hilletofth, 2011). Below the figure 4 shows the coordination of DCM and SCM across intra- and inter-organizational boundaries.

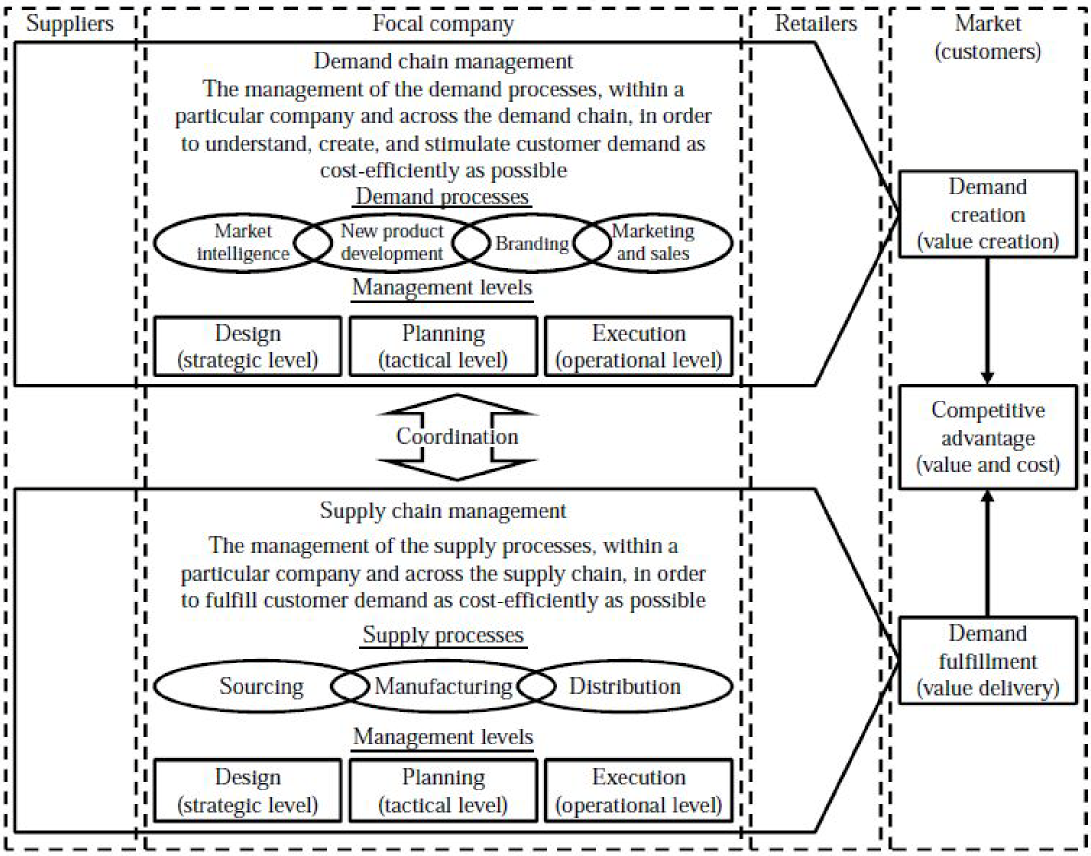


Figure 4. Demand-Supply Chain Management.

2.4. Demand Response Strategies

Any order for an end product trigger a series of work processes in the supply chain that have to be completed so that the end customer order is satisfied (Ming, 2001). Generally, the following demand management strategies are employed in supply chain management.

The ***make-to-order*** (MTO) systems offer a high variety of customer-specific and typically, more expensive products. The production planning focus is on order execution and the performance measures are order focused e.g. average response time, average order delay. The competitive priority is shorter delivery lead-time. Capacity planning, order acceptance/rejection, and attaining high due date adherence are the main operations issues (Soman, Donk &Gaalman, 2004).

The ***make-to-stock*** (MTS) systems offer a low variety of producer-specified and typically, less expensive products. The focus is on anticipating the demand (forecasting), and planning to meet the demand. The competitive priority is higher fill rate. The main operations issues are inventory planning, lot size determination and demand forecasting (Soman, Donk &Gaalman, 2004).

The ***assemble-to-order*** (ATO) systems offer a high level of product variety to customers, while maintaining reasonable response times and costs. The focus is on rapidly assembled from component inventories in response to customer orders (Plambeck & Ward, 2007). The competitive priority is efficient to deliver products to customer. The main operations issues are coordination of the components, allocation of the component among the products (Song & Zipkin, 2003).

The ***engineer-to-order*** (ETO) systems offer high level of customization, high customers design, volume flexible, short cycle time, no inventory costs products (Molina, Velandia & Galeano, 2007). The productions focus on receiving customer requirement and approval by the customer (Ming, 2001), while the systems coordination between production and sales (Bertrand, Wortmann & Wigingaard, 1991; Giesberts & Tang, 1992). The competitive priority is specific products to customer order and quickly defines aggregate networks for new project (Giesberts & Tang, 1992). The main operations issues are capacity planning and customer order scheduling.

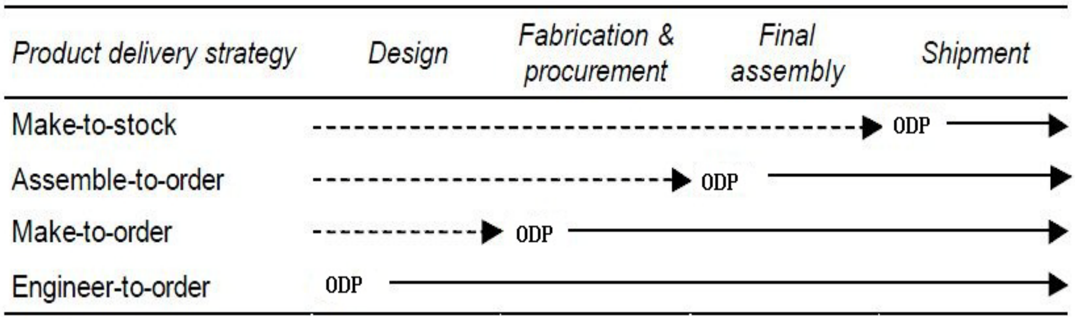


Figure 5. Different PDS relate to ODP.

Figure 5 shows different demand response strategies relate to different position of the order decoupling point. The dotted lines depict the production activities that are forecast-driven, whereas the straight lines depict customer order-driven activities (Olhager, 2003). Below the table 1 gives the attribute comparison between different demand management strategies (Ming, 2001).

The order-decoupling point (ODP) defined as the point in the manufacturing value chain for a product, where the product is linked to a specific customer order. Different manufacturing situations such as make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO) all relate to different positions of the ODP (Olhager, 2003). The decoupling point is the point in the material flow streams to which the customer's order penetrates. It is here where order-driven and the forecast driven activities meet. As a rule, the decoupling point coincides with an important stock point - in control terms a main stock point - from which the customer has to be supplied (Hoekstra & Romme 1992; Mason-Jones, Naylor & Towill, 2000). The point also is strategic stock which often held as a buffer between fluctuating customer orders and/or product variety and smooth production output (Helo, Xiao & Jiao, 2006).

A major problem in most supply chains is their limited visibility of real demand (Christopher, 2000). So we presented with the decoupling point in different positions along the supply chain as a stock holding point. In order to, lower inventory levels and enhance customer service via improved agility of manufacturing (Spathis & Constantinides, 2003).

Attributes \ Policies	MTS	ATO	MTO	ETO
Delivery time	Short	Medium	Normally long	Normally long
Product range	High	Medium	Low	Very low
Order promising (based on)	Available finished goods	Availability of components and major subassemblies	Capacity for manufacturing engineering	Capacity for manufacturing engineering
Basis for production Planning and scheduling	Forecast	Forecast and backlog	Backlog and orders	Customer orders
Handling of demand Uncertainty	Safety stocks	Over-planning of components and subassemblies	Little uncertainty exists	No control
Primary business Objective	Responsiveness	Customization	Lean production	Lean production

Table 1. Comparison different demand response strategies.

2.5. Inventory Models

If the money promote our world turning, then we can say that the inventory promote logistics world turning. Demand variability increases as one move up the supply chain away from customer and any small changes in customer demand can result in large variation in orders upstream. This phenomenon is known as bullwhip effect (Alok, 2006). The key problem of inventory is having enough items available when needed, but not so much that an unnecessarily costly surplus is incurred (Richard, 1982). So study inventory models for uncertain demand become necessary.

Inventory model definition as mathematical equation or formula that helps a firm in determining the economic order quantity, and the frequency of ordering, to keep goods or service flowing to the customer without interruption or delay. If a company stored too little inventory it causes costly interruptions and too much result in idle capacity. The inventory model determines the inventory level that balances the two extreme cases (http://www.oppapers.com/essays/Problems-On-Inventory-Model/637464). In this subchapter, we will consider several types of models start with ASDN tool in the next section.

Supplier Lead Time

Supplier lead time means expected time to get all components from suppliers. For this part calculate, the numerical of lead time to customer come from the upstream section, the numerical of order lead time come from the transport lead time.

Internal Lead Time

Internal lead time decided by the order decoupling point. The ILT equal to shipping time when the manufacturing situation is MTS; ILT is shipping time plus production throughput time (TPT) if ATO; ILT is shipping time plus TPT plus supplier lead time if

MTO; ILT is sum of shipping time, TPT, supplier lead time and engineering lead time if ETO.

Lead time To Customer

Lead time to customer means the how long of the operation time to customer. The lead time calculate result effect by internal lead time, order backlog and order time to delivery.

Service Level

Service level is defined as the percentage of demand in linear feet met from stock (Nahmias 1989; Xiong & helo, 2006). Service level is often measured in terms of an order cycle time, case fill rate, line fill rate, order fill rate, or any combination of these (Bowersox, Closs & Cooper, 2002). While one strategy to achieve a high service level is to increase inventory, other alternative approaches are the use of fast transportation and collaboration with customers and service providers to reduce uncertainty (Bowersox, Closs & Cooper, 2002).

Cycle Stock

Cycle stock means portion of inventory available (or planned to be available) for the normal demand during a given period, excluding excess stock and safety stock. It is the stock formed by items arriving infrequently but in large quantities to meet frequent but small-quantity demands (http://www.businessdictionary.com/definition/cycle-stock.html#ixzz1vzxiei20).

Safety Stock

The majority of inventory in the typical logistics system is typically safety stock. Safety stock is maintained in a logistical system to protect against demand and performance cycle uncertainty. Safety stock inventory is used only at the end of replenishment cycles when uncertainty has caused higher than expected demand or longer than expected performance cycle times (Bowersox, Closs & Cooper, 2002). The equation of safety stock is

$$SS = SF * \sigma * \sqrt{r + L}$$

Where SS is the system safety stock, SF is the safety factory which determines percent of service level, σ is the standard deviation of period demand, r is the time period between orders, and L is the delivery time of each other (Siefering, 2005).

Inventory Value

Inventory value is a definition in business that accounts for the value a business has for inventory that it has yet to sell. Inventory value is generally calculated at the end of a company accounting period (for example, at the end of a quarter evaluation) in order to accurately represent the value of the company, since unsold inventory has a value that must be accounted for (http://www.ehow.com/how_6505792_calculate-inventory-value.html#ixzz1vzvPcF1Z).

Average Inventory

Average inventory consists of the materials, components, work-in-process, and finished product typically stocked in the logistical system. From a policy viewpoint target inventory levels must be planned for each facility (Bowersox, Closs & Cooper, 2002).The average inventory focus of logistical management is one-half order quantity plus safety stock (Bowersox, Closs & Cooper, 2002).

Inventory Turn Rate

Inventory turns means the number if times that the inventory is replaced during a time period (usually a year). The standard accounting measure for inventory turns is the cost of goods sold divided by the average inventory investment (Hill, 2012).

Theory of Constraints (TOC)

The theory of constraints (TOC) adopts the common idiom "A chain is no stronger than its weakest link" as a new management paradigm. This means that processes, organizations, etc., are vulnerable because the weakest person or part can always damage or break them or at least adversely affect the outcome (http://en.wikipedia.org/wiki/Theory_of_Constraints). According to Goldratt et al. (2000), a good measure is required to bind each party to be accountable to improve supply chain performance as a whole. The TOC promotes inventory dollar days (IDD) as a measure of things done ahead of schedule and throughput dollar days (TDD) as a measure of things done behind schedule (Hill, 2012). The goal is attempts to reach zero TDD with as few IDD as possible.

Inventory Dollar Days (IDD)

Inventory dollar days (IDD) as a metric to be used to enable the supplier to judge the retailer’s inventory performance. IDD equal the sum of the dollars of inventory times the number of days on hand. The supplier can also offer the same measure to its vendors so they can measure the supplier’s inventory performance (Simatupang & Sridharan, 2003).

Throughput Dollar Days (TDD)

The retailer can judge the delivery performance of its suppliers by using the throughput dollar days (TDD) that equal the sum of sales dollars times the number of days’ delay. The supplier can use TDD to judge the delivery performance of its vendors. The supplier will be responsible for the results as measured by TDD (Simatupang & Sridharan, 2003).

Order point system

When the quantity of an item on hand in inventory falls to a predetermined level, called an order point, an order is placed. The quantity ordered is usually recalculated and based on economic-order-quantity concepts. Below the figure 6 shows the relationship between safety stock, order lead time, order quantity, and order point. The order point is determined by the average demand during the lead time. If the average demand or the order lead time changes and there is no corresponding change in the order point, effectively there has been a change in safety stock (http://mdcegypt.com/Pages/Purchasing/Material%20Management/Independent%20Demand%20Ordering%20Systems.asp).

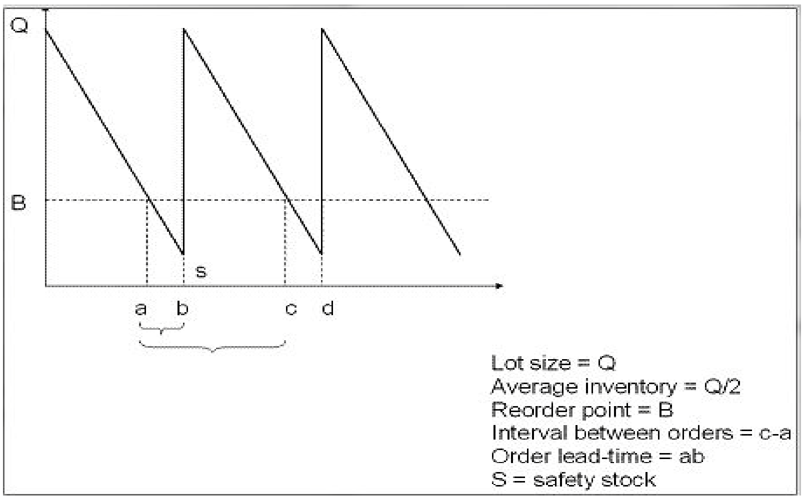


Figure 6. Inventory level Vs. Time.

Economic Order Quantity (EOQ) Model

The EOQ model is to find the optimal order quantity of inventory items at each time such that the combination of the order cost and the stock cost is minimal (Wang, Tang & Zhao 2007). EOQ model can be used to make optimal inventory decisions when demand is deterministic. The EOQ does not depend on the unit purchasing price, because the size of each order does not change the unit purchasing cost. Thus, the total annual purchasing cost is independent. In figure 7 illustrates the trade-off between holding cost and ordering cost. At the same time, the figure confirms the fact that at q*, the annual holding and ordering costs are the same (Winston, 2003).

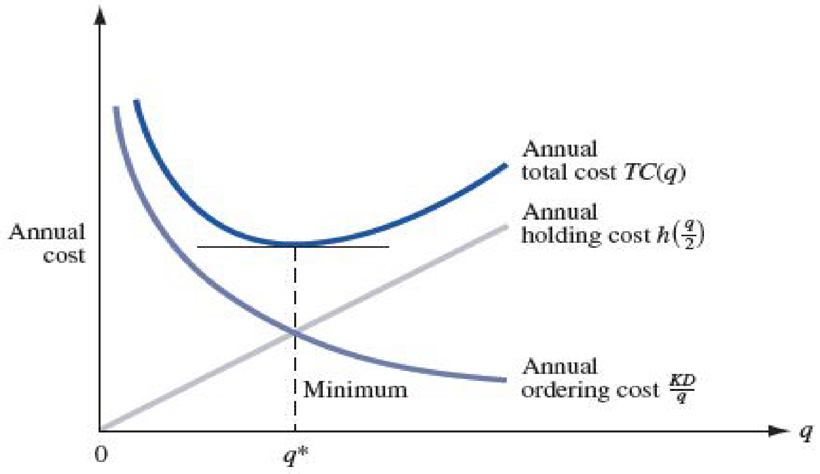


Figure 7. Trade-off between holding cost and ordering cost.

The customer demand is always changing and hence the inventory should also be changed in order to optimize inventory-holding cost (Alok, 2006). Traditional inventory management because of supplier not sure the order so they need build unnecessary inventory. But now application ASDN system will share the information between supply point and demand point. The supply chain should be able to act according to the change in demand, thus reduce the cost of inventory and minimal the lead-time. The detail explain and discuss will show the chapter 4.

3. ASDN SOFTWARE

In this chapter explain ASDN software, which it is includes definition of ASDN, the software background information and the functional modules of the ASDN tool are presented.

3.1. Definition of ASDN

ASDN - "Agile Supply Demand Networks" is software for analyzing and developing logistics networks. It is software developed for rapid modeling tool of supply chains which should help decision-making in network architecture design and performance management (ASDN, 2005). ASDN software design case model is drive by customer's requirement; even make fast reconfiguration and adjustment basic different chain strategy, so it is can agility and optimizing the level of inventory in industrial network operation. ASDN also can be used to analyze project-business networks; while the project-business activities can be optimized using the right resources at the right time with the right actors to take the right actions in a network approaches (Sandhu & Helo, 2006).

As a logistics analysis software of ASDN which concentrates on (Sandhu & Helo, 2006):

- the development of IT architectures to support global-network modeling and design;
- portraying the present status of network-level control;
- optimizing supply-demand processes for fast response time; and
- Improving financial performance.

3.2. Background of ASDN software

Agile supply demand networks (ASDN) software, which was developed at the University of Vaasa (Finland), is a network drawing tool for analyzing multi-site manufacturing and material flows (ASDN, 2005). ASDN software can help managing global supply demand networks to be more agile and time responsive, optimizing the level of inventory. It is based on Java Web Applet and equipped with interactive communication capabilities between peripheral software tools. It operates as an information platform, by which integrate with their customers and suppliers to quickly build supply demand network. All the information, activities and decision are visualized, synchronized and optimized by ASDN system (Helo, Xiao & Jiao, 2006).

The ASDN software was originally developed for the ABB Corporation to analyze large global supply demand networks. In the ASDN model, each node (such as a supplier, a manufacturer, or a retailer) is identified as having certain attributes in terms of lead-time, inventory levels, and so on. The software enables users to analyze industrial network in different scenarios from various perspectives – such as total inventory or order-fulfillment time. The calculation functionality of the system allows users to define the right levels of inventory to meet commitments to customers while minimizing cost. These calculations are based on predefined resource dependencies. The user can compare different chain strategies and analyze objectives – such as on-time delivery, lower inventory levels, fast delivery, and decreased cost of capital. (Sandhu & Helo, 2006).

3.3. Architecture of ASDN

ASDN adopts modular architecture design that the main functions are encapsulated in separated modules which are easy to modify and upgrade. The key functional modules in ASDN are modeling, optimization, analysis and report, interface, and database. It aims for modeling, analyzing, optimizing supply demand network, forms a scalable, extensible and interoperable application environment (Helo, Xiao & Jiao, 2006).

Modeling module It facilitates the user building and configuring the supply chain model quickly and efficiently. Users can easily click and drop in the main window to draw the supply chain nodes and link the nodes with transport arrows. All the related data and information of the network are retrieved and processes by this module to provide a straightforward and clear model structure.

Optimization module A variety of build-in mathematical algorithms are provided to optimize specified performance of supply demand network. User could select the optimizing models in order to adapt various operational circumstances. Comprehensive analytical models and real-time calculation optimize the supply chain from a systematic view.

Analysis and report module This module analyzes the supply demand network performance from different kinds of aspect and visualizes the result by a variety of geographic and tabular reports. It helps planners and managers to observe the supply demand network in a holistic view and examine issues such as: service level, overall cost, order fulfillment, inventory value and capacity of production and so on.

Interface This enables the users and other systems transform the data to ASDN and assess the concerned output information. Also it can graphically represent the network distribution including the location of facilities, transport channel, the attribute of supplier and customers with all details.

Database module It stores the data and information related to supply demand network, customer demand, supply ontology, etc. For example, the attributes of each company node that describe its status would be stored in the database and shared by the authorized users. The integrator is used to transform the data and information between ASDN and transactional systems according to prescribed rules and format.

4. METHODOLOGY

Toy industry as the creative business faces many challenges, variable and unpredictable demands, very short product life cycles, high costs on inventory and so on. Toy sellers and manufactures face high levels of risk and volatility. Therefore, some toy manufacturers offer early-order or quantity discounts to push the inventory risk to the retailers. Some retailers use their buying power to avoid risk-taking or pass some costs to the manufacturers (Chee, Jan & John, 2005). Finally both sellers and manufacturers have same problem is high levels inventory. ASDN model as strategy tool of agile supply chain management can fix the gap of inventory problem, through integrated retailers, distributors, manufacturers and suppliers to reduce inventory and lead time to customers.

In this chapter, we are design one simulate example about Barbie Doll products supply demand networks at global supply chain environment, then analyze and optimize solution with ASDN software. Aim to resolve below the research question through application ASDN software.

How to use ASDN software to analyze and optimize current toy industrial logistics network?

The figure 8 shows the example of supply demand network infrastructure. This network consists of eight elements: four suppliers, one manufacturer, one retailer, one sales company and one end customer. The main supplier from China, assemble factory locate in China, the finish product ship to North Europe for sale. We use ASDN software to designing and developing the case which base on below supply chain map.

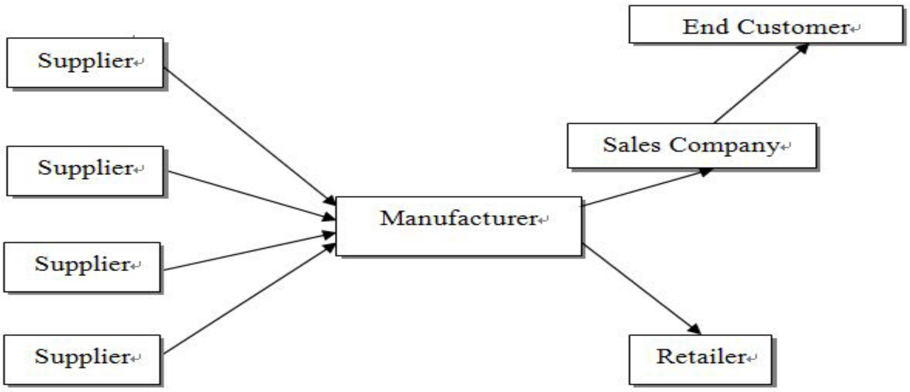


Figure 8. An example of network infrastructure.

In this chapter, we will use ASDN software to do the below steps:

- Building the construction of Barbie Doll supply demand networks
- Report of graph and table view
- Improvements the base case
- Save file and exit the ASDN tool
- Discuss the analysis results

4.1. Building the basic construction

ASDN is a free software for user to download and easy to set up. In this subchapter we will give a brief guideline to use the ASDN software, which enables the user to build the required supply demand networks, draw graphs, select and improvement calculate, and find better solution. At same time, the calculations results not only display from the ASDN software system, but also show side by side coming from equations by hand calculate, which in order to prove the ASDN software system has correct calculation logic.

4.1.1. Navigation of start ASDN software

In order to build the supply demand network of Barbie Doll product, we need download and install ADSN software at first. The software comes from the web server (http://sourceforge.net/projects/asdn), which is supported by Java Virtual Machine. So we need setup the Java as well if your computer not running Sun's Java, which comes from the web server (http://www.java.com/en/download/manual.jsp). Finally, we need to download the files of asdn.jnlp which will start and automatically ASDN software. From the web server (http://switch.dl.sourceforge.net/sourceforge/asdn/asdn.jnlp) can download it. When we work with ASDN software, we need double-click the document of asdn.jnlf files to open the ASDN software system at begin. Below the figure 9 shows the basic ASDN software screen.

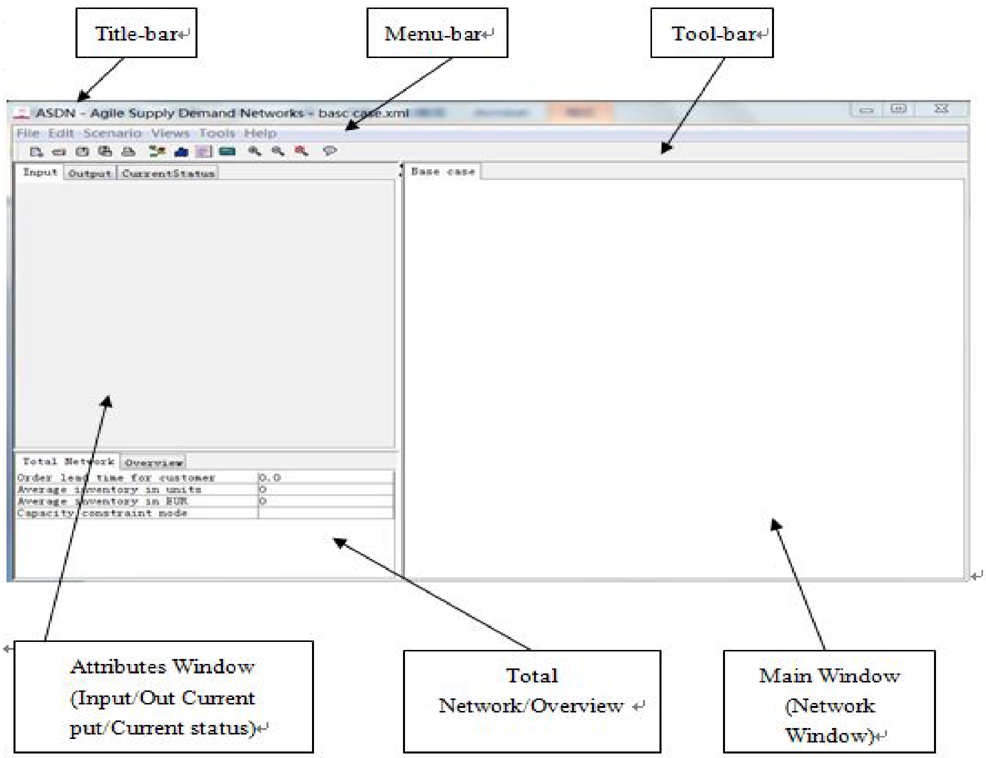


Figure 9. Basic ASDN screen.

From the figure 9, we can see that the basic ASDN screen includes three main areas. The title-bar, Menu-bar and tool-bar located at the very top of the screen. Attributes windows provides the input, output and current status of selected node or arrow of the designed network located at the left of the screen. The right white area is the main window which use to building the construction of Barbie Doll supply demand network, which shows the initial designed logistics network and 'After improvements' represents the improvement done with the initial network (Guangyu & Natalia, 2008).

4.1.2. Add the Nodes and Input the data

Node is basic unit of a network, which represents suppliers, manufacturer, retailers and customers are added in the main window. Build construction of supply demand network use reverse engineering to design and the network by demand-drive , so create the start node will come from customers, then manufacturer, the last is suppliers. Select *Edit* > *Add Node* from the main menu-bar, a new node appears. The figure 10 shows the node of end customer. When we highlight (turn into blue color) the node, the data can be input through a series of on-screen format. We can define and modify the input data in the section of general, finance, manufacturing and inventory. From the left input panel we select the node type as "end customer", order decoupling point as "make-to-stock", enter price as "35.0€", cost as "35.0€", demand as "800.0units/year", demand st. deviation "96.0 units/year", working time as "52.0weeks", production throughput time as "1.0days", St. deviation of OLT and order backlog as "0.0days", engineering lead-time and maximum order fulfillment time as "0.0days", capacity as "800.0units/day", holding cost rate as "10.0%". Attributes of a node show at figure 11, which explain the number function of node

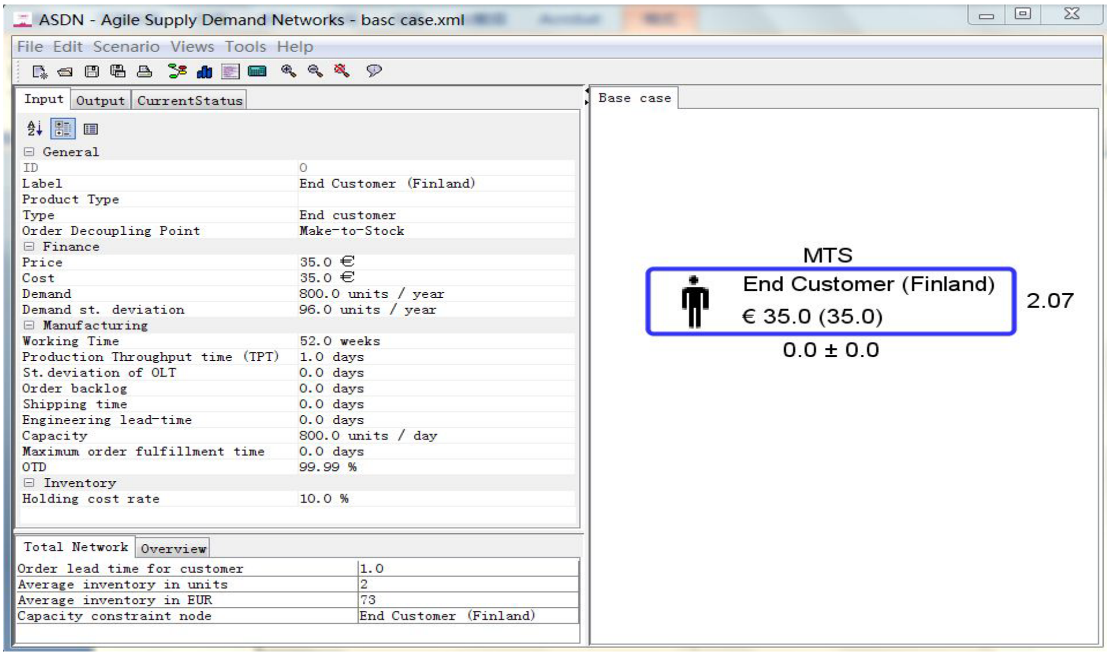


Figure 10. The Node of end customer.

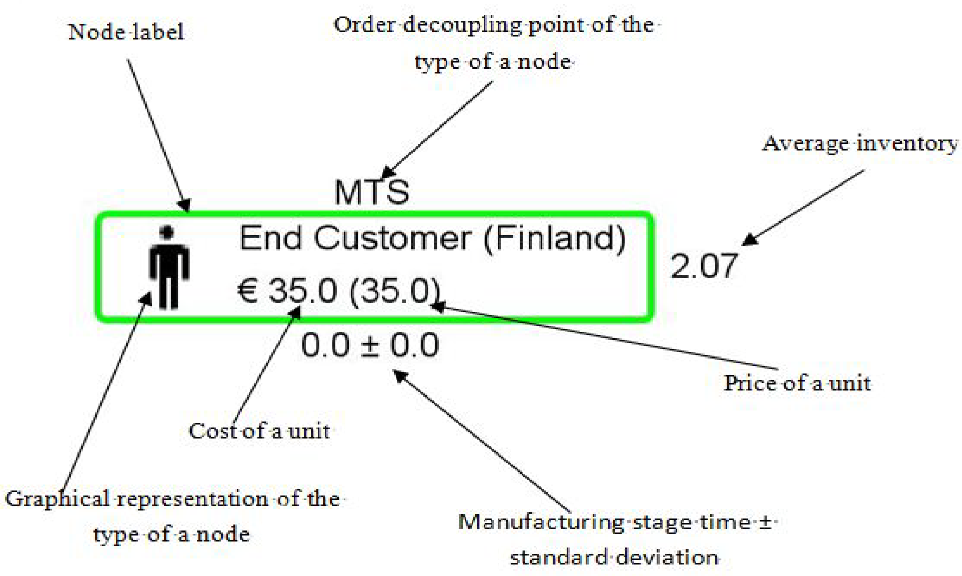


Figure 11. Attributes of a node.

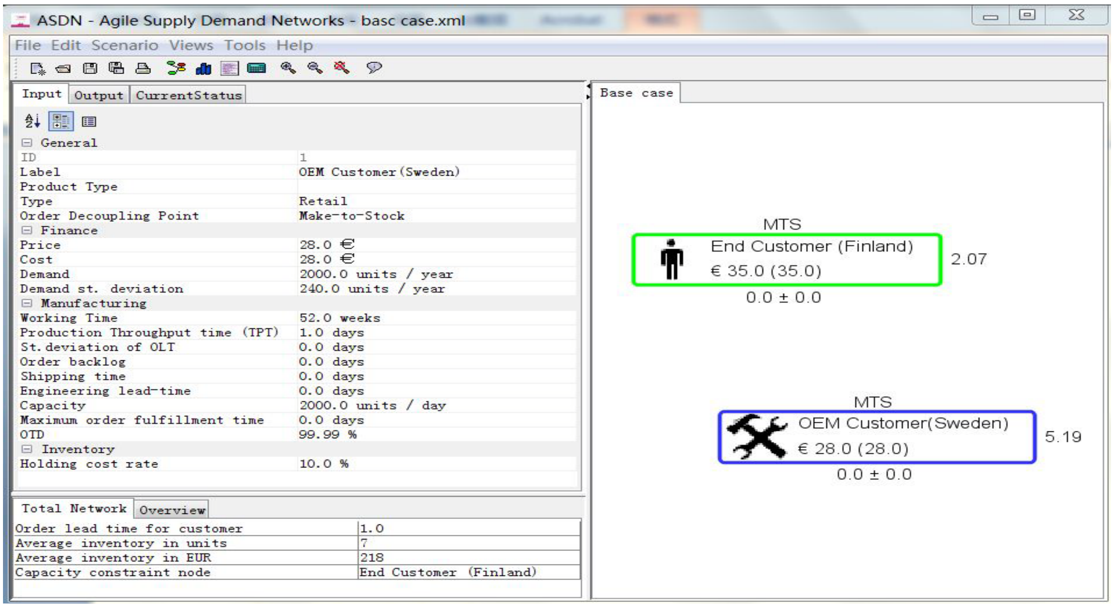


Figure 12. The node of retailer.

The figure 12 shows other node of customer, named "OEM customer (Sweden)" and type as "retail" When we highlight (turn into blue color) the node, input data show on the left of attributes windows. Next we are adding node type as "sales company" and label name as "SOKOS (Finland)", the input data shown in the left of figure 13.

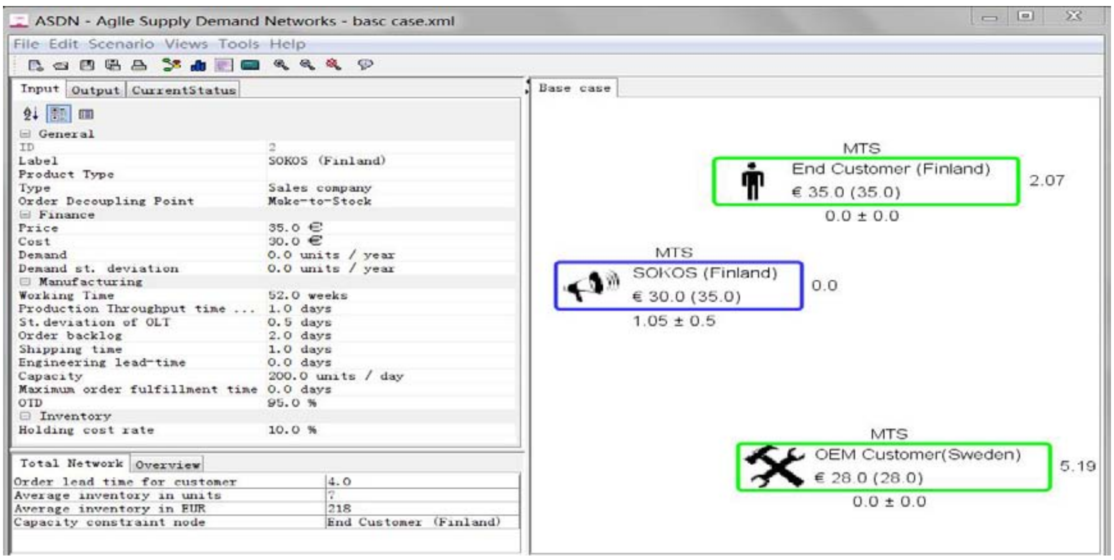


Figure 13. The node of sales company.

Continue to added node of manufacturer, the highlight (blue color) node type as "manufacturing" and label as "Barbie Doll factory (China)" show in figure 14.

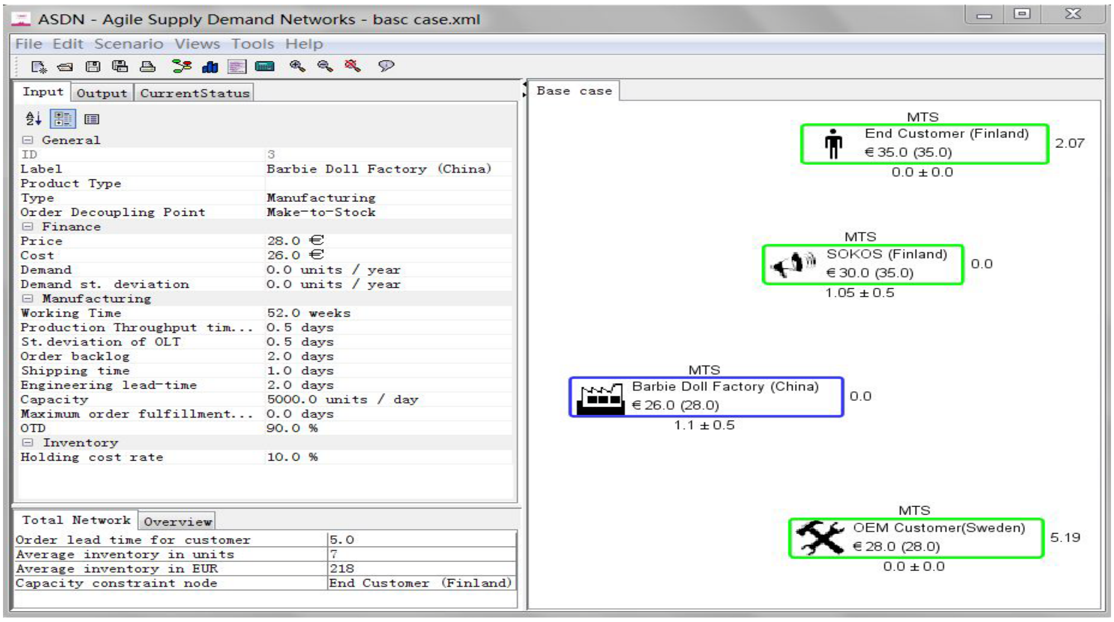


Figure 14. The node of manufacturing.

Finally to add the node of suppler, the figure 15 shows the nodes of four suppliers which respective named as Doll hair, Doll clothes, Doll body and Doll shoes. We can input different information from each node of supplier by clicking the intended node. For example, highlight (Blue color) the node of supplier named "supplier for doll hair" (Goods originate from China) and its information such as: label as "doll hair (China)", type as "supplier", order decoupling point as "Make-to-Stock", price as "0.65€", cost as "0.5€", demand as "0.0 units/year", Demand st. deviation "0.0units/year", working time as "52.0weeks", production throughput time as "1.0days", St. deviation of OLT as "0.5days", order backlog as "2.0days",shipping time as "1.0days", engineering lead-time as "1.5days", maximum order fulfillment time as "0.0days", Capacity as "2000.0 units/day", OTD as "68.0%"holding cost rate as "10.0%" are displayed in the input section on the left side of the attributes window. Other leave suppliers input the information process at the same way.

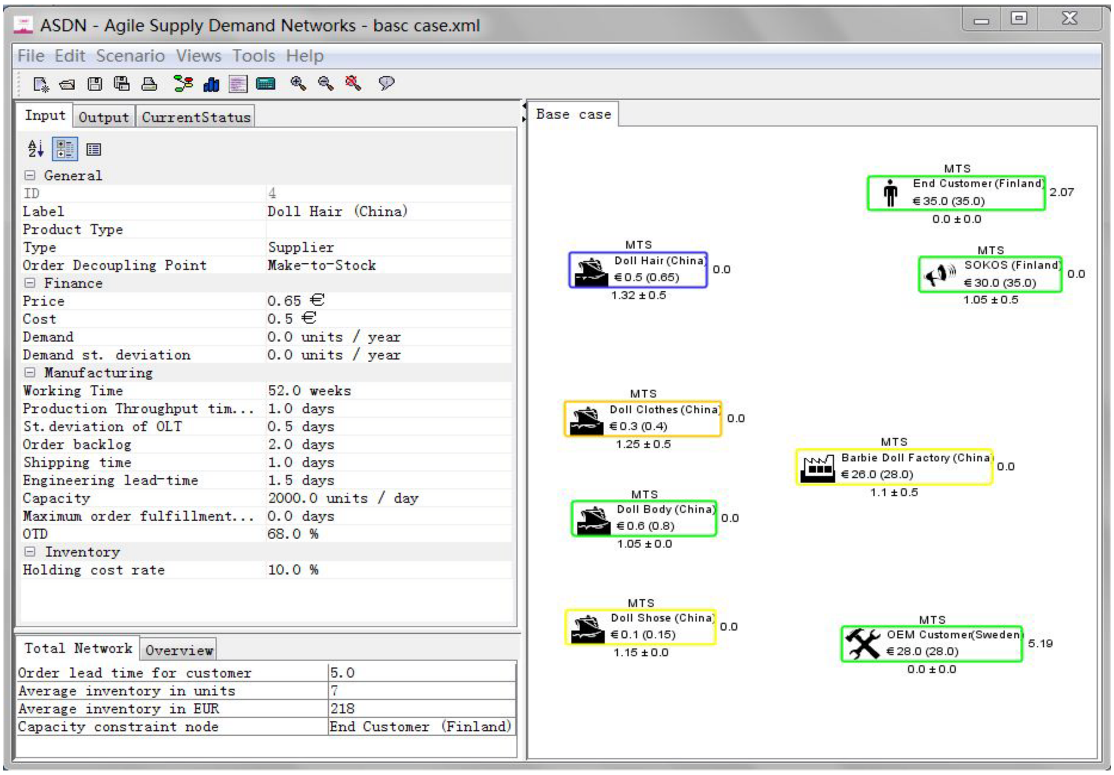


Figure 15. The node of suppler.

4.1.3. Add the arrows

Arrow is an element of a network which connects nodes with each other. It is also the model of transport. To build the arrow, we need highlight (turn to blue color) the start node at first, Select *Edit > Add Arrow* from the main menu-bar, then chooses the end node and one-click it turn to blue color, a new arrow appears. Next step input data to add arrow, when we are highlight (one-click arrow turn to blue color) the select arrow and the input section display on the left side screen. Below the figure 16 show the attributes of an arrow.

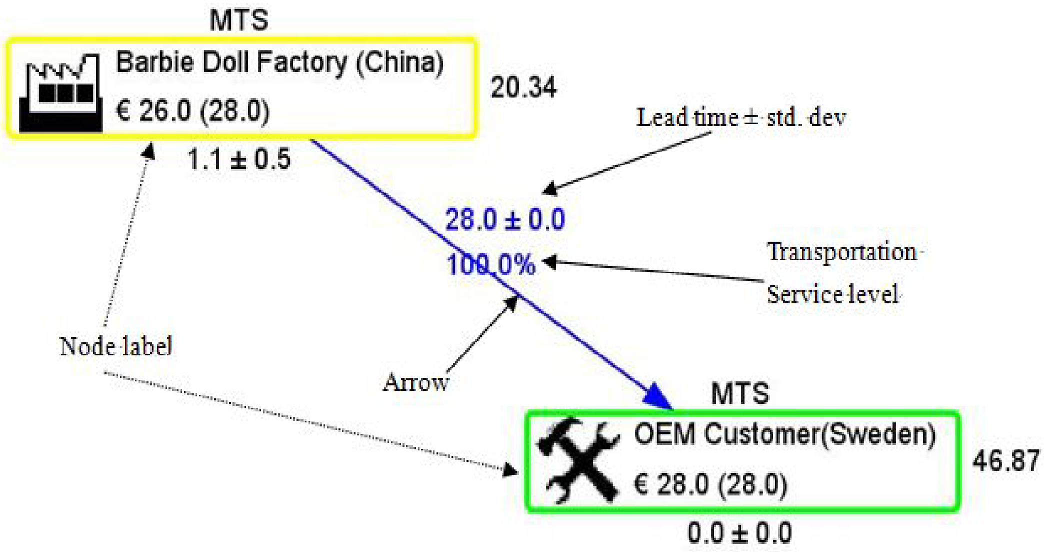


Figure 16. Attributes of an arrow.

Below figure 17 shows the arrow from the start node of manufacturing to end node of retailer. Same like node of input section, we can define and modify the input data in the section of general and number. From the left input panel we select the arrow type as "ship", price as "7300.0€", cost as "6800.0€",transportation time as "28.0days", service lvl as "90.0%", Inv.lvl.cur as "1.0units", Inv.lvl.min and max as "1.0units", lot-size as "1.0units", transport frequency as "10.0days", number of lots as "0.0", holding cost rate as "10.0%". After the arrow connect between the node of manufacturing and the node of retail, the node of manufacturing input data in the section of general changed immediately. From the left input panel display the demand as "2000.0units/year" and demand st. deviation "240.0 units/year" shown in figure 18. That mean the demand data of each node will change after add arrow connect to node of end, the demand data will base on the node of customers' demand data automatically change.

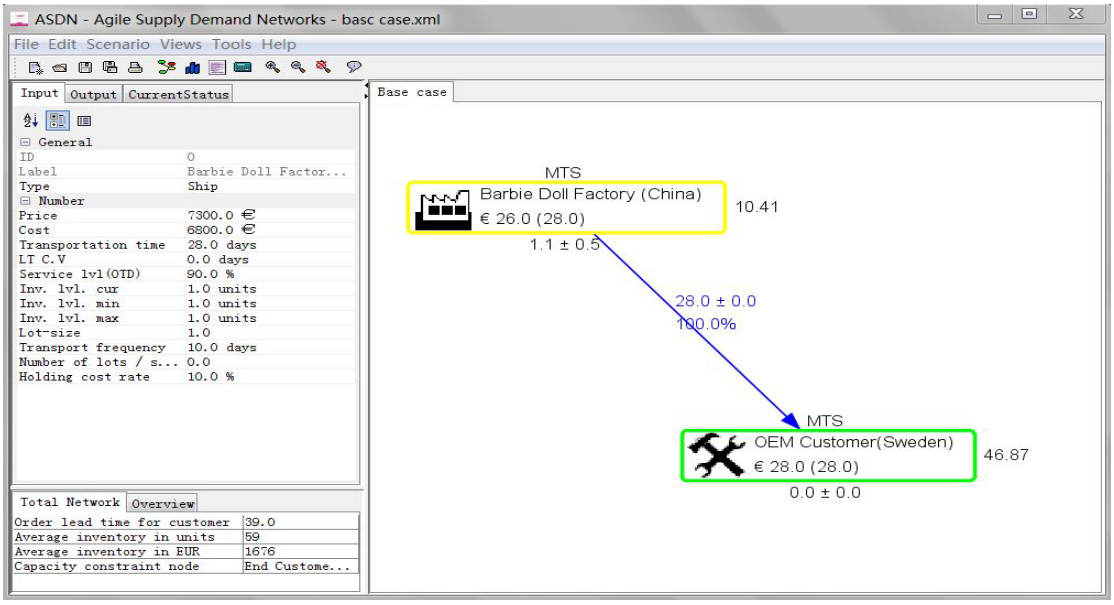


Figure 17. Add arrow from manufacturer to retailer.

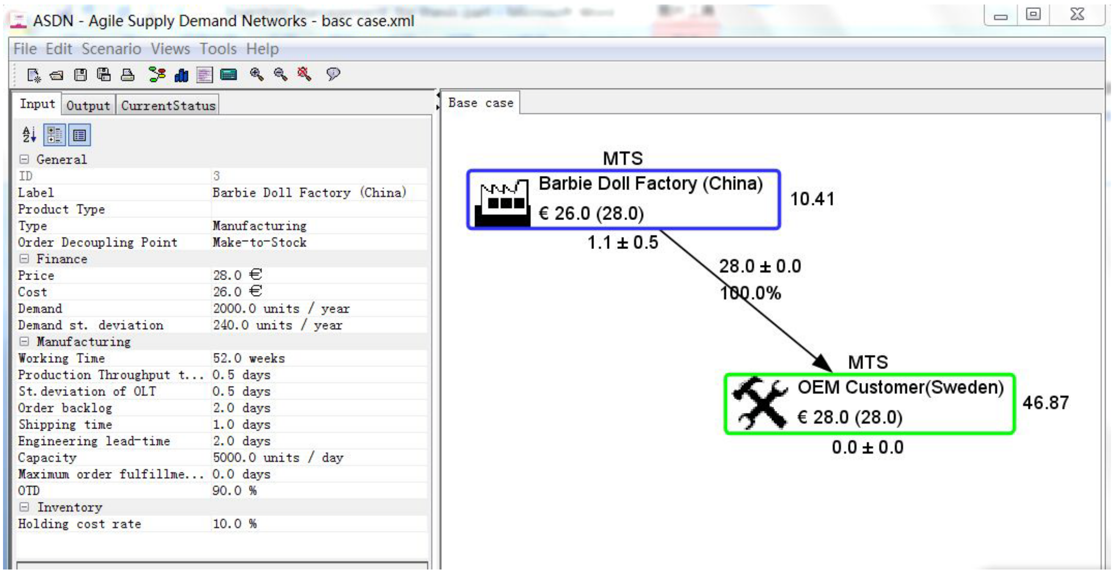


Figure 18. Arrow connects manufacturing and retailer.

Figure 19 shows the arrow from the start node of retailer to end node of end customer. Figure 20 shows the arrow from the start node of manufacturer to end node of end retailer. From figure 21 to figure 24 separate displays four suppliers connect manufacture with arrows. All the input number displayed in the input section on the left side of the attributes window.

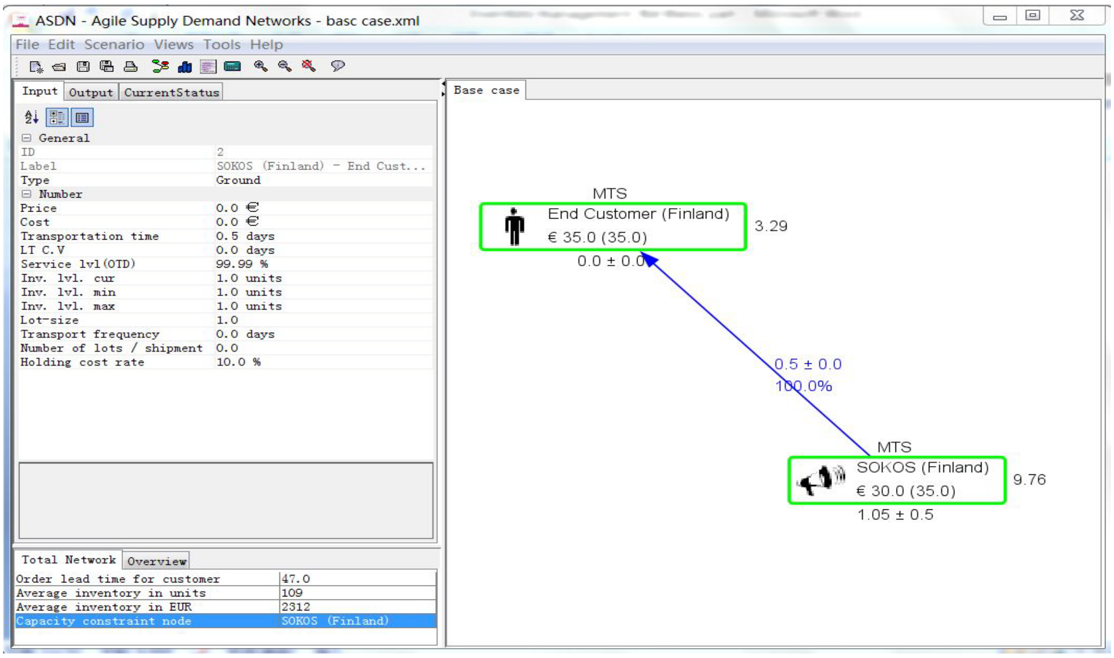


Figure 19. Add arrow from sales company to end customer.

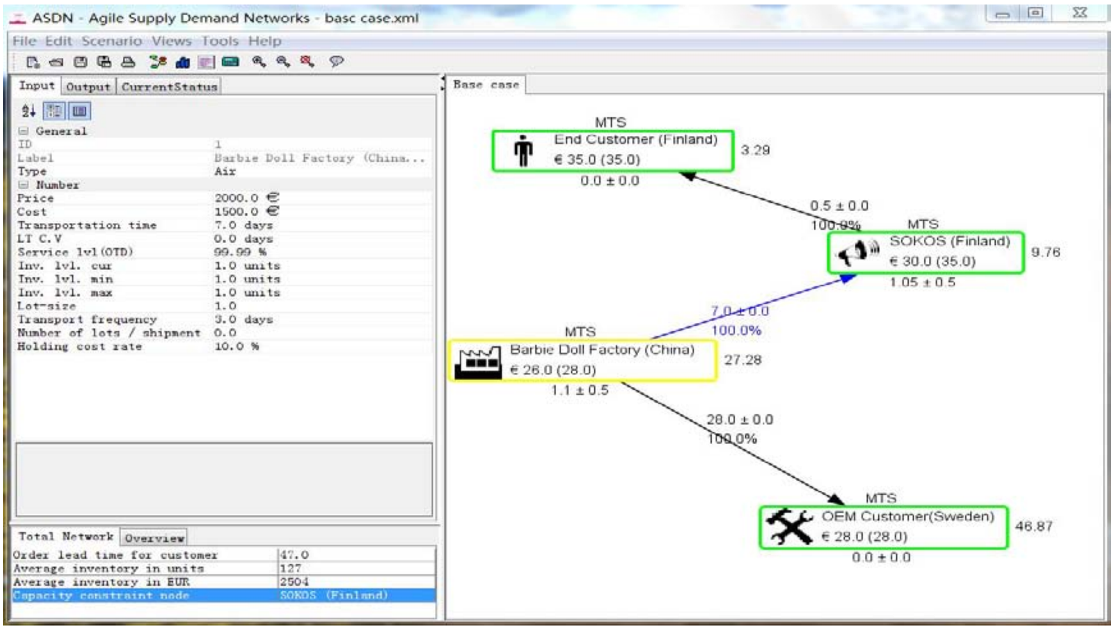


Figure 20. Add arrow from manufacturer to sales company.

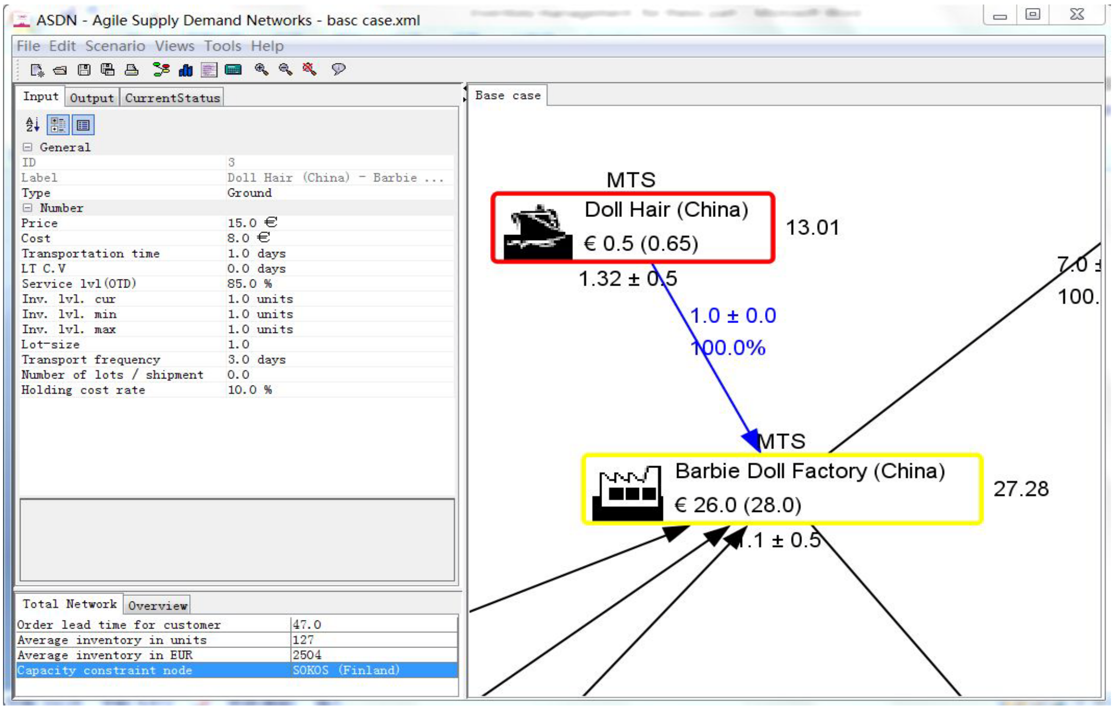


Figure 21. Add arrow from supplier to manufacturer.

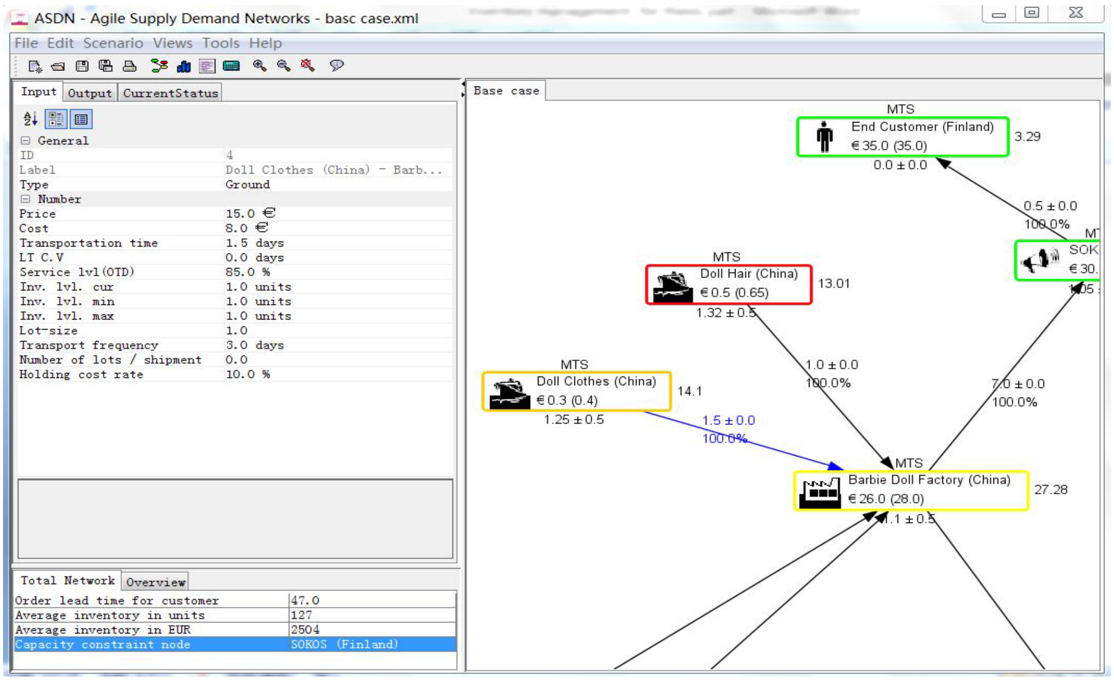


Figure 22. Add arrow from supplier to manufacturer.

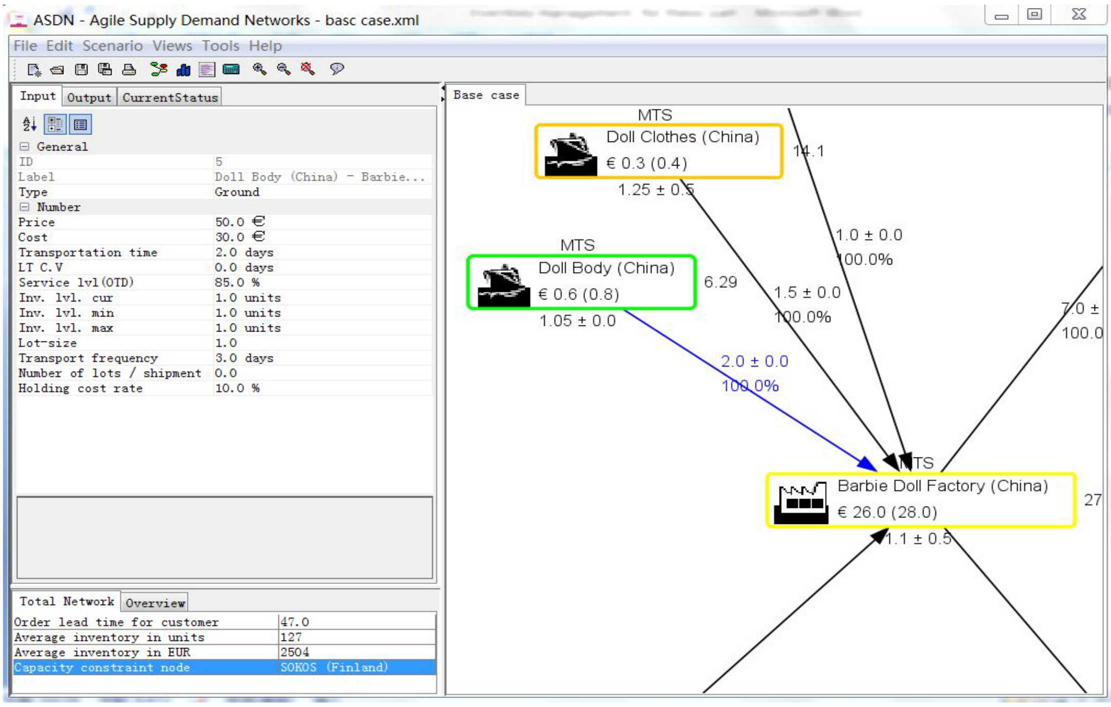


Figure 23. Add arrow from supplier to manufacturer.

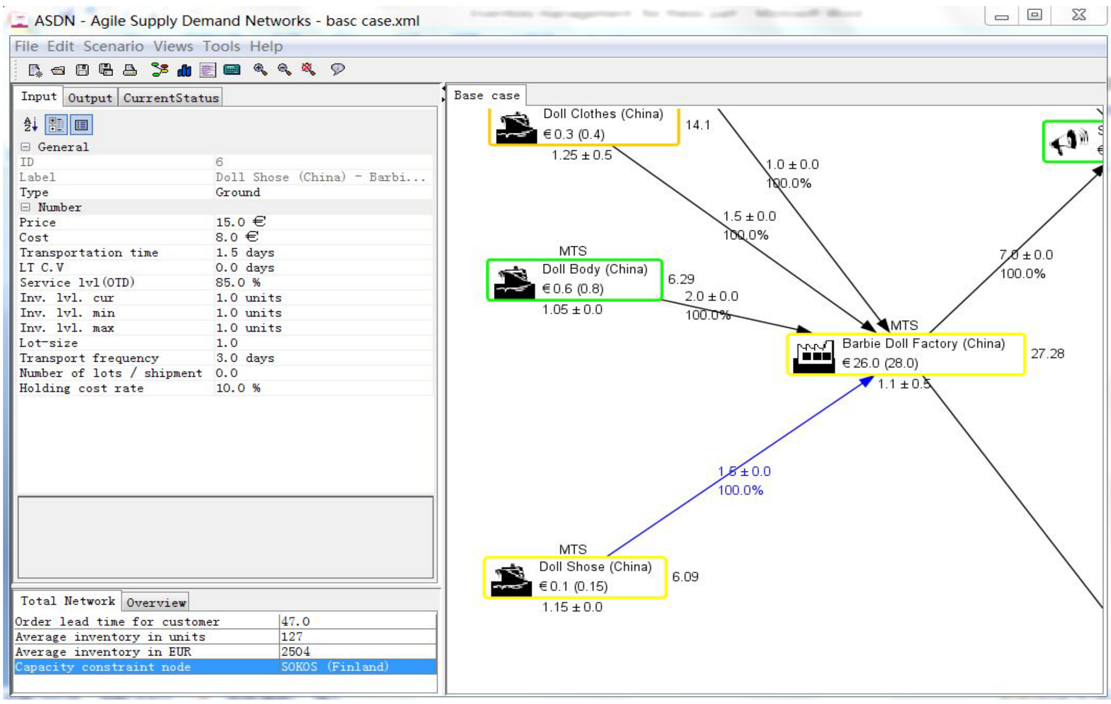


Figure 24. Add arrow from supplier to manufacturer.

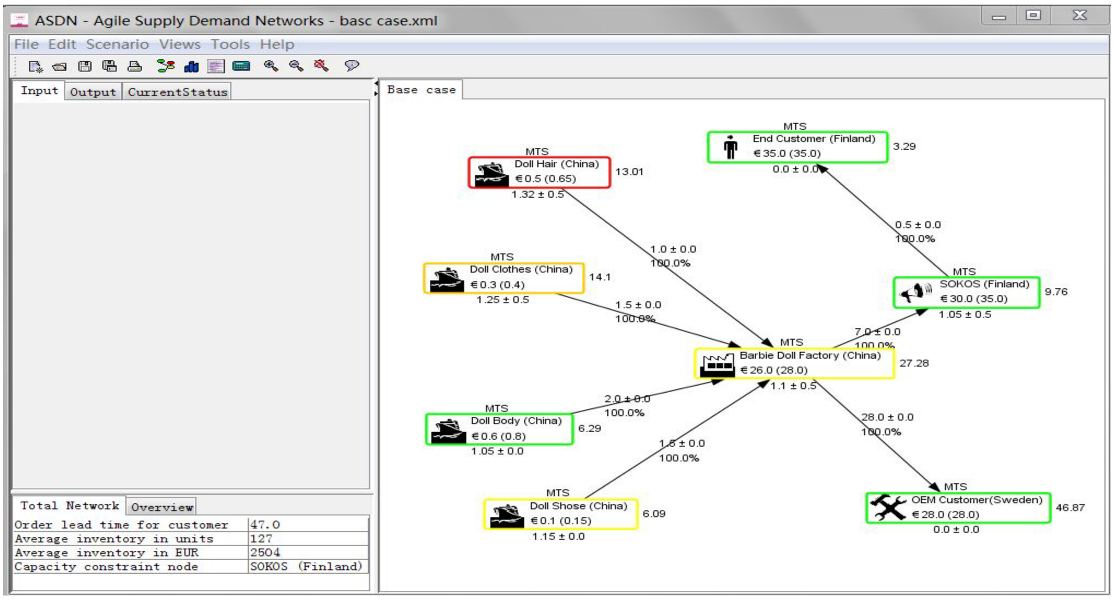


Figure 25. Supply Demand network of Barbie doll product.

After define and modify all input data for each arrow, we have already done the base construction. From above figure 25 shows supply demand network which combination of nodes and arrows layout of supplier-customers relationship with different color. The node show four different colors in the base network construction. The colors represent a level of OTD (On time to delivery), which means percent of how many orders are currently delivered on time. The percent level of OTD show on the below list:

- 95% > Green level > 100%
- 85% > Yellow level > 95%
- 75% > Brown level > 85%
- 0% > Red level >75%

The lower left corner shows the output data of total networks based on our input data to each node and arrow in the network. Its information such as; order lead time for customer: 47.0, average inventory in units: 127, average inventory in EUR: 2504, capacity constraint node: SOKOS (Finland). All the list of information will automatically change with BOM (Bill of materials) or improvement of node.

4.1.4. Output the data

In the output section of the window, we can get detail information from Manufacturing, Inventory, In (Out) bound and TOC. Below from the figure 26 to figure 33 show the Node of output data information. In this subchapter, the calculations results not only display from automatism calculate of ASDN software system, but also show the process of calculate side by side coming from equations by hand calculate. Aim to explain the ASDN software how to get the numbers of output data and prove the calculation logic of ASDN tool.

All the calculations equations of the output, while it can found from the Menu-bar click *Tools* select *Inventory Models*, then the new window of appear will display all the information.

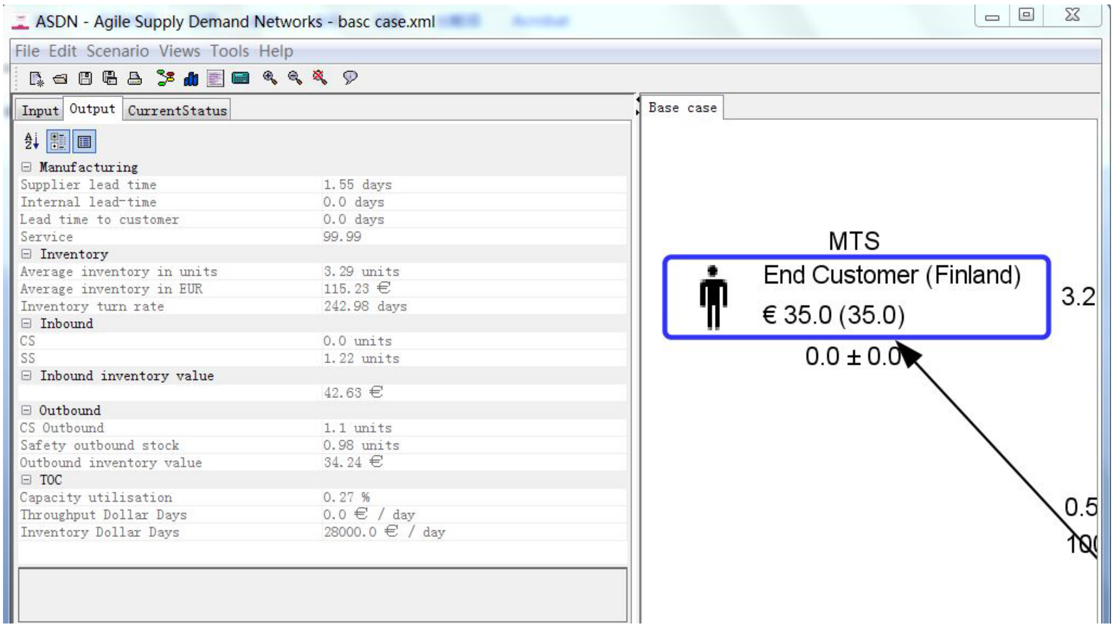


Figure 26. Node of end customer output.

Supplier Lead Time

SLT means expected time to get all components from suppliers. For this part calculate, the numerical of lead time to customer come from the upstream section, the numerical of order lead time come from the transport lead time. Because the Sokos sales company lead time to customer is 1.05days and the transportation order lead time from the sales company to end customer is 0.5day.

Supplier lead time = Lead time to customer + Order lead time

So SLT = 1.05 days + 0.5day = 1.55days.

Internal Lead Time

If odp=MTS: X = Shipping time, if odp = ATO: X = Shipping time + Production Throughput Time (TPT), if odp = MTO: X = Shipping time + TPT + Supplier lead-time, if odp = ETO: X=Shipping time + TPT + Supplier lead-time + Engineering lead-time. End customers=MTS: X = Shipping time, at same time the shipping time of end customer is 0.0 day, so the internal lead time of end customer is 0.0day.

Lead time To Customer

Lead time to customer means the how long of the operation time to customer. The numerical of order backlog come from the downstream section. Because the internal lead time and order backlog is 0.0day, OTD is 99.99.

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100)*Internal lead-time

So LTC = 0.0day + 0.0days + ((100 – 99.99)/100)*0.0day = 0.0day.

Service

Service means percent of how many orders are currently delivered on time, which equal to the OTD (On time delivery), so the result is 99, 99%.

Cycle Stock Inbound

CIS means amount of units required for the reorder time. For end customer not need to think about this, so the number is 0.0units.

CS = Demand * Transport Freq/2

So CS= 800units / 365days * 0.0 days / 2 = 0.0unit.

Safety Inbound Stock

SIS is Safety stock which kept for the uncertainty from supply.

SIS = sf * Math.sqrt(Math.pow(demand, 2) * Math.pow(transportLtcv, 2) + slt * Math.pow(dsd, 2)

SF = service factor, sf =3.72 for a 99.9% service level

SLT = supplier lead time

DSD = Demand st. deviation

So SIS = $3.72 * \sqrt{(\frac{800\text{ units}}{365\text{ days}})^2 * (0.0\text{ day})^2 + 1.55\text{ days} * (\frac{96\text{unites}}{365\text{ days}})^2} =$ 1.22unites.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT = lead time

OB = order backlog

So CSO = 800unites / 365days * (0.0day + 0.0day) / 2 = 0.0unit.

Safety Outbound Stock

SOS means kept for the uncertainty from demand.

SOS = sf * Math.sqrt(Math.pow(demand,2)*Math.pow(Ltcv,2) +lt*Math.pow(dsd, 2)

SF = service factor, sf =3.72 for a 99.99% service level

LT = lead time

DSD = Demand st. deviation

So SOS = $3.72 * \sqrt{(\frac{800\ \text{units}}{365\ \text{days}})^2 * (0.0\ \text{day})^2 + 1.0\ \text{day} * (\frac{96\text{unites}}{365\ \text{days}})^2} =$ 0.98 unite.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 35.0€ * 0.98unit = 34.3€.

Average inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU = 0.0unit + 1.22units + 1.1units + 0.98unit = 3.3units.

Average inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock) * Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (0.0 unit + 1.22 units) * 35.0€ + (1.1 units + 0.98unit) * 35.0€ = 115.5€.

Inventory Turn Rate

ITR means Demand per year divided by average inventory in units.

Inventory turn rate = Demand * 365/Average inventory in units

So ITR = 800units/year * 365/3.29units = 243.16days.

Inbound Inventory Value

IIV = Cost * Average inventory in units

Average inventory in units = CSI + SSO

So IIV= 35.0€ * (0.0unit + 1.22units) = 42.7€.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 800units/365days/800units * 100 = 0.27%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity). For End customer the price equal to the cost, so the function result is 0.0 € /day.

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 115.23€ * 242.98days = 27998.59€/day.

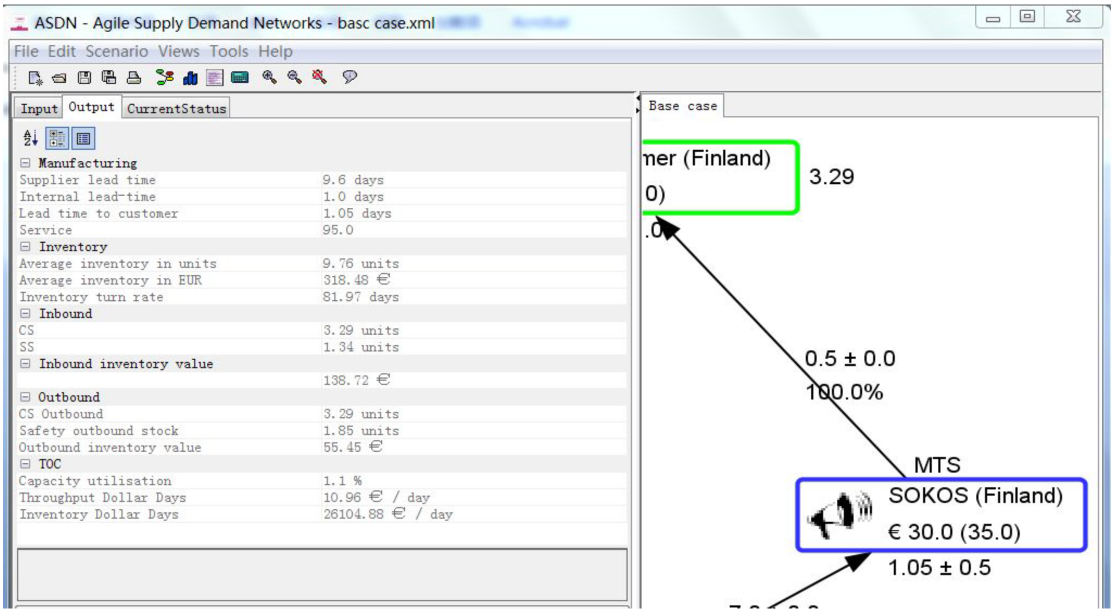


Figure 27. Node of sales company output.

Supplier Lead Time

SLT = Lead time to customer + Order lead time

From Barbie doll factory to Sokos sales company lead time is 1.1days, and the ground transport time means order lead time is 8.5days from the Sokos sales company to End customer.

So SLT = 1.1days + 8.5days = 9.6days.

Internal Lead Time

Sokos sales company=MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

The numerical of order backlog come from the downstream section. The order backlog come from the End customer's input data is 0.0day.

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 95)/100)*1.0day = 1.05days

Service

S = OTD (On time delivery) = 95%.

Cycle Stock Inbound

CSI = Demand * Transport Freq/2

So CS = 800units/365 days*3.0 days/2 = 3.29 units.

Safety Inbound Stock

SIS = sf * Math.sqrt(Math.pow(demand, 2)*Math.pow(transportLtcv, 2) + slt*Math.pow(dsd, 2)

SF = service factor, sf =1.64 for a 95% service level

SLT = supplier lead time

DSD = Demand st. deviation

So SIS = $1.64 * \sqrt{(\frac{800\text{ units}}{365\text{ days}})^2 * (0.0\text{ day})^2 + 9.6\text{ days} * (\frac{96\text{unites}}{365\text{ days}})^2} = 1.34$ unites.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

So CSO = 800unites/365days*(1.0day + 2.0days) / 2 = 3.29units.

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2)

SF = service factor, sf =1.64 for a 95% service level

LTCV = St.deviation of OLT

DSD = Demand st. deviation

So SOS = $1.64 * \sqrt{(\frac{800\text{ units}}{365\text{ days}})^2 * (0.5\text{ day})^2 + 1.0\text{ day} * (\frac{96\text{unites}}{365\text{ days}})^2} = 1.85$ unites.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 30.0€ * 1.85units = 55.5€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 3.29units + 1.34units + 3.29units + 1.85units = 9.76units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (3.29units + 1.34units) * 30.0€ + (3.29units + 1.85units) * 35.0€ = 318.8€

Inventory Turn Rate

ITR = Demand*365/AIU = 800units/year*365 /9.76units = 81.97days.

Inbound Inventory Value

IIV = Cost * Average inventory in units

Average inventory in units = CSI + SSO

So IIV= 30.0€ * (3.29units + 1.34units) = 138.9€.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 800units/365days/200units * 100 = 1.1%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity)

If the demand is 800units with one year, so we can get the time for capacity is 200unites/day.

Manufacturing stage time = Production Throughput time (TPT) = 1.0days

So IDD = (35.0€/unit – 30.0€/unit)/1.0days * 800units/365days = 10.95€/day

Inventory Dollar Days

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 318.8€ * 81.97days = 26132.04€/day.

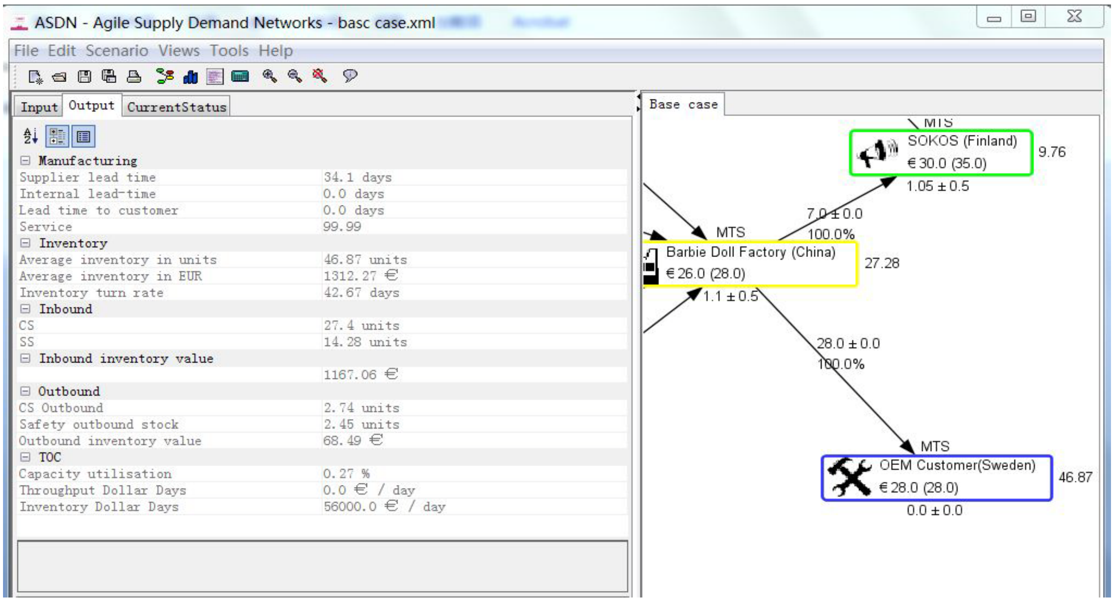


Figure 28. Node of retailer output.

Supplier Lead Time

SLT = Lead time to customer + Order lead time

So SLT = 1.1days + 33.0days = 34.1days.

Internal Lead Time

OEM customer = MTS: X = Shipping time

So ILT = 0.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 0.0day + ((100- 100)/100)*1.0day = 0.0day.

Service

S = OTD (On time delivery) = 99.99%.

Cycle Stock Inbound

CSI = Demand*Transport Freq/2

So CS = 2000units/365days*10.0 days/2 = 27.4units.

Safety Inbound Stock

SIS = sf * Math.sqrt(Math.pow(demand, 2)*Math.pow(transportLtcv, 2) + slt*Math.pow(dsd, 2),

SF = service factor, sf =3.72 for a 99.99% service level,

SLT = supplier lead time,

DSD = Demand st. deviation,

So SIS= $3.72 * \sqrt{(\frac{2000\text{ units}}{365\text{ days}})^2 * (0.0\text{day})^2 + 34.1\text{days} * (\frac{240\text{unites}}{365\text{ days}})^2} = 14.28$ unites.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2,

LT= lead time,

OB = order backlog,

So CSO = 2000unites/365days*(1.0day + 0.0day) / 2 = 2.74units

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2).

SF = service factor, sf =3.72 for a 99.99% service level,

LT= lead time,

LTCV = St.deviation of OLT,

DSD = Demand st. deviation,

So SOS = $3.72 * \sqrt{(\frac{2000\text{ units}}{365\text{ days}})^2 * (0.0\text{day})^2 + 1.0\text{days} * (\frac{240\text{unites}}{365\text{ days}})^2} = 2.45$ unites

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 28.0€ * 2.45units = 68.6€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 27.4units + 14.28units + 2.74units + 2.45units = 46.87units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (27.4units+14.28units) * 28.0€ + (2.74units + 2.45units)*28.0€ = 1312.36€.

Inventory Turn Rate

ITR = Demand*365/AIU = 2000units/year*365 /46.87units = 42.67days.

Inbound Inventory Value

IIV = Cost * Average inventory in units

Average inventory in units = CSI + SSO

So IIV= 28.0€ * (27.4units + 14.28units) = 1167.04€.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2000units/365days/2000units * 100 = 0.27%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity).

For OEM customer the price equal to the cost, so the function result is 0.0 € /day.

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 1312.36€ * 42.67days = 55998.40€/day.

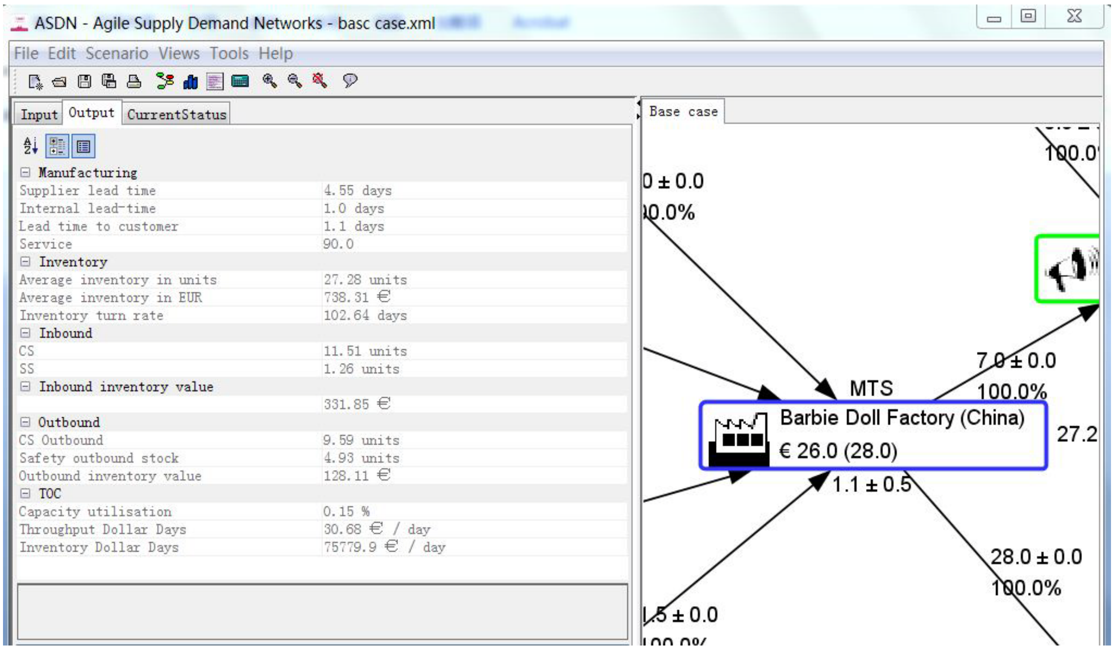


Figure 29. Node of manufacturer output.

Supplier Lead Time

SLT = Lead time to customer + Order lead time

Use the supplier of Doll body to calculate data, because of it take the longest transport lean time compare others.

So SLT = 1.05days + 3.5days = 4.55days.

Internal Lead Time

Factory = MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 90)/100)*1.0day = 1.1days.

Service

S = OTD (On time delivery) = 90%.

Cycle Stock Inbound

CSI = Demand*Transport Freq/2

So CS = 2800units/365days*3.0 days/2 = 11.51units.

Safety Inbound Stock

SIS = sf * Math.sqrt(Math.pow(demand, 2)*Math.pow(transportLtcv, 2) + slt*Math.pow(dsd, 2)

SF = service factor, sf =1.28 for a 90% service level

SLT = supplier lead time

DSD = Demand st. deviation

So SIS= $1.28 * \sqrt{(\frac{2800 \text{ units}}{365 \text{ days}})^2 * (0.0\text{day})^2 + 4.55 \text{ days} * (\frac{168\text{unites}}{365 \text{ days}})^2} = 1.26$unites.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

There have four suppliers to support the factory, so we need calculate the average order backlog at first.

(Average order backlog = (2.0days + 2.0days + 1.0day +1.0day)/4 = 1.5days)

So CSO = 2800unites/365days*(1.0day + 1.5days) / 2 = 9.59units

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2)

SF = service factor, sf =1.28 for a 90% service level

LT= lead time

LTCV = St.deviation of OLT

DSD = Demand st. deviation

So SOS = $1.28 * \sqrt{(\frac{2800 \text{ units}}{365 \text{ days}})^2 * (0.5\text{day})^2 + 1.0\text{day} * (\frac{168\text{unites}}{365 \text{ days}})^2} = 4.94$ unites.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 26.0€ * 4.94 unites = 128.44€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 11.51units + 1.26units + 9.59units + 4.94units = 27.30units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (11.51units + 1.26units) * 26.0€ + (9.59units + 4.94units) * 28.0€ = 738.86€

Inventory Turn Rate

ITR = Demand*365/AIU = 2800units/year*365 /27.30units = 102.56days.

Inbound Inventory Value

IIV = Cost * Average inventory in units

Average inventory in units = CSI + SSO

So IIV= 26.0€ * (11.51units + 1.26units) = 332.02€.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2800units/365days/5000units * 100 = 0.15%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity).

Manufacturing stage time = Production Throughput time (TPT) = 0.5day

So IDD = (28.0€/unit – 26.0€/unit)/0.5day * 2800units/365days = 30.68€/day

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 738.86€ * 102.56days = 75777.48€/day.

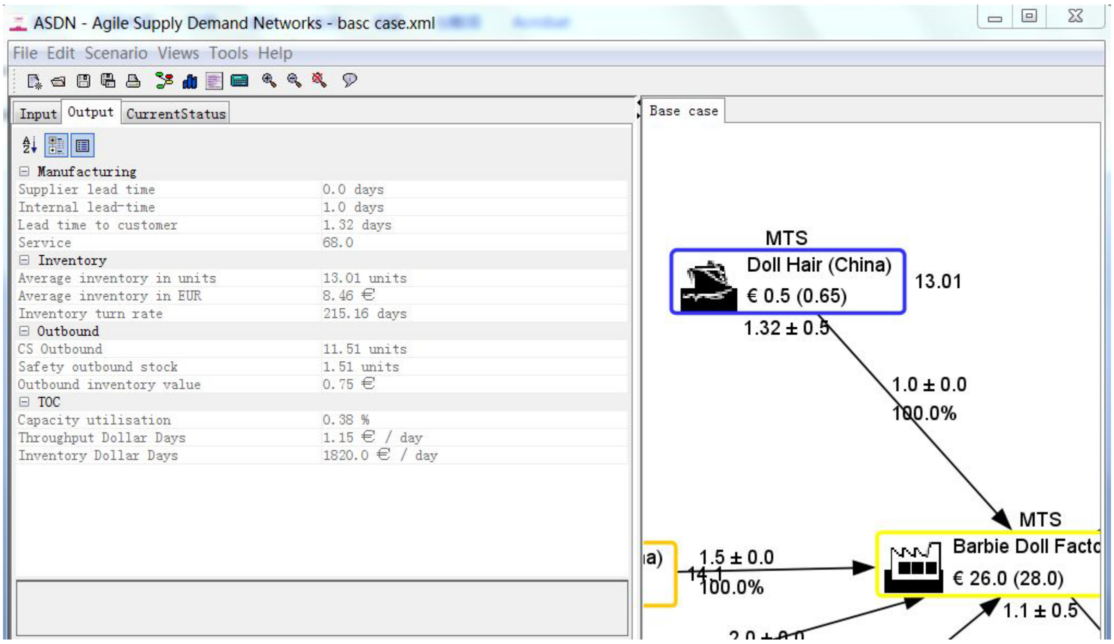


Figure 30. Node of supplier output (Doll Hair).

Supplier Lead Time

SLT = Lead time to customer + Order lead time

So SLT = 0.0day + 0.0day = 0.0day.

Internal Lead Time

Doll hair supplier = MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 68)/100)*1.0day = 1.32days.

Service

S = OTD (On time delivery) = 68%.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

So CSO = 2800unites/365days*(1.0day + 2.0days) / 2 = 11.51units.

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2)

SF = service factor, sf = 0.52 for a 68% service level

LT= lead time,

LTCV = St.deviation of OLT

DSD = Demand st. deviation

So SOS = $0.52 * \sqrt{(\frac{2800\text{ units}}{365\text{ days}})^2 * (0.5\text{day})^2 + 1.0\text{day} * (\frac{168\text{unites}}{365\text{ days}})^2} = 2.00$ unites.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 0.5€ * 2.0units = 1.0€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 0.0unit + 0.0unit + 11.51units + 2.00 unites = 13.51units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (0.0unit + 0.0unit) * 0.5€ + (11.51units + 2.00 unites) * 0.65€ = 8.78€.

Inventory Turn Rate

ITR = Demand*365/AIU = 2800units/year*365 /13.51units = 207.25days.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2800units/365days/2000units * 100 = 0.38%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity).

Manufacturing stage time = Production Throughput time (TPT) = 1.0day

So IDD = (0.65€/unit – 0.5€/unit)/1.0day * 2800units/365days = 1.15€/day

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 8.78€ * 207.25days = 1820.0€/day.

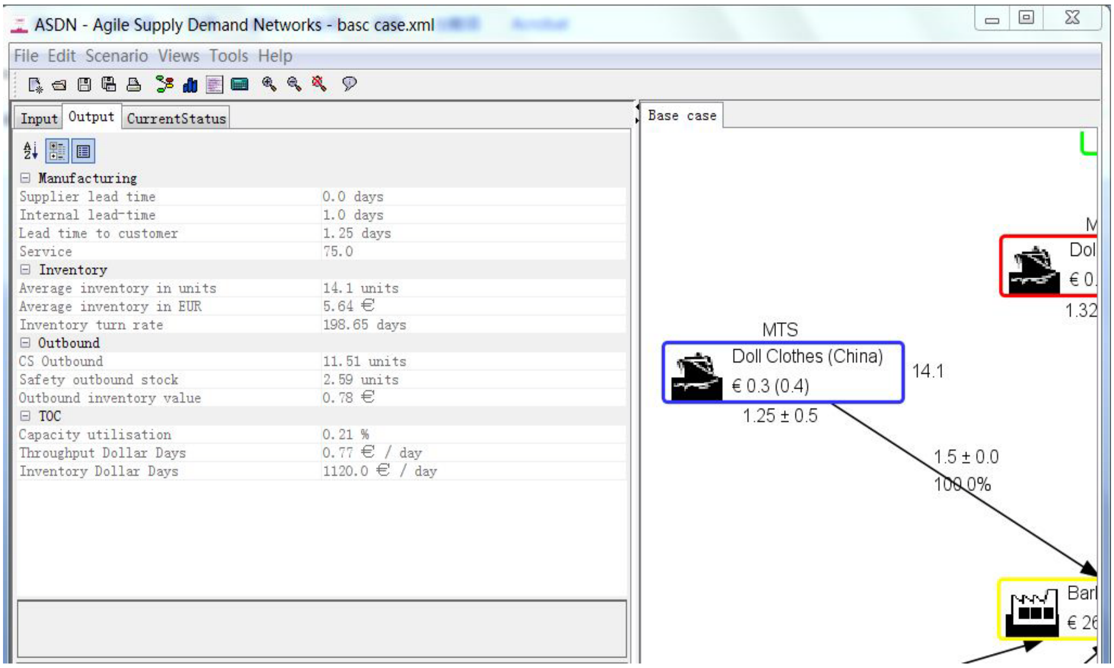


Figure 31. Node of supplier output (Doll Clothes).

Supplier Lead Time

SLT = Lead time to customer + Order lead time (Ground transportation)

So SLT = 0.0day + 0.0day = 0.0day.

Internal Lead Time

Doll clothes supplier = MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 75)/100)*1.0day = 1.25days.

Service

S = OTD (On time delivery) = 75%.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

So CSO = 2800unites/365days*(1.0day + 2.0days) / 2 = 11.51units.

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2).

SF = service factor, sf = 0.67 for a 75% service level,

LT= lead time,

LTCV = St.deviation of OLT,

DSD = Demand st. deviation,

So SOS = $0.67 * \sqrt{(\frac{2800 \text{ units}}{365 \text{ days}})^2 * (0.5\text{day})^2 + 1.0\text{day} * (\frac{168\text{unites}}{365 \text{ days}})^2} = 2.59$ unites.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 0.3€ * 2.59units = 0.78€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 0.0unit + 0.0unit + 11.51units + 2.59units = 14.10units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (0.0unit + 0.0unit) * 0.3€ + (11.51units + 2.59units) * 0.4€ = 5.64€

Inventory Turn Rate

ITR = Demand*365/AIU = 2800units/year*365 /14.10units = 198.58days.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2800units/365days/3600units * 100 = 0.21%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity).

Manufacturing stage time = Production Throughput time (TPT) = 1.0day

So IDD = (0.4€/unit – 0.3€/unit)/1.0day * 2800units/365days = 0.767€/day.

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 5.64€ * 198.58days = 1119.99€/day.

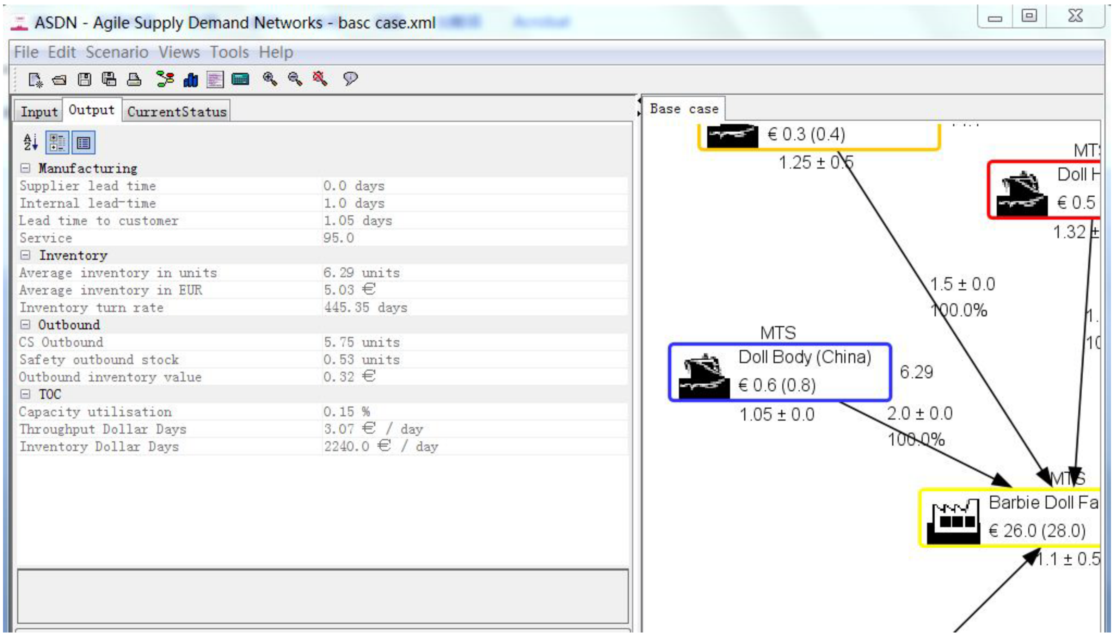


Figure 32. Node of supplier output (Doll Body).

Supplier Lead Time

SLT = Lead time to customer + Order lead time

So SLT = 0.0day + 0.0day = 0.0day.

Internal Lead Time

Doll body supplier = MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 95)/100)*1.0day = 1.05days

Service

S = OTD (On time delivery) = 95%.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

So CSO = 2800unites/365days*(0.5day + 1.0day) / 2 = 5.75units.

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2)

SF = service factor, sf = 1.64 for a 95% service level

LT= lead time

LTCV = St.deviation of OLT

DSD = Demand st. deviation

So SOS = $1.64 * \sqrt{(\frac{2800 \text{ units}}{365 \text{ days}})^2 * (0.0\text{day})^2 + 0.5\text{day} * (\frac{168\text{unites}}{365 \text{ days}})^2} = 0.53$ unite.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 0.6€ * 0.53unit = 0.318€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 0.0unit + 0.0unit + 5.75units + 0.53 unite = 6.28units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (0.0unit + 0.0unit) * 0.6€ + (5.75units + 0.53unite) * 0.8€ = 5.024€

Inventory Turn Rate

ITR = Demand*365/AIU = 2800units/year*365 /6.29units = 445.15days.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2800units/365days/5000units * 100 = 0.15%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity).

Manufacturing stage time = Production Throughput time (TPT) = 0.5day

So IDD = (0.8€/unit – 0.6€/unit)/0.5day * 2800units/365days = 3.068€/day

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 5.03€ * 445.35days = 2240.11€/day.

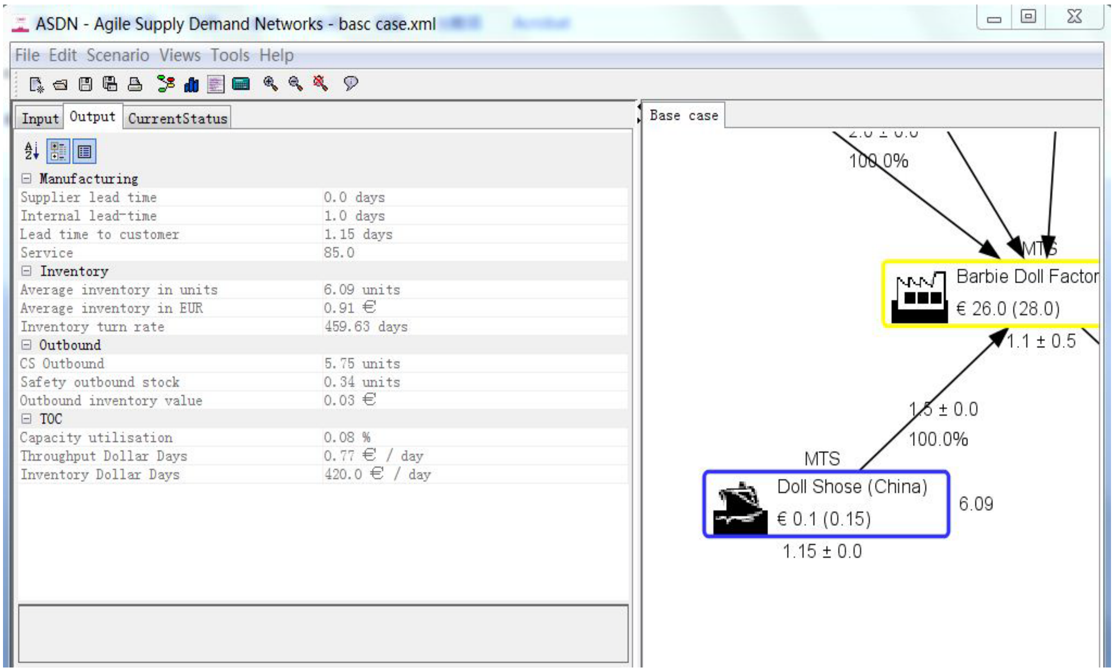


Figure 33. Node of supplier output (Doll Shose).

Supplier Lead Time

SLT = Lead time to customer + Order lead time

So SLT = 0.0day + 0.0day = 0.0day.

Internal Lead Time

Doll shoes supplier = MTS: X = Shipping time

So ILT = 1.0 day.

Lead Time to Customer

LTC = Order backlog + Internal lead-time + ((100 - OTD)/100) * Internal lead-time

So LTC = 0.0day + 1.0day + ((100- 85)/100)*1.0day = 1.15days

Service

S = OTD (On time delivery) = 85%.

Cycle Stock Outbound

CSO = demand * (LT+OB) / 2

LT= lead time

OB = order backlog

So CSO = 2800unites/365days*(0.5day + 1.0day) / 2 = 5.75units.

Safety Outbound Stock

SOS= sf*Math.sqrt(Math.pow(demand, 2)*Math.pow(Ltcv, 2)+lt*Math.pow(dsd, 2)

SF = service factor, sf = 1.04 for a 85% service level

LT= internal lead time

LTCV = St.deviation of OLT

DSD = Demand st. deviation

So SOS = $1.04 * \sqrt{(\frac{2800\text{ units}}{365\text{ days}})^2 * (0.0\text{day})^2 + 0.5\text{day} * (\frac{168\text{unites}}{365\text{ days}})^2} = 0.33$unite.

Outbound Inventory Value

OIV = Cost * Safety outbound stock

So OIV = 0.1€ * 0.33 unite = 0.03€.

Average Inventory in UNITS

AIU = Total Cycle Stock + Total Safety Inbound Stock + CS Outbound + Safety Outbound Stock

So AIU= 0.0unit + 0.0unit + 5.75units + 0.33 unite = 6.08units.

Average Inventory in EUR

AIE = (Total Cycle Stock + Total Safety Inbound Stock)*Cost + (CS Outbound + Safety Outbound Stock) * price

So AIE = (0.0unit + 0.0unit) * 0.1€ + (5.75units + 0.33 unite) * 0.15€ = 0.91€.

Inventory Turn Rate

ITR = Demand*365/AIU = 2800units/year*365 /6.08units = 460.53days.

Capacity Utilization

CU = Demand/capacity*100

So CU = D/C*100 = 2800units/365days/10000units * 100 = 0.08%.

Throughput Dollar Days

IDD = (Price - Cost)/Manufacturing stage time * MIN (demand, capacity)

Manufacturing stage time = Production Throughput time (TPT) = 0.5day

So IDD = (0.15€/unit – 0.1€/unit)/0.5day * 2800units/365days = 0.77€/day.

Inventory Dollar Days

Inventory dollar-days are the dollar-value of the inventory at hand multiplied by the time since the inventory entered the responsibility of the link.

IDD = tiv * itr

TIV = Totally Inventory Value = Average inventory in EUR

ITR = Inventory Turn Rate

So IDD= 0.91€ * 460.53days = 419.08€/day.

4.2. Report of graph and table view

All the above mentioned steps focus on built the network construction. Next step we will depend on the base network construction to report of the related graphs and tables view. When we click on *views > Graph view* from the menu-bar, the drop-down menu list many model of view such as: *Gantt, Inventory, Service, Total inventory values vs. service level, inventory* and so on.

4.2.1. Graph view

Figure 34 shows the lead time view of the supply demand network by using the Gantt graph view. The Gantt graph can adjust different time periods on the network and available display the bottleneck of lead time through the entire material flow. User can select the relevant time period to check the network schedule, such as: shipping time, order backlog time, engineering lead time and production throughput time (TPT). From Figure 30 shows the time period from end of May to middle of July. The red color line display the products lead time to customers. The OEM customer has the longest lead time of 34.1days. The OEM customers' located in Sweden, so the transport time very long and transport type as "ship". Although the transport cost get lower than other type, but the long lead time will cause trouble in later stages. The factory cannot very quick to respond the customer uncertainty needed in the future. For that reason, the Barbie Doll Factory maybe thinking about other transport type to balance the transport cost and lead time, for example railway and air transport combines.

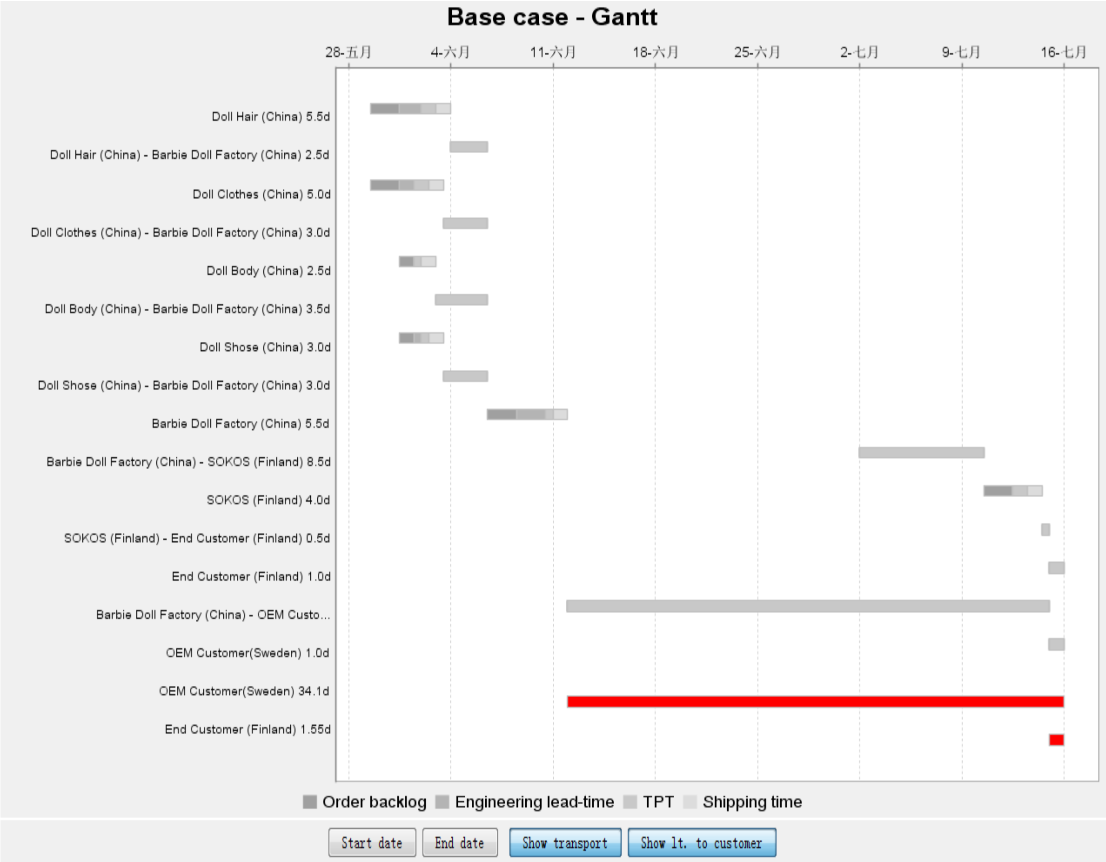


Figure 34. Gantt graph view.

Figure 35 shows the over view of inventory amounts and uses different color to present the type of inventory. For example, the red color refers to the cycle stock inbound; the blue color refers to the safety stock inbound; the green color refers to the safety stock outbound; the yellow color refers to the cycle stock outbound. The figure shows the OEM customer (retailer) is quite high amount. For improvement, the user should reduce the high amount level to balance the network; means reduce the downstream inventory amount level to increase the upstream level.

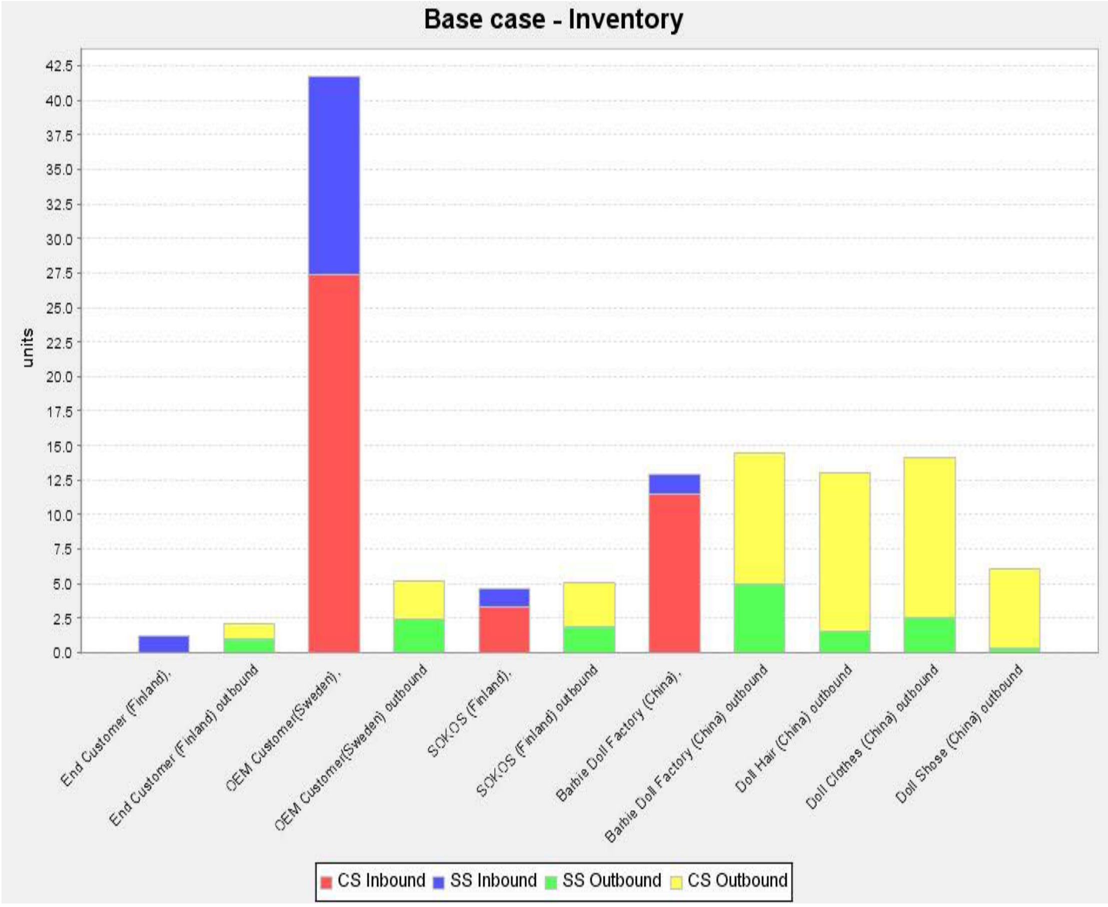


Figure 35. Inventory view.

Figure 36 shows the view of the inventory value and uses the curve describe the inventory holding cost level. The high inventory value level goes with high inventory holding cost level. In this figure the OEM customer (retailer located at Sweden) has the highest inventory value with the highest holding cost. For future improvement, user should reduce the highest inventory value to balance the whole network inventory value, at the same time the highest inventory holding cost get decrease.

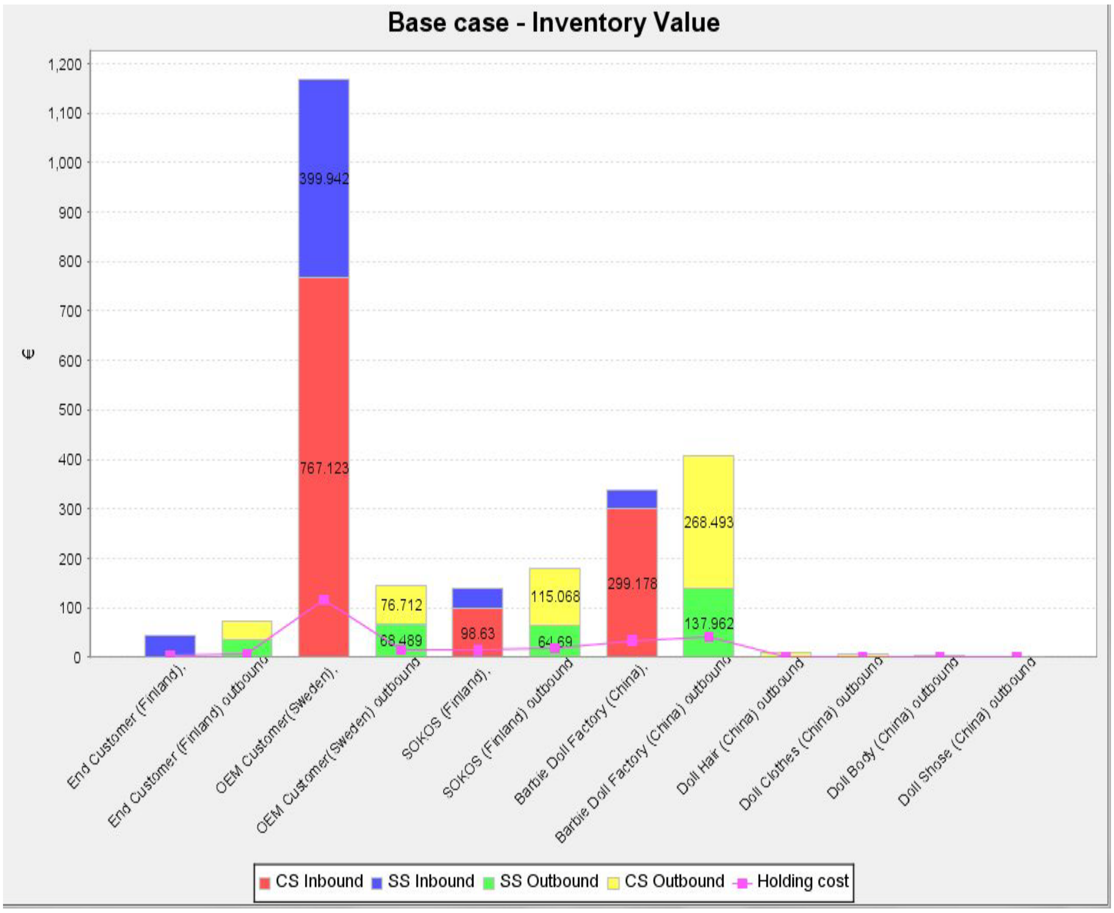


Figure 36. Inventory value view.

Figure 37 shows the service chart of Barbie Doll supply demand network. It is clearly shows the lowest service come from supplier of Doll hair which on time-to-delivery (OTD) lower than 70 percent. Maybe the 68.0% of OTD level is satisfaction for Doll hair supplier, but it will suffer unnecessary delay to the whole network. So the service chart can help user to analysis the network OTD and make the suitable decision to performance customer satisfaction. In case improvement, the OTD of Doll hair supplier is improve from 68.0% to 80.0% while the OTD of Doll clothes supplier is improve from 75.0% to 85.0%.

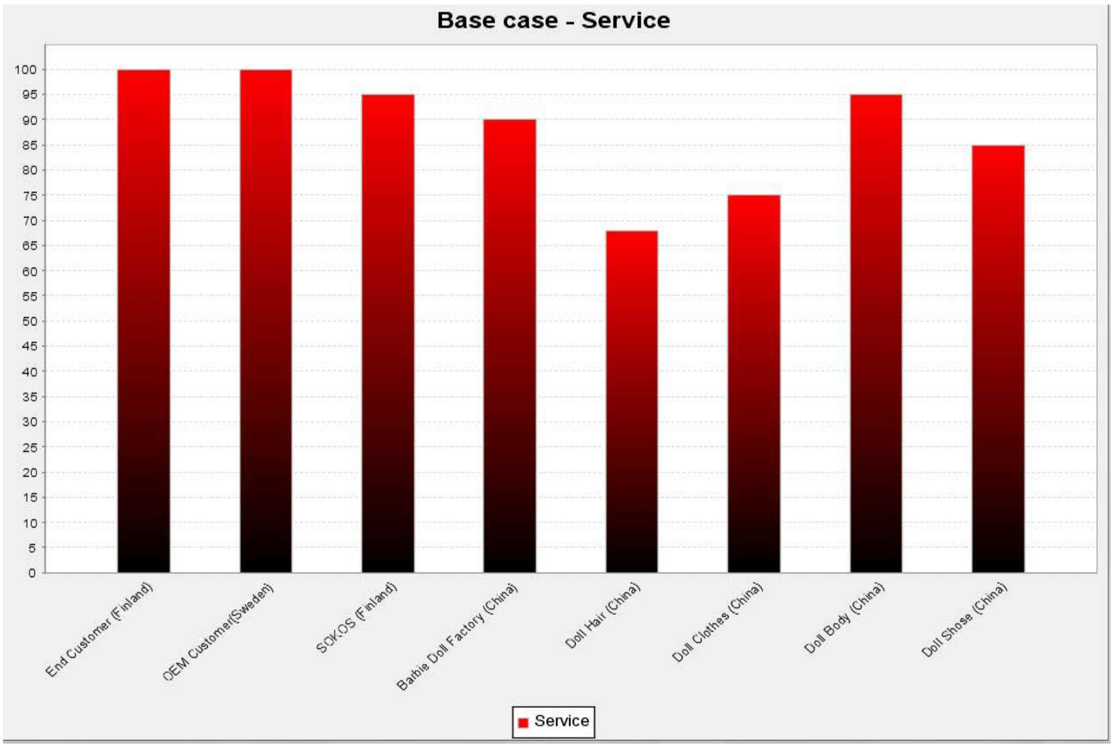


Figure 37. Service view.

To balance the inventory cost and service level not easy for manager. When we improvement the serves level always with the increase of the inventory cost. Figure 38 shows the curve describe the relationship between total inventory values and service level. User can through blow the curve to find the balance point that maintains a suitable service level without too higher inventory cost. For example, 2016.193€ of inventory cost can maintain 65% service level; while 2146.656€ inventory cost can maintain 90% service level. So the user can compare the two points, just increase 130.463€ of inventory cost get the service level improvement from 65% to 90%. Even the Total inventory Value VS. Service Level graph view can draw the curve with different individual component, such as supplier, manufacturing, retail, and customer.

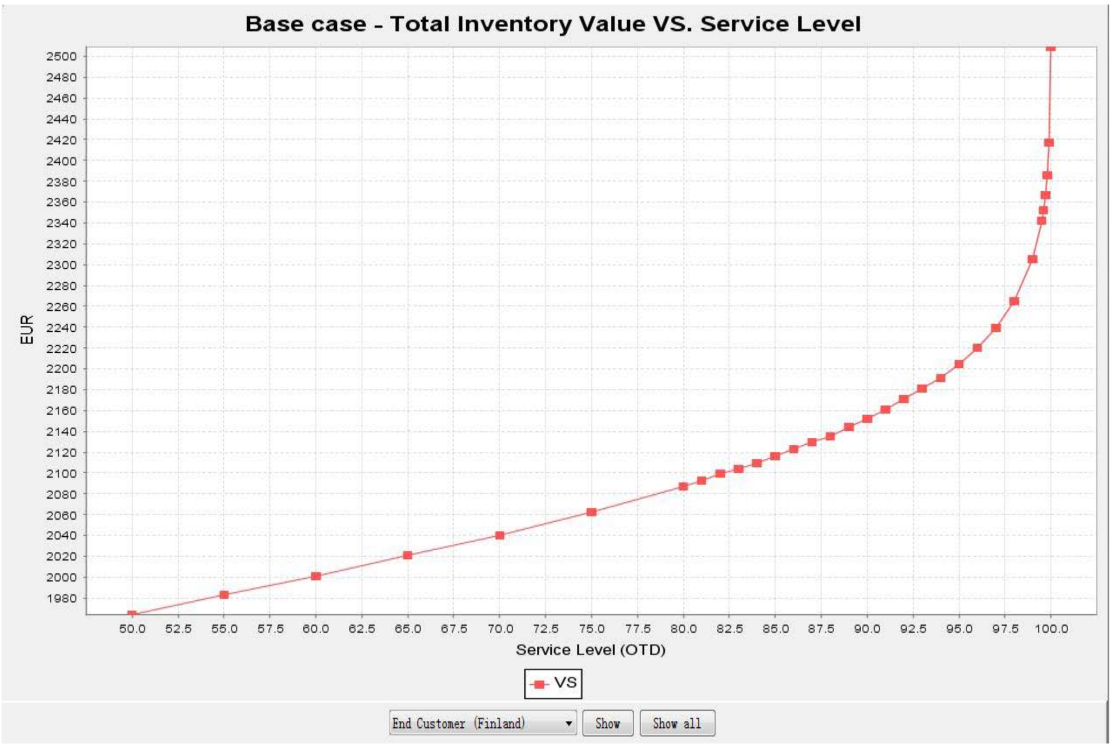


Figure 38. Total inventory value VS. Service level view.

4.2.2. Table view

Node table view offers us the current status of every node in the supply demand network, includes input and output data. When we select *Views* > *node table view* from the main menu-bar, a node table view appears show in table 2, While shift to output show in table 3. The table 2 displays all the input information of every node such as: label, product type, price, cost, OTD, lead time and so on. The table 3 list the calculate result of every node such as: lead time to customer, average inventory in units and EUR, cycle stock, safety stock, inventory turn rate and so on. We can define and modify the input data in the section of input from the node table view.

Node table view...

Input | Output

	End Customer...	OEM Customer...	SOKOS (Finland)	Barbie Doll ...	Doll Hair (C...	Doll Clothes...	Doll Body (C...	Doll Shose (...
ID	0	1	2	3	4	5	6	7
Label	End Customer ...	OEM Customer(...	SOKOS (Finland)	Barbie Doll F...	Doll Hair (Ch...	Doll Clothes ...	Doll Body (Ch...	Doll Shose (C...
Product Type								
Type	End customer	Retail	Sales company	Manufacturing	Supplier	Supplier	Supplier	Supplier
Order Decoupling Point	Make-to-Stock	Make-to-Stock	Make-to-Stock	Make-to-Stock	Make-to-Stock	Make-to-Stock	Make-to-Stock	Make-to-Stock
Price	35.0	28.0	35.0	28.0	0.65	0.4	0.8	0.15
Cost	35.0	28.0	30.0	26.0	0.5	0.3	0.6	0.1
Demand	800.0	2000.0	800.0	2800.0	2800.0	2800.0	2800.0	2800.0
Demand st. deviation	96.0	240.0	96.0	168.0	168.0	168.0	168.0	168.0
Working Time	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0
Production Throughp...	1.0	1.0	1.0	0.5	1.0	1.0	0.5	0.5
St.deviation of OLT	0.0	0.0	0.5	0.5	0.5	0.5	0.0	0.0
Order backlog	0.0	0.0	2.0	2.0	2.0	2.0	1.0	1.0
Shipping time	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Engineering lead-time	0.0	0.0	0.0	2.0	1.5	1.0	0.0	0.5
Capacity	800.0	2000.0	200.0	5000.0	2000.0	3600.0	5000.0	10000.0
Maximum order fulfi...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTD	99.99	99.99	95.0	90.0	68.0	75.0	95.0	85.0
Holding cost rate	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Ok

Table 2. Node table view with input data.

Node table view...

Input | Output

	End Customer...	OEM Customer...	SOKOS (Finland)	Barbie Doll ...	Doll Hair (C...	Doll Clothes...	Doll Body (C...	Doll Shose (...
Supplier lead time	1.55	34.1	9.6	4.55	0.0	0.0	0.0	0.0
Internal lead-time	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Lead time to customer	0.0	0.0	1.05	1.1	1.32	1.25	1.05	1.15
Service	99.99	99.99	95.0	90.0	68.0	75.0	95.0	85.0
Average inventory i...	3.29	46.87	9.76	27.28	13.01	14.1	6.29	6.09
Average inventory i...	115.23	1312.27	318.48	738.31	8.46	5.64	5.03	0.91
CS Inbound	0.0	27.4	3.29	11.51	0.0	0.0	0.0	0.0
Safety inbound stock	1.22	14.28	1.34	1.26	0.0	0.0	0.0	0.0
Inbound inventory v...	42.63	1167.06	138.72	331.85	0.0	0.0	0.0	0.0
CS Outbound	1.1	2.74	3.29	9.59	11.51	11.51	5.75	5.75
Safety outbound stock	0.98	2.45	1.85	4.93	1.51	2.59	0.53	0.34
Outbound inventory ...	34.24	68.49	55.45	128.11	0.75	0.78	0.32	0.03
Inventory turn rate	242.98	42.67	81.97	102.64	215.16	198.65	445.35	459.63
Capacity utilisation	0.27	0.27	1.1	0.15	0.38	0.21	0.15	0.08
Throughput Dollar Days	0.0	0.0	10.96	30.68	1.15	0.77	3.07	0.77
Inventory Dollar Days	28000.0	56000.0	26104.88	75779.9	1820.0	1120.0	2240.0	420.0

Ok

Table 3. Node table view with output data.

Transport table view shows the transportation status of every arrow in the supply demand network. When we select *Views* > *Transport table view* from the main menu-bar, a transport table view appears show in table 4, While shift to output show in table 5. The table 4 displays the type, price, cost, lead time, transport frequency and etc. The table 5 shows calculate result such as: demand, average waiting time, order lead time and goods in transport. We can check all the input data of arrow or modify data in the section of input from the transport table view.

Transport table view...

Input | Output

	Barbie Doll ...	Barbie Doll ...	SOKOS (Finla...	Doll Hair (C...	Doll Clothes ...	Doll Body (C...	Doll Shose (...
ID	0	1	2	3	4	5	6
Label	Barbie Doll F...	Barbie Doll F...	SOKOS (Finlan...	Doll Hair (Ch...	Doll Clothes (...	Doll Body (Ch...	Doll Shose (C...
Type	Ship	Air	Ground	Ground	Ground	Ground	Ground
Price	7300.0	2000.0	0.0	15.0	15.0	50.0	15.0
Cost	6800.0	1500.0	0.0	8.0	8.0	30.0	8.0
Transportation time	28.0	7.0	0.5	1.0	1.5	2.0	1.5
LT C.V	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Service lvl(OTD)	90.0	99.99	99.99	85.0	85.0	85.0	85.0
Inv. lvl. cur	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Inv. lvl. min	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Inv. lvl. max	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lot-size	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Transport frequency	10.0	3.0	0.0	3.0	3.0	3.0	3.0
Number of lots / sh...	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Holding cost rate	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Ok

Table 4. Transport table view with input data.

Transport table view...

Input | Output

	Barbie Doll ...	Barbie Doll ...	SOKOS (Finla...	Doll Hair (C...	Doll Clothes...	Doll Body (C...	Doll Shose (...
Demand	2000.0	800.0	800.0	2800.0	2800.0	2800.0	2800.0
Average waiting time	5.0	1.5	0.0	1.5	1.5	1.5	1.5
Order lead-time	33.0	8.5	0.5	2.5	3.0	3.5	3.0
Goods in transport	180.82	18.63	1.1	19.18	23.01	26.85	23.01
Transport capacity ...	Infinity	Infinity	Infinity	Infinity	Infinity	Infinity	Infinity

Ok

Table 5. Transport table view with output data.

Table 6 shows the result of financials analysis. Go to the main menu-bar, select *Views* > *Financials* can be displayed as below.

Financials

	Base case
Safety Stock Holding Cost [EUR / year]	0.0
Lead time to customer [days]	17.82
Cycle time [days]	47.0
Inventory turns [turns/year]	6.31
Inventory Holding Cost [EUR]	250.43

Close

Table 6. Totally financials view.

4.3. Improvement the base case

ASDN provides the user with a variety of analysis tools that visualize the supply chain from multiple dimensions (Helo, 2006). The graphs and tables help the user to make suitable decision at strategy level. After the graphs and tables view of base case, next task is to improve it. Below subchapter shows how to reach the improvement result and optimize goal. ASDN practices applied to improve the supply demand networks with the decoupling point marked as a stock holding point.

4.3.1. Modified the input data for improvement

Any improvements or change within the base case could create new scenario, select *Scenario > Add new scenario* from the menu-bar. The new scenario named as *Modified model* and display on the main window as show below figure 39. For case improvement, there have three nodes and one arrow will get modified at the section of input. The three nodes include: Barbie Doll factory, Supplier of Doll hair and Doll clothes. One arrow of data belongs to the transport from Barbie Doll factory to OEM customer.

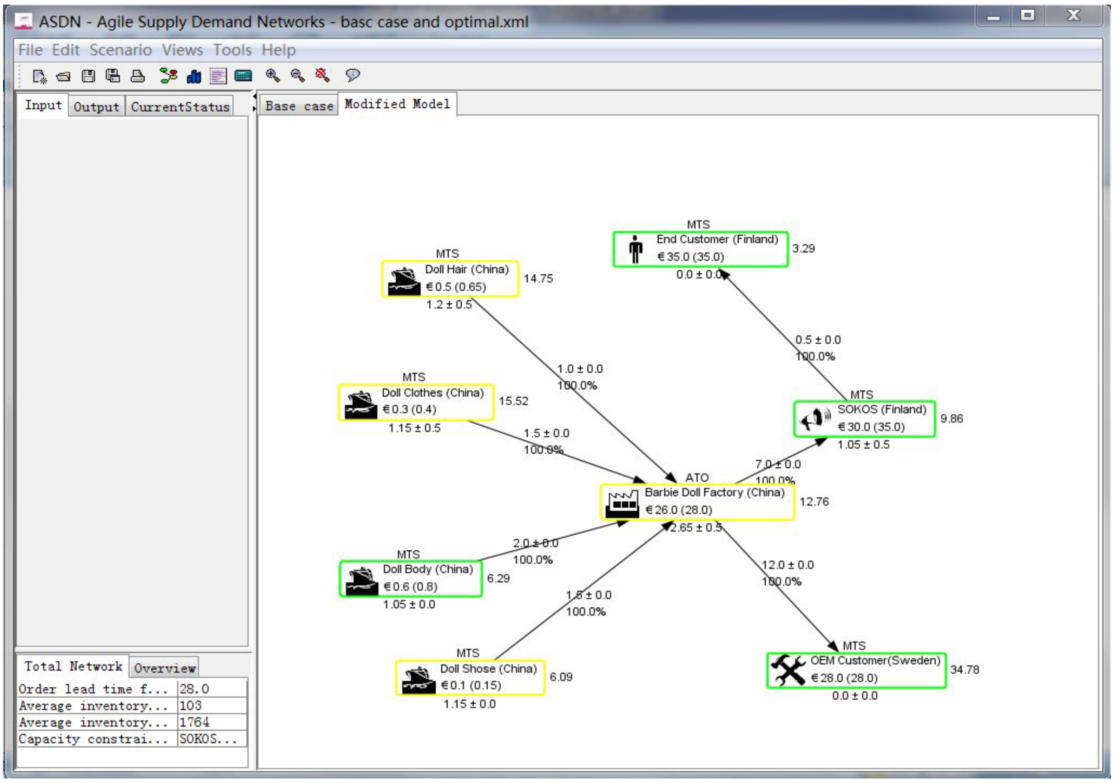


Figure 39. Modified Barbie Doll supply demand network.

Barbie Doll factory modified the input data, improve the type from “MTS” to “ATO”, improve order backlog from “2.0days” to “1.0day”, and improve engineering lead time from “2.0days” to “1.0day”. the OTD of Doll hair supplier is improve from 68.0% to 80.0% while the OTD of Doll clothes supplier is improve from 75.0% to 85.0%. The arrow of transport from the Barbie Doll factory to OEM customer, change the type from “ship” to “Rail”, price “7300.0€” increase to “15000.0€”, cost from “6800.0€” increase to “13500.0€”, transportation time reduce from “28.0days” to “12.0days”, transport frequency also reduce from “10.0days” to “7.0days”.

Compare with figure 25, the lower left corner of figure 39 shows the output data have new result. Its information such as; order lead time for customer: 47.0days reduce to 28.0days, average inventory in units: 127units reduce to 103units, average inventory in EUR: 2504€ reduce to 1764€, capacity constraint have same node: SOKOS (Finland).

After the modified, the new result of financial view compare with base case shown in table 7. The lead time to customer get shorter than base case from 17.82days reduce to 9.85days, cycle time reduce from 47.0days to 28.0days, inventory turns increase from 6.31turns/year to 7.74turns/year, inventory holding cost decrease from 250.43€ to 176.44€.

Financials

	Base case	Modified Model
Safety Stock Holding Cost [EUR / year]	0.0	0.0
Lead time to customer [days]	17.82	9.85
Cycle time [days]	47.0	28.0
Inventory turns [turns/year]	6.31	7.74
Inventory Holding Cost [EUR]	250.43	176.44

Close

Table 7. After modified of financials view.

4.3.2. Goal Seek function for improvement

ASDN provides several spreadsheet models for logistic networks, with data covering different inputs and outputs throughout the network. The user may use Goal Seek functionality where new scenarios are created by setting objectives with regard to inventory level, lead-time and service level (Helo, Xiao & Jiao, 2006). Select *Tools > Goal Seek* from the main menu-bar, Goal Seek option appears show like figure 40. It used for decision making process such as, minimize inventory and order-decoupling points. Subject to some constrains such as, keep lead time short than, keep total inventory value less than and keep lead time to customer < Maximum order fulfillment time. Different decision making scenarios can be optimized by clicking on the button “Optimize” which is shown below too.

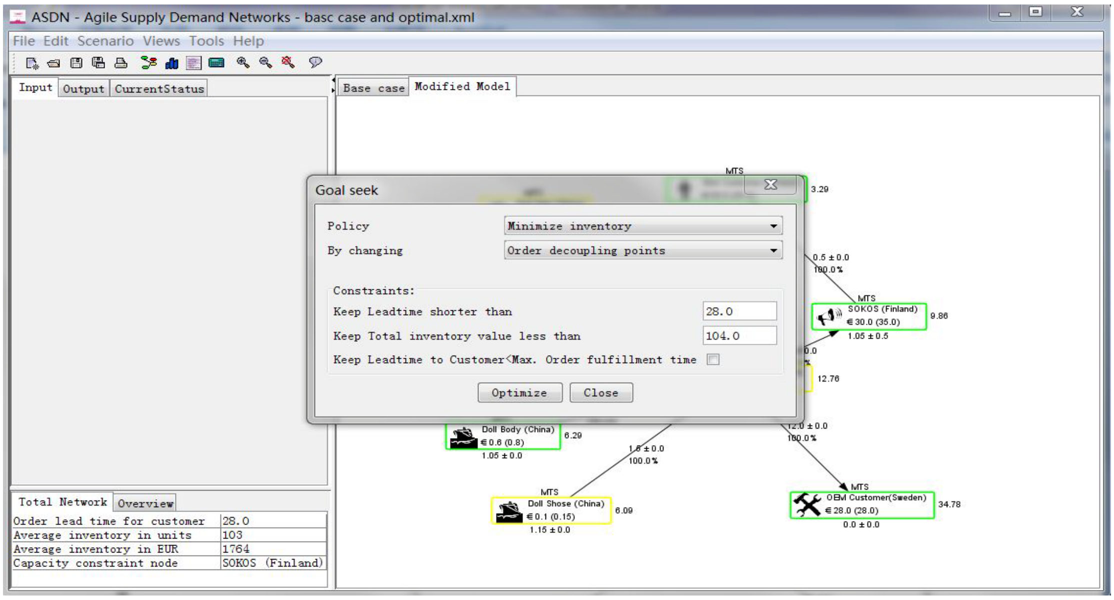


Figure 40. Goal seek.

Click the button of optimize, then the ASDN tool start to calculate the optimal values through a series of build-in mathematical models (Petri, 2007) and the optimizing processing shows in figure 41. After the calculation done, click the button of create new scenario to add new scenario result on the main window.

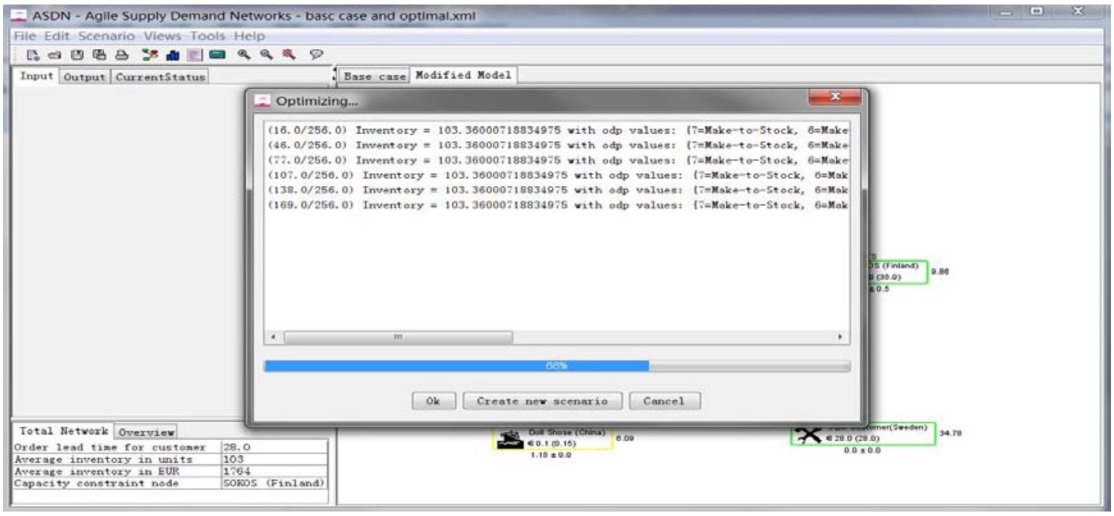


Figure 41. Optimizing process of Goal Seek function.

Next step we are renamed scenario as optimize of base case, select *Scenario* > *Rename scenario* from the menu-bar, click accept on the rename, the scenario of optimize model appears show in figure 42.

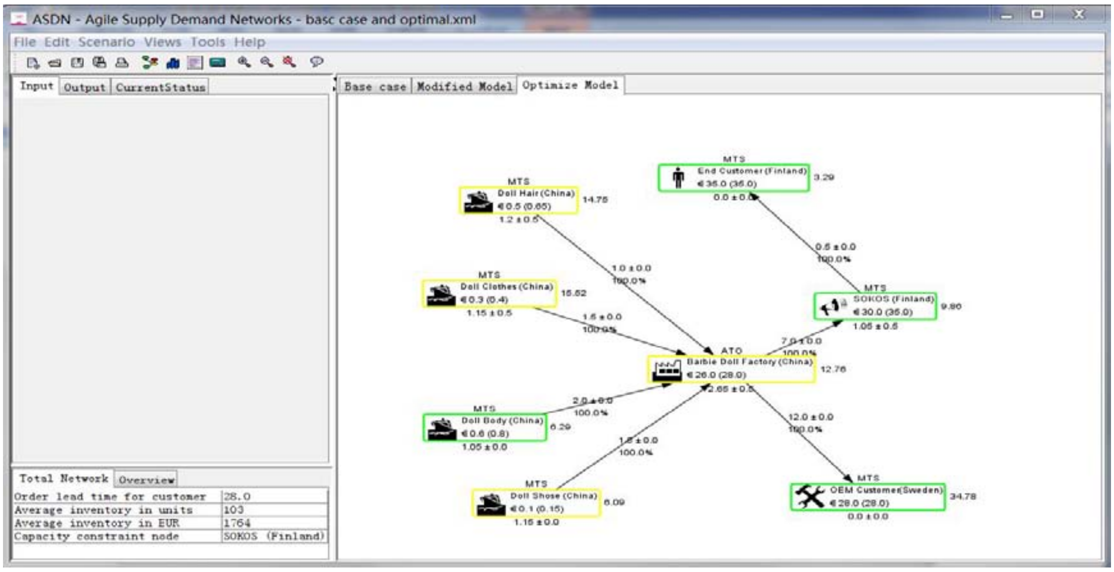


Figure42. Scenario of optimize model.

Go to the main menu-bar; select *Views* > *Financials* result displayed as below table. Table 8 shows the compare result of financials analysis between the base cases, modified remodel and optimize model.

Financials

	Base case	Modified Model	Optimize Model
Safety Stock Holding Cost [EUR...	0.0	0.0	0.0
Lead time to customer [days]	17.82	9.85	9.85
Cycle time [days]	47.0	28.0	28.0
Inventory turns [turns/year]	6.31	7.42	7.74
Inventory Holding Cost [EUR]	250.43	206.04	176.44

Close

Table 8. Optimize of Financials view.

4.4. Save file and exit ASDN tool

Finally user does not forget to save the file, click File > Save from the menu-bar, select the location where you want your file to save and give our file a name, click save. If we want to exit the ASDN tool, click File > Exit from the menu-bar to exit the ASDN.

4.5. Results

ASDN implementation has facilitated toy industrial to build the Barbie Doll products supply demand networks quickly and improvement responsiveness and inventory level with agility. It has given the operation managers more clear information visibility across the entire dispersed network. The final improved result will come from compare the analysis at two views.

From the total network view, we are comparing the figure 25 and figure 39 of the lower left corner get the analysis results such as:

- Order lead time for customer: reduce 19 days
- Average inventory in units: reduce 24 units
- Average inventory in EUR: reduce 740 €

From compare base case and optimize model of Financials view show in table 7, we get the results such as:

- Lead time to customer: reduce 7.97 days
- Cycle time: reduce 19 days
- Inventory turns: increased 1.43 turns / year
- Inventory holding cost: reduce 73.99

4.6. Discussion

We get know the software function and operation in this chapter when using ASDN to design and analysis an example of toy supply demand networks. ASDN as agile supply chain management software, which operation can quick to build supply demand networks and present clear visible analysis result, even improvement project of currently status. ASDN implementation in this case has improved responsiveness, delivery performance and agility, reduced inventory carrying and obsolescence costs.

The major advantage of ASDN includes:

1) Operation very easy and friendly for new user;
2) Visible the network relation between supply and demand;
3) The analysis through friendly graph interface and inventory models to user;
4) Multiple scenarios display before and after improvement.

But there still have some gaps when we are operate the ASDN software. The disadvantage of ASDN includes:

1) ASDN software system only support open one *XML* document, we cannot open multi-*xml* document at same time. That means you cannot compare and analysis tow design models with one system;
2) The Gantt graph display the time periods at horizontal abscissa have language error. The effect language of graph displays the same language with the computer windows system language. For example, the graph display x- axes with Chinese if the computer operation system with Chinese, while the problems shown at figure 30 Gantt graph view (this problem appear basis on my laptop test);
3) When Select *Tools* > *Lot size calculator* from the main menu-bar, a calculator window of optimize appears, all the text cannot show hold sentence with myself computer. The suspension points instead the long word and sentence.

5. SUMMARY AND CONCLUSIONS

The summary and conclusions of the present study are presented in this chapter. There are two subchapters. In the first subchapter, the present study is summarized the study and answer the research problem. Conclusions are given in the second subchapter, in which the results in application of ASDN software and limitations of the study are given.

5.1. Summary

In general, this study focuses on application of the ASDN (Agile Supply Demand Networks) software to improvement toy logistics network. In more detail, the present research has given specific attention to agile supply chain management, demand supply chain management, demand response strategies and inventory models. The researcher worked as a development engineer with ASDN software and tasks were design an example of complex toy supply demand networks, improvement the toy industrial logistics network, optimize inventory value level, reduce lead time and inventory holding cost. The topic of the present study is stated as follows: agile supply demand networks approach to optimize inventory and reduce lead time. The research problem is ***how to use ASDN software to analyze and optimize current toy industrial logistics network?*** In order to resolve the research problem, four following objectives are discussed. And meanwhile, in order to summarize the whole study, the discussions of each objective are briefly presented and reviewed.

The first objective *is study agile supply chain management, demand supply chain management, demand response strategies and inventory models in order to increase basic understanding ASDN software.*

To understand agile supply chain, we need to first clarify the meaning of agility. In brief, Agile means fast moving. The concept of Agility defines as ability to respond quickly and effectively to satisfy customers (Veeramain & Joshi, 1997). The concept of the agile supply chain is advocated as a new way forward for business networks to succeed in the highly changing and turbulent business environments. Christopher (2000) defines four key characteristics for agile supply chain, such as: 1) more demand driven rather than forecast-driven (market sensitive and responding to real demand); 2) share information between buyers and suppliers; 3) join product development and common system between buyers and suppliers; 4) network based with shared targets (create competing networks with committed and close buyers and suppliers relationships with final customers). Compare with traditional supply chain management (SCM), agile supply chain management (ASCM) can effectively or efficiently support a customer-driven and dynamically changing market. ASCM operation system is a network-based operation, which strategic inventory driven by demand.

Demand supply chain management need to coordinate the demand and supply processes has been emphasized in the chain of organizations. It is includes demand chain management and supply chain management. The demand chain management (DCM) obtains a competitive advantage by providing superior customer value. The supply chain management (SCM) obtains a competitive advantage by providing comparable customer value at lower cost. In customer-centered marketing approach, the chain of organization need for DCM to be in charge of SCM, which means in environments with increasing diversity, in customer needs and requirements, so agile companies must rapidly adjust their supply to meet demand.

A major problem in most supply chains is their limited visibility of real demand

(Christopher, 2000). So we presented with the decoupling point in different positions along the supply chain as a stock holding point, which in order to lower inventory levels and enhance customer service. Demand response strategies includes: make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO). The ***make-to-order*** (MTO) systems offer a high variety of customer-specific and typically, more expensive products, production planning focus on order execution; the ***make-to-stock*** (MTS) systems offer a low variety of producer-specified and typically, less expensive products, which focus on anticipating the demand (forecasting), and planning to meet the demand; the ***assemble-to-order*** (ATO) systems offer a high level of product variety to customers, while maintaining reasonable response times and costs, which focus on rapidly assembled from component inventories in response to customer orders; the ***engineer-to-order*** (ETO) systems offer high level of customization, high customers design, volume flexible, short cycle time, no inventory costs products, which focus on receiving customer requirement.

Inventory model definition as mathematical equation or formula that helps a firm in determining the economic order quantity, and the frequency of ordering, to keep goods or service flowing to the customer without interruption or delay. So study inventory models for uncertain demand is necessary. We are consider several types of models to study, such as ***Supplier Lead Time***, ***Internal Lead Time***, ***Lead time To Customer***, ***Service Level***, ***Cycle Stock***, ***Safety Stock***, ***Inventory Value*** , ***Average Inventory***, ***Inventory Turn Rate***, ***Theory of Constraints (TOC)***, ***Inventory Dollar Days (IDD)***, ***Throughput Dollar Days (TDD)***, ***Order point system***, ***Economic Order Quantity (EOQ) Model.*** We can understand the inventory calculation logic of ASDN software through inventory models study.

The second objective *is study the definition and function modules of ASDN software in order to understanding application of ASDN tool.*

Agile Supply Demand Networks is software for analyzing and developing logistics networks. It is a network drawing tool for analyzing multi-site manufacturing and material flows, which can help managing global supply-demand networks to be more agile and time responsive, optimizing the level of inventory. It operates as an information platform, by which integrate with their customers and suppliers to quickly build supply demand networks. All the information, activities and decision are visualized, synchronized and optimized by ASDN system (Helo, Xiao & Jiao, 2006).

The key functional modules in ASDN are modeling, optimization, analysis and report, interface, and database. ***Modeling module***, which can help user building and configuring the supply chain model quickly and efficiently. ***Optimization module***, which provided to optimize specified performance of supply demand network with a variety of build-in mathematical algorithms. ***Analysis and report module***, which analyzes the supply demand network performance from different kinds of aspect and visualizes the result by a variety of geographic and tabular reports. ***Interface***, which enables the users and other systems transform the data to ASDN and assess the concerned output information. ***Database module***, which stores the data and information related to supply demand network, customer demand, supply ontology, etc.

The third objective *is use ASDN tool to design a complex toy supply demand networks and explain related inventory models calculation.*

ASDN is a free software for user to download and easy to set up. In this task, we are given a brief guideline to use the ASDN software. The first, we are design the network consists of eight elements: four suppliers, one manufacturer, one retailer, one sales company and one end customer. The main supplier from China, assemble factory locate in China, the finish product ship to North Europe for sale. The second, we are through ***modeling module*** function to draw the supply chain nodes. Node is basic unit of a network, which represents suppliers, manufacturer, retailers and customers. We basic reverse engineering and networks by demand-drive mind to design the construction of network, so create the start node will come from customers, then manufacturer, the last is suppliers. The third, we are defined and modify the input data in the section of general, finance, manufacturing and inventory to each node. The finally, we are link the nodes with transport arrows and defined and modify input data in the section of general and number to each arrow. After the modeling, the lower left corner shows the output data of total networks based on our input data to each node and arrow in the network. Its information such as; order lead time for customer: 47.0, average inventory in units: 127, average inventory in EUR: 2504, capacity constraint node: SOKOS (Finland).

In the output section of each node, we are get detail information from Manufacturing, Inventory, In (Out) bound and TOC to each node. The related inventory models calculation not only display from the windows of ASDN software, but also show side by side coming from equations by hand calculate. The related type of models calculation, such as: ***Supplier Lead Time***, ***Internal Lead Time***, ***Lead time To Customer***, ***Service Level***, ***Cycle Stock***, ***Safety Stock***, ***Inventory Value*** , ***Average Inventory***, ***Inventory Turn Rate***, ***Theory of Constraints (TOC)***, ***Capacity Utilization***, ***Inventory Dollar Days (IDD)***, ***Throughput Dollar Days (TDD).*** After all calculations, we are not only explaining how to get the numbers of output data, but also the equation by hand calculates obtain same results with ASDN calculation logic. So it is proved the software system has correct calculation logic. ASDN as logistics analysis tool can be trust to use for analyzing and developing the complex toy logistics networks.

The fourth objective *is use ASDN tool to create graph interface to analysis the complex toy supply demand networks, and optimize the analysis results.*

We are use function of ***analysis and report module*** to draw the related graphs and tables view, which present toy supply demand networks in a holistic view and examine issues such as: Gantt graph view, Inventory view, Inventory value view, Service view, Total inventory value VS. Service level view, Node table view, Transport table view, and Totally Financials view.

Gantt graph view can show the lead time over view of the network, which can adjust different time periods on the network and available display the bottleneck of lead time, which assistant user select the relevant time period to check the network schedule. ***Inventory view*** display all the components' inventory level, which can help user find and reduce the high amount level to balance the network. ***Inventory value view*** is describing the inventory holding cost level, which can help user find and reduce the highest inventory value to balance the whole network inventory value. ***Service view*** shows all the nodes' service level, which can help user to monitor the service level and protect the service quality. ***Total inventory value VS. Service level view*** can draw the curve with different individual component, such as supplier, manufacturing, retail, and customer. To balance the inventory cost and service level not easy for manager. When we improvement the services level always with the increase of the inventory cost. ***Node table view*** displays the input/output information of all nodes; we can define and modify the input/output data in the section of input/output from the node table view. ***Transport table view*** shows the transportation status of all arrows in the toy supply demand networks; we can define and modify the input/output data in the section of input/output from the transport table view. ***Totally Financials view*** shows the result of financials analysis.

We through two steps to optimize the result: the first step is modified the input data for some nodes, such as service level, lead time, demand response strategies, type of transportation and transportation fee; the second step is use the function of ***Goal Seek*** continue to optimize the modified network. Compare base case and after remodel of Financials view after the calculation done, we get the results such as:

- Lead time to customer: reduce 7.97 days
- Cycle time: reduce 19 days
- Inventory turns: increased 1.43 turns / year
- Inventory holding cost: reduce 73.99 €

5.2. Conclusions

In this thesis, we use ASDN software to model, analyze and optimize the toy supply demand networks. Performance measures such cost, inventory, value-add, lead time and throughput in the network are analyzed and optimized through the network. We are through performance four objectives to resolve the research problem: ***how to use ASDN software to analyze and optimize current toy industrial logistics network?*** Application of ASDN software not only help toy industrial to fix the gap of inventory problem, improvement the logistics network, optimize inventory value level; but also through integrated retailers, distributors, manufacturers and suppliers to reduce the lead time to customers and inventory holding cost.

ASDN software as IT platform, which support to information exchange between the supplier and customer, thus it can easily make flexible schedule and inventory allocation policy according to received demand information. So it can resolve the problem of high levels inventory for both sellers and manufacturers. ASDN software as analysis tool supports configuration flexibility, view flexibility and algorithm flexibility. Configuration flexibility is the ability to configure an alternative supply chain scenario based on the main supply demand network and get the analysis results quickly. View flexibility refers to diversified reports that analyze supply chain scenarios from different types of aspects like inventory amount, value-added, service level, etc. Algorithm flexibility includes optimization algorithm selection in the lot size calculator which provides a variety of algorithms that are suitable for specific production circumstance (Helo, Xiao & Jiao, 2006). ASDN as strategy tool of agile supply chain management can get guaranteed lead-time from supplier, which provides support to the manager in making improved business strategy decisions that lead to maximizing customer service and profits by capitalizing on the added-value of the entire supply chain (Helo, 2006).

In general, the major advantage of application ASDN software includes: ***Firstly***, the whole operation very easy and friendly for new user. ***Secondly***, the visible the network relation between supply point and demand point. ***Thirdly***, the analysis through friendly graphs interface and inventory models display to user. ***Fourthly***, multiple scenarios separate to display basic networks and after improvement networks.

The research limitations discuss at below. ***Firstly***, the network view cannot connect with Google map is one of the limitation and therefore the map function won't support re-evaluate the supply demand strategic plan and pinpoint accuracy, for instance plant location and physical distribution structure. ***Secondly***, design the simple simulate example aim to show the application process of ASND, so the numerical result not good consult for real complex supply demand networks analysis. ***Thirdly***, the simple simulate example was mainly working for the internal system, so integrate the external information system like ERP will not show in this paper. ***Lastly but not the least***, ASDN software can analyze variants for products. It is means ASDN tool can analyze several families of Barbie Doll Models at same times. Because this thesis only considers one simple Barbie Doll product supply demand networks, so this function also not show in this paper.

REFERENCES

ASDN (2005). “Agile Supply-Demand Networks software”, available at: <URL: http://asdn.sourceforge.net/index1.htm >.

Arthur V. Hill (2012). “The Encyclopedia of Operations Management”, Publishing as FT Press, Upper Saddle River, New Jersey.

Alok K. Verma. (2006). "Improving agility of supply chains using base stock model and computer based simulations", I*nternational Journal of Physical Distribution & Logistics Management*, Vol. 36 Iss: 6, pp.445 – 454.

Ben Naylor J., Naim M.M. and Berry D. (1999), “Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain - Strategies for Enriching”, *International Journal of Production Economics*, Vol.62, No.1, pp. 107-118(12).

Bertrand, J. W. M., Wortmann, J. G. and Wijngaard, J. (1991). “Production Control: A Structural and Design Oriented Approach”, Elsevier Science Publishers, Amsterdam.

Bowersox, D.J., Closs, D.J., Cooper, M.B. (2002). “Supply Chain Logistics Management”, McGraw-Hill Irwin, Boston, MA.

Brian W. Siefering (2005). “Reducing Inventory and Order Delivery Time in an Internal Extended Value Chain”, Massachusetts Institute of Technology.

Chee Yew Wong, Jan Stentoft Arlbjørn and John Johansen (2005). "Supply chain management practices in toy supply chains", *Supply Chain Management: An International Journal*, Vol. 10, Iss: 5, pp.367 – 378.

Chetan Anil Soman, Dirk Pieter van Donk and Gerard Gaalman (2004). “Combined make-to-order and make-to-stock in a food production system”, *International Journal of Production Economics,* Vol. 90, Iss: 2, Pages 223–235.

Christopher, M. and Towill, D.R. (2001). “An integrated model for the design of agile supply chains”, *International Journal of Physical Distribution & Logistics Management,* Vol. 31, No. 4, pp. 235.

Christopher, M. (2000). “The agile supply chain: competing in volatile markets”, *Industrial Marketing Management,* Vol. 29, No. 1, pp. 37-44.

Christopher, M., Lowson, R. and Peck, H. (2004). “Creating agile supply chains in the fashion industry”, *International Journal of Retail & Distribution Management*, Vol. 32, No. 8, pp. 367-76

Colin Rigby, Marc Day, Paul Forrester and John Burnett (2000). "Agile supply: rethinking systems thinking, systems practice", *International Journal of Agile Management Systems,* Vol. 2, Iss: 3, pp.178 – 186.

Collin, J, and Lorenzin, D. (2006). "Plan for supply chain agility at Nokia: Lessons from the mobile infrastructure industry", *International Journal of Physical Distribution & Logistics Management,* Vol. 36 Iss: 6, pp.418 – 430.

Cooper, M.C., Lambert, D.M. and Pagh, J.D. (1997). “Supply chain management: more than a new name for logistics”, *International Journal of Logistics Management*, Vol. 8 No. 1, pp. 1-14.

Dekkers, R. and van Luttervelt, C.A. (2006). “Industrial networks: capturing changeability”, *International Journal of Networks and Virtual Organizations*, Vol. 3, No. 1, pp. 1-24.

Dong, Ming (2001). “Process Modeling, Performance Analysis and Configuration Simulation in Integrated Supply Chain Network Design”, Dissertation of PHD, URN: etd-08242001-102340.

Edmund Prater, Markus Biehl and Michael Alan Smith (2001). “International supply chain agility - Tradeoffs between flexibility and uncertainty”, *International Journal of Operations & Production Management*, Volume 21, Numbers 5-6, 2001, pp. 823-839(17).

Erica, L., Amy, P., and Ward, R. (2007). “Note: A Separation Principle for a Class of Assemble-to-Order Systems with Expediting”, *Operations research*, Vol. 55, No. 3, pp. 603–609.

Fisher, M. L. (1997). “What is the right supply chain for your product”, *Harvard Business Review*, 75(2), 105–116.

Goldratt, E.M., Schragenheim, E. and Ptak, C.A. (2000). “Necessary But Not Sufficient”, North River Press, Great Barrington, MA.

Goldratt, E.M. and Cox, J. (1992). “*The Goal - A Process of Ongoing Improvement*”, Second Rev. Ed., North River Press Publishing Corporation, Great Barrington, MA.

Guanyu, Xiong, and Helo, P. (2006). "An application of cost-effective fuzzy inventory controller to counteract demand fluctuation caused by bullwhip effect", *International journal of production research*, Vol. 44, Iss: 24, pp. 5261-5277.

Harrison, A. (1997). Investigating the sources and causes of schedule instability, Third International Symposium on Logistics, Padua, Italy, pp. 155-164.

Harrison, A., Christopher, M. and van Hoek, R. (1999). "Creating the agile supply chain'", *School of Management Working Paper*, Cranfield University.

Helo, P. (2004). "Management agility and productivity in the electronics industry", *Industrial Management & Data Systems*, Volume 104, Number 7, 567-577

Helo, P., Xiao, Y. and Jiao, J.R. (2006). "A web-based logistics management system for agile supply demand network design", *Journal of Manufacturing Technology Management*, Vol. 17, No. 8, pp. 1058-1077

Helo, P. and Szekely, B. (2005). "Logistic information system: an analysis of software solutions for supply chain coordination", *Industrial Management and Data System*, Vol. 105, No. 1, pp. 5-18.

Hoekstra, S. and Romme, J. (1992). Integral Logistics Structures: Developing Customer Oriented Goods Flow, McGraw-Hill, London.

Houlihan, J.B. (1987). "International supply chain management", *International Journal of Physical Distribution & Materials Management*, Vol. 17, No. 2, pp. 51-66.

http://en.wikipedia.org/wiki/Theory_of_Constraints

http://mdcegypt.com/Pages/Purchasing/Material%20Management/Independent%20Demand%20Ordering%20Systems.asp

http://scholar.lib.vt.edu/theses/available/etd-08242001-102340/unrestricted/Chapters_1-2.pdf

http://sourceforge.net/projects/asdn

http://switch.dl.sourceforge.net/sourceforge/asdn/asdn.jnlp

http://www.businessdictionary.com/definition/cycle-stock.html#ixzz1vzxiei20

http://www.ehow.com/how_6505792_calculate-inventory-value.html

http://www.inventoryops.com/safety_stock.htm

http://www.oppapers.com/essays/Problems-On-Inventory-Model/637464

http://www.java.com/en/download/manual.jsp

Intaher Marcus AMBE (2010). “Agile supply chain: Strategy for competitive advantage”, *Journal of Global Strategic Management*, Vol. 07, No.6, pp3-7.

Johnson, M.E. (2001a). “Learning from toys: lessons in managing supply chain risk from the toy industry”, *California Management Review*, Vol. 43 No. 3, pp.

106-24.

Kidd, Paul T. (1994). “Agile Manufacturing: Forging New Frontiers”, Addison-Wesley, pp17.

Kumar, N., Scheer, L. and Kotler, P. (2000), “From market driven to market driving”, *European Management Journal*, Vol. 18 No. 2, pp. 129-42.

Lee, W.B. and Lau, H.C.W. (1999). “Factory on demand: the shaping of an agile production network”, *International Journal of Agile Management Systems*, Vol. 1, No. 2, pp. 83-7.

Lee, H. (2004). “The triple-A supply chain”, *Harvard Business Review*, Vol.10, pp. 102-12.

Li, X., Chung, C., Goldsby, T. and Holsapple, C. (2008). “A unified model of supply chain agility: the work-design perspective”, *International Journal of Logistics Management*, Vol. 19, No. 3, pp. 408-35.

Li, Cai-fen. (2009). “Agile Supply Chain: competing in volatile markets”, *Management Science and Engineering*, Vol.3 No.2, pp61- 62.

Martin, C. (2000). “The agile supply chain: competing in volatile markets”, *Industrial Marketing Management*, Vol. 29, No. 1, pp. 37-44.

Martin, C., Robert, L. and Helen, P. (2004). "Creating agile supply chains in the fashion industry", *International Journal of Retail & Distribution Management*, Vol. 32 Iss: 8, pp.370.

Mason-Jones, R., Naylor, B. and Denis R. T. (2000). “Lean, agile or leagile? Matching your supply chain to the marketplace”, *International Journal of Production Research*, Vol, 38, Iss:17.

Maqsood Sandhu, and Helo, P. (2006) "A network approach to project business analysis", *Engineering, Construction and Architectural Management*, Vol. 13 Iss: 6, pp.600 – 615.

Molina, A., Velandia, M. and Galeano N. (2001). “Virtual enterprise brokerage: a structure-driven strategy to achieve build to order supply chains”, *International Journal of Production Research*, Vol. 45, Iss; 17.

Nahmias, S. (1989). “Production and Operations Analysis”, Homewood, IL: Richard D. Irwin, Inc.

Naylor, J.B. (2000). “A decision support system for the product introduction process in a steel supply chain”, Ph.D. thesis, University of Wales, Cardiff.

Olhager, J. (2003). “Strategic positioning of the order penetration point”, *International Journal of Production Economics*, Vol. 85, Iss: 3, Pages 319-329.

Paul, M.J., Giesberts, Laurens Van Der Tang. (1992). “Dynamics of the customer order decoupling point: impact on information systems for production control”, *Production Planning & Control*, Vol 3, No 3, pp300-313.

Per Hilletofth (2011). "Demand-supply chain management: industrial survival recipe for new decade", *Industrial Management & Data Systems*, Vol. 111 Iss: 2, pp.184

– 211.

Richard, J. T. (1982). “Principles of inventory and materials management”, Elsevier North Holland, Inc., pp6.

Scott J. Mason, Michael H. Cole, Brian T. Ulrey and Li Yan (2002). “Improving electronics manufacturing supply chain agility through outsourcing”, *International Journal of Physical Distribution & Logistics Management*, Vol.32, No.7, pp611.

Song, Jing-sheng and Zipkin, P. (2003). “Supply Chain Operations: Assemble-to-Order Systems”, *Operations Research*, Vol.11, Elsevier, pp. 561-596.

Sheth, J., Sisodia, R. and Sharan, A. (2000). “The antecedents and consequences of customer-centric marketing”, *Journal of the Academy of Marketing Science*, Vol. 28, No. 1, pp. 55-66.

Sharifi, H., Ismail, H.S. and Reid, I. (2006). "Achieving agility in supply chain through simultaneous ‘design of’ and ‘design for’ supply chain", *Journal of Manufacturing Technology Management*, Vol. 17, Iss: 8, pp.1078.

Spathis, C. and Constantinides, S. (2003). “The usefulness of ERP systems for effective management”, *Industrial Management & Data Systems*, Vol. 103, No. 9, pp. 677-85.

Steven, L., Goldman, Roger N., and Nagel Kenneth P. (1995). “Agile competitors and virtual organizations: strategies for enriching the customer”, V*an Nostrand Reinhold*, *University of Michigan*, pp72-75.

Simchi-Levi, D., Kaminski, P. and Simchi-Levi, E. (2000). Designing and Managing the Supply Chain, McGraw-Hill, New York, NY.

Togar, M. Simatupang and Ramaswami Sridharan (2003). “A Benchmarking Scheme for Supply Chain Collaboration”, *An International Journal*, Vol. 9, No. 6.

Thomas, D.J. and Griffin, P.M. (1996). “Coordinated supply chain management”, *European Journal of Operational Research*, Vol.94, No.1, pp. 1-15.

Tam, J.M., Yen, D.C. and Beaumont, M. (2002). “Exploring the rationales for ERP and SCM integration”, *Industrial Management & Data Systems*, Vol. 102, No. 1, pp. 26-34.

Veeramani, D. and Joshi, P. (1997). “Methodologies for rapid and effective response to requests for quotation (RFQs)”, *IIE Teansactions*, Vol.29, No. 10, pp.825-38.

Vokurka, R.J. and Fliedner, G. (1998). “The journey toward agility”, *Industrial Management & Data Systems*, Vol. 4, pp. 165-71.

Wayne L. Winston (2003). “Operations Research: Applications and Algorithms”, Duxbury, 4th. Edition.

Walters, D. (2008). “Demand chain management + response management = increased customer satisfaction”, *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 9, pp. 699-725.

Xiaobin, Wang, Wansheng, Tang and Ruiqing, Zhao (2007). “Fuzzy Economic Order

Quantity Inventory Models Without Backordering", Tsinghua Science and Technology, Vol. 12, No.1, ISSN 1007-0214 14/17, pp91-96.

Xun Li, Thomas J. Goldsby and Clyde W. Holsapple. (2009). "Supply chain agility: scale development", *International Journal of Logistics Management*, Vol. 20 Iss: 3, pp.408 – 424.

Yohanes Kristianto, Mian M. Ajmal and Helo, P. (2011). "Advanced planning and scheduling with collaboration processes in agile supply and demand networks", *Business Process Management Journal*, Vol. 17, Iss: 1, pp.107 – 126.

APPENDIX SEVICE LEVEL AND SEVICE FACTOR

Service Level	*Service Factor*	*Service Level*	*Service Factor*
50.00%	0.00	90.00%	1.28
55.00%	0.13	91.00%	1.34
60.00%	0.25	92.00%	1.41
65.00%	0.39	93.00%	1.48
70.00%	0.52	94.00%	1.55
75.00%	0.67	95.00%	1.64
80.00%	0.84	96.00%	1.75
81.00%	0.88	97.00%	1.88
82.00%	0.92	98.00%	2.05
83.00%	0.95	99.00%	2.33
84.00%	0.99	99.50%	2.58
85.00%	1.04	99.60%	2.65
86.00%	1.08	99.70%	2.75
87.00%	1.13	99.80%	2.88
88.00%	1.17	99.90%	3.09
89.00%	1.23	99.99%	3.72

Service level
Desired service level expressed as a percentage.

Service factor
Factor used as a multiplier with the Standard Deviation to calculate a specific quantity to meet the specified service level. I have included a service factor table below or you can use Excel function NORMSINV to convert service level percentage to service factor.

Source: http://www.inventoryops.com/safety_stock.htm