IMPROVING THE DEMAND PLANNING AND INVENTORY MANAGEMENT IN OPHTHALMIC LENS CHINA'S MANUFACTURING : A CASE STUDY

SIRIPORN SAEPUENG

AN INDEPENDENT STUDY REPORT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN
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THESIS TITLE	Improving The Demand Planning And Inventory Management In Ophthalmic Lens China's Manufacturing: A Case Study
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ABSTRACT

This research developed an inventory management system for the ophthalmic lens manufacturing focusing on the demand and supply in between China and Thailand factories that were merged together under the Essilor group. The company had faced with high inventory level of the common products between both factories affecting to the budget status. The study improved the inventory level in total stock quantity of both plants by starting to implement the demand forecasting method in China factory and integrated the forecast volume into Distribution Requirement Planning system in order to replenish the real requirement to Thailand factory. This study improved the demand forecasting process based on the analysis of historical usage volume in 2014 to August 2016 together with interviewing the planner for the change management on demand forecasting process. The data used to determine the system parameters and the performance of the resulting system were measured by simulating the situation under the new system compared the actual data experience through the year 2017. The research also studied the DRP system to contribute the net requirement with the determination of "Reorder Point" and "Safety Stock".

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Miss Siriporn Saepueng

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The optical lens industry in the global market was growing up because the percentage of elderly population had grown dramatically in many countries and a number of people with visibility problem had increased continuously by reason of the technology evolution, especially in some economic countries that social change had begun such as China, India, other Asian countries and Africa. Thailand was the top manufacturer and exporter in the world which is 1.8%, Europe 41% and China 39% respectively. Many world-class brands had the largest manufacturing base in Thailand as well as the top of Thailand companies produced and exported to overseas around 90%. This industry was constantly developing the production and quality of lenses. Based on statistical data from the Observatory of Economic Complexity (OEC) [1], in 2015, Thailand's lens import was the 3rd in the Asia ranking due to most manufacturers wanted to expand market to ASEAN and AEC, because it was a region that people were increasingly aware of the importance of using glasses.

The company in case study provided a variety of products quality corresponding with customers' needs by harmoniously combining technology and supply chain so as to achieve optimal benefits to customers, shareholders, employees and the country. The research focused on the inventory improvement with efficient demand planning referring that the company sales was growing continuously every year while the goal was reducing the inventory carrying cost but provided a good service level in order to reach the role of the company. Moreover, the efficient inventory management was necessary for demand forecast and conducted the inventory as suitable level to support the target groups. Thus, this company had to realize how to manage the lens stock whereas abatement the inventory cost

1.2 Problem statement

Using supply chain collaboration more strategically had become crucial in today's increasingly demanding business process to create new revenue opportunities, efficiencies and customer's loyalty.

Lack of demand visibility was an important challenge for the supply chain management resulting inefficient capacity utilization, poor product availability and high stock levels for China factory. Because of this, increasing the demand visibility on production and inventory control was the first step to improve this collaboration between members of the supply chain.

The process demand planning would help reducing costs and meeting customer needs more efficiently. Impact due to a problem of planning and inventory control would result in a cost penalty due to delayed product to customers, opportunity cost of selling, costs arising from the loss of goodwill and lose the opportunity to use the resources available or necessary could apply to the other to give a greater return. Therefore, it needed to improve planning, inventory control and more efficient to solve such problems. It was one important factor because it associated with inventory and responsiveness to customer's needs.

Improving the inventory management was not only inventory reduction, but it should be maintained the inventory of each SKU level in order to balance demand and supply. Therefore, the achievement of inventory improvement needed to improve the demand forecast accuracy and must be done the inventory management step by step in order to make decisions about production scheduling that would be able to deliver goods to customers without any problem of delayed delivery and no product shortage. To ensure that each product would be produced adequately to meet the needs of customers or as set in the business plan targets.

1.3 Objectives of study

To reduce the inventory carrying cost with good service levels, the study focused on;

1. Studying and analyzing the existing flow of inventory management
2. Increasing the demand visibility by using the demand planning process tools
3. Improving the demand forecasting accuracy by transform VMI to demand planning.

1.4 Scope of the research

This research aims to study only the optical lens products that had been produced by manufacturer in China for standard components and storage the inventory on hand in factory in Thailand to produce next process for finished product. There were 3 products families and 31 items were selected to study in this research.

CHAPTER 2

LITERATURE REVIEW

The review of relevant literature points that the inventory managed problem in many firms had been inquired in a member of studies and research. The past of studies would be organized around key issues to be speech in developing the inventory management systems as following;

2.1 Theories and conceptual of demand management

2.2 Theories and conceptual of inventory management

2.3 Theories and conceptual of distribution inventor

2.4 The related research to apply the inventory management

2.1 Demand Management

Arnold et al (2012) stated that demand management was the function of recognizing and managing all demands for products. It occurred in the short, medium, and long term. In the long term, the demand projections were needed for strategic business planning. In the medium term was to project aggregate demand for production planning. And in the short term was needed for items and was associated with master production scheduling.

If material and capacity resources were to be planned effectively, all sources of demand must be identified. These included domestic and international customers, other plants in the same corporation, branch warehouse, service parts and requirements, promotions, distribution inventory, and consigned inventory in customers' locations.

Demand management included four major activities:

1. Forecasting
2. Order Processing
3. Making delivery promises.
4. Interfacing between manufacturing planning and control, and the marketplace.

Figure 2.1 showed the relationship of demand planning interface between demand management and manufacturing planning and control.

Figure 2.1 Demand management and the manufacturing planning and control system

2.1.1 Demand Management Process

Demand Management Processes described the significance of marketing management and customer relationship management, and explained the role and objectives of demand planning such as forecasting and customer order management. Marketing management entrusted the tools as called the marketing mix or the four Ps, which was Product, Price, Promotion and Place (Arnold et al, 2012). The purpose was to leverage each P in order to create products and service with order winning and qualifying characteristics consistent with strategy, price, promote and place them in the right distribution channels. Customer Relationship Management (CRM) helped customers achieving better business results through the design assistance that explained helping in the design of new products or improvement of existing ones, customer needs which was assessing the customer's business and creating or expanding product offerings, information, and communications by collecting and analyzing customer data to support marketing, sales, and customer service.

Customer order management was a major CRM activity and played a major role in operations efficiency and customer service through fast and accurate order entry and tracking, meeting promised delivery dates and quantities, handing customer inquiries and service complaints, returns and repair, and accurate timely shipping documentation, invoicing, and recording of sale history.

Demand planning was the recognition of customer requirements through the forecasts and management of orders from internal and external customers.

2.1.2 Characteristics of Demand

The characteristics of demand that influenced on the demand forecasting were Independent and Dependent Demand. Independent demand was the basic for demand planning in terms of forecasting and customer orders. Independent demand was demand for a product that was not related to the demand for any other product. It was only independent demand which needed to be forecasted. While dependent demand was demand for a product that was related to the demand for another product. It was not necessary to forecast the dependent demand; it was calculated from the independent demand. Demand for dependent demand was dependent on the number of forecast on independent demand. The source of demand were forecasts, customer orders, replenishment orders from distribution centers, interplant transfers and other sources of demand such as order for products needed for marketing and product demonstrations.

There were four basic demand patterns or components as showing in Figure 2.2.

1. Trend demand; there were three trends; increasing, decreasing, and level. In the increasing and decreasing trends, demand changed at a steady rate from period to period. This graph showed a linear rate of the increase and decrease, but the year-to-year rate of change could be illustrated. The trend could be level, having no change from period to period or it could rise or fall.
2. Seasonality demand: the regular fluctuation of quarterly demand over the course of three year. The result of seasonal influences such as weather, social customs, holiday seasons, or particular events that took place on a season basis. Seasonal demand patterns also could occur in shorter time intervals, such as weekly, daily or hourly as in sales of consumer products and could show signs of trend.
3. Random variation: demand fluctuation due to random occurrences such as inclement weather, special events, and the vagaries of human behavior. Over time, random demand would vary near the average and the variations would cancel each other out. If variations were small, the random variation would be considered stable. When they were large, it would be considered unstable. Random variation could exist within a trend or seasonal demand pattern but did not alter the general pattern.
4. Cyclical demand: was characterized by wave-like fluctuations that took place over long time spans, such as several years, and were tied to external influences such as the business cycle. Forecasting of cycles was the

domain of economic forecasters, though businesses recognized their impact on demand and sales

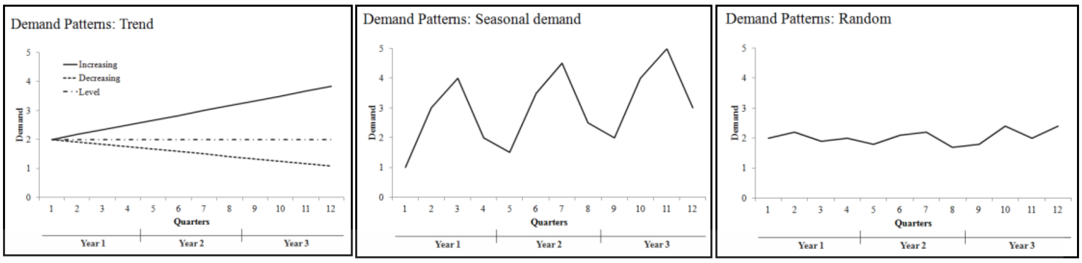


Figure 2.2 Three Demand Patterns: Trend, Seasonal and Random

The demand patterns from some products or services might change over time that retained the general shape were called “stable” and were easier to forecast while dynamic change made the prediction and forecasting of demand difficult and prone to error, though technically in the long run they might have random pattern. Figure 2.3 highlighted the implication of the difference between stable and dynamic demand. The average demand was the same over time for both stable and dynamic demand even average demand was the same in the stable and dynamic demand scenarios showing that the wide and irregular fluctuations of dynamic demand made it difficult to develop and accurate forecast. The variations in the stable demand scenario were relatively predictable and remained consistently within predetermined or expected upper and lower limits, allowing for random variations. It was easier to develop a forecast based on average demand and develop an inventory policy for example, safety stock.

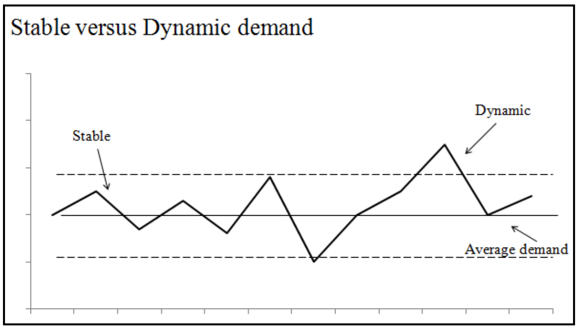


Figure 2.3 Stable versus Dynamic demand

2.1.3 Principle of Forecasting

Arnold et al (2012) determined that forecast had four major simple, and common-sense principles of forecasting as follow:

1. Forecasts were usually wrong as the forecast were based on statistical probability. Errors were inevitable and must be expected.
2. Every forecast must include an estimate of error, because the error could be used to determine the level of safety stock required to minimize the impact of the forecast error.
3. Forecasts were more accurate for families or groups of items.
4. Forecasts were more accurate for nearer time periods. Long-rang were more susceptible than short-term forecasts to unexpected events that would affect the forecast.

The forecast was usually based on historical data, and the collection and preparation of the data for using in forecasting was of utmost importance. It required judgment or a statistical technique. There were three major principles of data collection and preparation. First, record data in the same terms as needed for the forecast. Record demand, customer requests and not sales or shipment were not a true indication of demand. Use the same forecast periods as the production schedule:

weeks, months, quarters, and so on. And the items forecast should match those controlled by manufacturing. Next, record the circumstances relating to the data. Historical demand data could be influenced by events such as promotions, weather, price change, strikes, and competitor marketing initiatives. These factors needed to be accounted for in the data analysis. Then, record demand separately for different customer groups. Different channels of distribution (customer types) had different ordering cycles and lot-size order quantities. Record data for each group separately to account for the lumpiness of demand over the forecast horizon.

2.1.4 Forecasting Techniques

There were many forecasting methods, but they could usually be classified into three categories: qualitative, quantitative that consisted of two extrinsic and intrinsic.

1. Qualitative techniques

It based on intuition and informed opinion. It was supposed to be subjective and used for business planning and forecasting for new products. These techniques were used for medium-term to long-term planning. There were several other methods of qualitative forecasting. One, called the Delphi method, used a panel of experts to give their opinion on what was likely to happen

2. Quantitative techniques: Extrinsic

Extrinsic techniques were based on correlation and causality. They relied on external indicator. Extrinsic had two types of leading indicators: economic and demographic. Extrinsic forecasts tended to look beyond the short term and were useful in forecasting total company demand or demand for families of products.

3. Quantitative techniques: Intrinsic

Intrinsic forecasting techniques used time-sequenced historical data, or time series data for the item future demand. This technique was based on several assumptions. The past helped you understanding the future, time series were available and the past pattern of demand predicted the future pattern of demand.

Some important intrinsic forecasting techniques were moving average and exponential smoothing.

4. Moving-Average Forecast technique

Moving averages were best used when demand was stable, there was little trend or seasonality, and demand variations were random. When past demand showed random variation, it was better to forecast based on average demand than second-guess the effect of random fluctuation. Moving-Average Forecast logic used the average of demand for the

$$\text{Moving average forecast for next month} = \frac{\sum \text{demand for months}}{\text{number of months}} \qquad (2.1)$$

Arnold et al (2012) explained the lessons learned the moving average forecast logic as follows:

a. The moving average forecast would make the development of a rising or falling trend lag.

b. The farther back the moving average forecast reached for data, the greater the lag.

c. The three-month moving average forecast might have overreacted if the demand surge had abated.

d. The moving average forecast worked best when demand was stable with random variation; it would filter out random variation.

5. Exponential Smoothing technique

The exponential smoothing forecast technique was similar to the moving-average forecast, but required less data management and easier calculations. The logic of calculations took the old forecast and the demand for the latest, most current period. It assigned a weighting factor or smoothing constant (α, alpha) to the latest period demand versus the old forecast and calculated the weighted average of the old forecast and the latest demand. The weighted average calculation as follows:

$$\text{New forecast} = (\alpha)\ (\text{latest demand}) + (1 - \alpha)\ (\text{previous forecast}) \qquad (2.2)$$

A low smoothing constant gave more weight to the old forecast for example, a low alpha value such as 0.2 would give much more weight to the old forecast (1-0.2 = 0.8), which might more not be appropriate if there was an upward or downward demand trend. On the other hand, a higher α would be appropriate. By running simulation with different α values to see which one best fitted the historical demand pattern.

2.1.5 Measures of Forecast accuracy

To analyze how well one forecasting models worked, or to compare that model with other model, the forecasted values were compared with the actual or observed values. The forecast error or deviation was defined as follow:

$$\text{Forecast error} = \text{actual value} - \text{forecast value} \qquad (2.3)$$

One measure of accuracy was the *mean absolute deviation* (MAD). This was computed by taking the sum of the absolute values of the individual forecast errors and dividing by the number of errors (n):

$$\text{MAD} = \frac{\sum|\text{forecast error}|}{n} \qquad (2.4)$$

There were other measures of the historical errors accuracy in forecasting that sometime used besides the MAD. It was mean squared error (MSE) which was the average of squared error:

$$MSE = \frac{\sum (\text{error})^2}{n} \tag{2.5}$$

Besides the MAD and MSE, the mean absolute percent error (MAPE) was sometimes used. The MAPE was the average of the absolute values of the errors expressed as percentages of the actual values. This computed as follow:

$$MAPE = \frac{\sum |\text{error/actual}|\ 100\%}{n} \tag{2.6}$$

There was another common associated with error in forecasting. Bias was the average error and told whether the forecast tended to be too high or too low and by how much. Thus, bias might be negative or positive. It was not a good measure of the actual size of the errors because the negative errors could cancel out the positive errors.

2.2 Inventory Management

Bowersox (2007) stated that inventory was a necessary cost of doing business. It was a cost that companies were constantly trying to minimize while getting the good performance of production efficiency goal. Supply chain management looked at inventory from two overlapping perspectives of enterprise-wide and supply chain. The enterprise-wide's perspective objected how to smooth and manage the flow of materials through the materials transformation process to the finished goods stage while supply chain's perspective objected how to smooth the inflow of materials from suppliers and the outflow to customers to meet financial and strategic objectives.

Concern the inventory in manufacturers and throughout the supply chain including service establishments were following.

1. Sales and marketing view inventory from the perspective of customer due dates and service levels.
2. Materials management and purchasing were concerned about having adequate raw materials on hand while keeping inventory costs low.
3. Manufacturing and finance were concerned with balancing production costs and efficiency with inventory costs.
4. Retailers and distributors within the supply chain faced similar issues when it came to managing inventory costs while approaching the customer service goals.

Inventory was managed at both the aggregate and item level. Aggregate inventory management was concerned with the business-level impacts and implications of inventory. The objectives supported business strategy and operations, ensured that inventory practices supported financial objectives and balanced customer service, operations efficiency, and inventory investment cost objective. While Item inventory management must establish decision rules about the individual inventory items to emphasize that which item was the most important, how to control inventory, how much to order at one time and when to place an order.

2.2.1 Definitions of inventory cost

CPIM (2014) classified there were five categories of costs associated with inventory and management decisions.

1. Item costs

They were two item costs; purchased costs and manufactured costs. Purchased item included raw materials that were consumed in production, and

MRO suppliers. It included the purchase price (transpiration, customer duties and insurance) and direct costs incurred in getting the item into the plant. The total of these costs was called "landed cost". Manufactured costs were direct material, direct labor and factory overhead.

2. Carrying costs

Carrying costs included all costs attributable to the volume of inventory on hand in a designated time period such as annual, monthly. These costs consisted three main categories; capital costs, shortage costs and risk costs. A capital cost was money that invested in inventory, or cost of all purchased and WIP items. Shortage costs included cost of space, personnel and equipment. Risk costs included obsolescence, damage, pilferage, deterioration and insurance.

3. Ordering costs

Ordering costs were incurred when planning orders on the factory and with outside suppliers. There were 4 categories; production control costs, setup and teardown costs, lost capacity cost and purchasing costs.

4. Stockout costs

Stockouts occurred in make-to-stock environments when demand during lead time exceeded forecast and available inventory and the problem in production and supplier caused inventory shortages. Stockout costs included the backorder costs, lost sales costs, lost customer costs, expediting costs and additional manufacturing and purchasing costs.

5. Capacity-related costs

These costs resulted from changing production levels and varied with the number of changes. It included overtime, hiring, layoff, training and shift premiums.

2.2.2 Inventory Concept

1. Safety stock

It was used to prevent a stockout and to protect against uncertainty in demand and supply. It was a calculated extra amount of stock carried.

2. Inventory on hand

It was the current actual number of items to support production as the materials and work-in-process items. And customer service as the finished goods and spare parts.

3. Net stock

It was the inventory on hand minus the amount of backlog.

4. Inventory position

It was defined as the stock on-hand plus on-order minus backordered stock.

5. On-order inventory level

It was the summation of inventory on hand and inventory that had been ordered.

2.2.3 Inventory Control System

Bowersox (2007) defined the inventory control how often inventory levels were reviewed to determine when and how much to order. It was performed on either a perpetual or a periodic basic. Inventory control divided systems into three characteristics as following:

1. Reorder Point System was the inventory levels at which an order should be placed. The new inventory arrived at the same instant when the inventory level reached the ROP.

$$OP = DDLT + SS \quad (2.7)$$

Where

OP = order point

DDLT = demand during the lead time

SS = safety stock

Demand during the lead time was important as it only time a stockout was possible in the period of the lead time. If the demand was higher than expected, it would be a stockout unless sufficient safety stock was carried. The safety factor could determine the service level was directly related to the number of standard deviations provided.

2. Periodic Review System reviewed the inventory levels status at regular intervals such as weekly or monthly. It used when products were perishable, with short shelf life, retail locations and warehouses receiving deliveries of many items from one source at one time was economical, tracking and posting transactions of many small issues from inventory were costly, and the ordering costs were low; short-interval ordering was not an issue. The quantity on hand of this system was determined at specified, fixed-time intervals, and an order was planned at target level or maximum-level inventory. The target level (maximum) could be calculated as formula below.

$$T = D(R + L) + SS \tag{2.8}$$

Where

T	=	target (maximum) inventory level
D	=	demand per unit of time
L	=	lead-time duration
R	=	review period duration
SS	=	safety stock

The order quantity calculation could determine as below.

$$Q = T - I \tag{2.9}$$

Where

Q	=	order quantity
I	=	inventory on hand

3. Material Requirement Planning System or MRP, exploded the master schedule to plan the supply of materials. MRP needed a lot of information, with three main sources being; Master Schedule, Bill of Materials and Inventory Records.

2.3 Distribution Inventory management

Distribution inventory was a management concern in Make-To-Stock (MTS) production environments. MTS supplier needed to meet customer expectations for quick order delivery or on-hand availability of desired items. Arnold et al. (2012) pointed that distribution system, which contained in-transit or pipeline inventory, became the factory's customer and therefore was a link between the supplier and the final customer.

The business-level objectives of distribution inventory management were to

1. Provide required levels of customer service
2. Minimize the cost of transportation and handling
3. Minimize inventory cost
4. Interact with the factory to minimize scheduling problems.

2.3.1 Distribution Inventory Planning Systems

The three systems used to control distribution inventory were as follows:

1. The pull (decentralized) system

The distribution inventories in a pull distribution system in which distribution centres used a reorder point method with fixed order quantity lot sizes. Each distribution centres ordered from central supply what it needed when required without regard for needs of other distribution centres, available inventory at central supply and production schedule at the factory.

Advantages of pull system were allowed each centre to operate independently and demand data might be more accurate.

Disadvantages for pull system were lack of coordination, poor customer service and disrupted factory schedules.

2. The push (centralized) system

The central supply could use the demand planning applications to push inventory to distribution centres based on a centrally made forecast

Advantage for push system had coordination among factory, central supply and the distribution centres

Disadvantage for push system was not fully responsive to local development that might influence demand

3. Distribution Requirements Planning (DRP)

DRP involved collaboration between the distribution centres, centre supply, and the factory. The logic used by DRP to translate distribution centre demand into forecasts in the factory master scheduling process which was used a time-phased netting rather than an order point system (such as a pull system). A planned order released from each distribution centre, which varied at each on depending on their requirements, was sent to central supply and became a gross requirement for central supply. Then the planned order released from central supply became a gross requirement in the factory's master schedule. Thus, the distribution centre's time-phased requirements were included in the master production schedule for the factory. The presumption was that the distribution centre's requirements reflected local input on events that might affect the forecast. Figure 2.4 showed the system schematically. The records were all for the same part number

Distribution Center A

Week	1	2	3
Planned Order Release	200		200

Distribution Center B

Week	1	2	3
Planned Order Release		100	

Central Supply
Lead Time: 2 weeks
Order Quantity: 500

Week		1	2	3
Gross Requirement		200	100	200
Scheduled Receipts				
Projected Available	400	200	100	400
Planned Order Release		500		

Figure 2.4 Distribution requirement planning logic

2.4 Related works

Fildes et al. (2003) suggested that the demand forecasting needed to focus less on methods and more on management practices, and to apply the lessons learned from the forecasting methods. There were three problems leading to the development of forecast error. First the researcher was lack of proper consulting and training. Second, performance assessment was still a traditional system one. Finally, companies were not willing to accept the new techniques and methods that suggested by the researchers.

Ana Julia Dal et al. (2014) studied the demand forecasting process from multiple case companies in southern Brazil area. The researcher was evaluated by launching a questionnaire with 20 questions to 15 large companies. The practices were consisted four dimensions of the analysis: functional integration, application, systems and forecasting errors. The results demonstrated that of the 20 practices analyzed; 60% had a low performance. The positive points found were communication mainly by computer, the forecasting process was conducted collaboratively among the various areas, and there was an understanding that forecasting errors had a strong impact on the organization's goals. The issue pointed that could be improved for the demand forecasting process found were the improving system was necessary between the company information systems as well as integration between these systems with the software that generated the forecasts that everyone could see the indicators and the status of the forecast and were able to plan in the medium and long term and the forecasting error needed to compare the real and forecasted demand to measure that the forecasting error was also essential for the company's success. Therefore, the purpose of the researcher sketch an initial view of how organizations were using demand management practices.

M.Ikhwn Maulana Haeruddin (2017) reviewed several extant literatures on mergers and acquisitions (M&A's) and relevant areas, considering the high investment return and great risk of failure involved in these processes. The researcher presented the characteristics of M&A's advantages and disadvantage. Its activities did not base on the similar reasons. There were several different reasons for organizations in getting other organizations. Several researchers had come to the conclusion that mergers and acquisitions should bring about an improvement in performance of the combined companies which created a competitive advantage to the firms. The collaboration between the combined organizations would likely stimulate interaction to improvement in the competitive position and thus resulting in an effective performance. The common challenges encountered how to manage the transformation and shifting organizational culture from two different entities to one integrated entity. It was also claimed that the extent of success in merger and acquisition processes would be determined by the readiness, extensive planning, and a careful implementation. Failing to do so would not only damage projected competitive advantages but also induce morale suffering for the employees and managers of both organizations. The failure would result in many forms such as productivity and loss of effective human resources and also people mismanagement.

It was recommended that a successful merger and acquisition process not only included comprehensive planning on financial and strategic analysis aspects, but also in planning regarding compatibility between the both organizations' preferences about the implementation strategy for the transformation.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Company background

Essilor was formed in 1972 with the mission “To preserve and correct the eyesight of people around the world” [2]. It is a French company that produces ophthalmic lenses along with ophthalmic optical equipment. A headquarter is based in Charenton-le-Pont (near Paris), France. Globally, Essilor distributes the products in more than 100 countries consisting with 33 production sites with production capacity more than 570 million lenses in manufacturing in 2016 and 16 distribution centers. Moreover, there are 490 prescription laboratories and more than 350,000 clients (eye care professionals, buying groups and chains). Throughout the world, the company has about 64,000 employees all over the world (Figure 3.1)

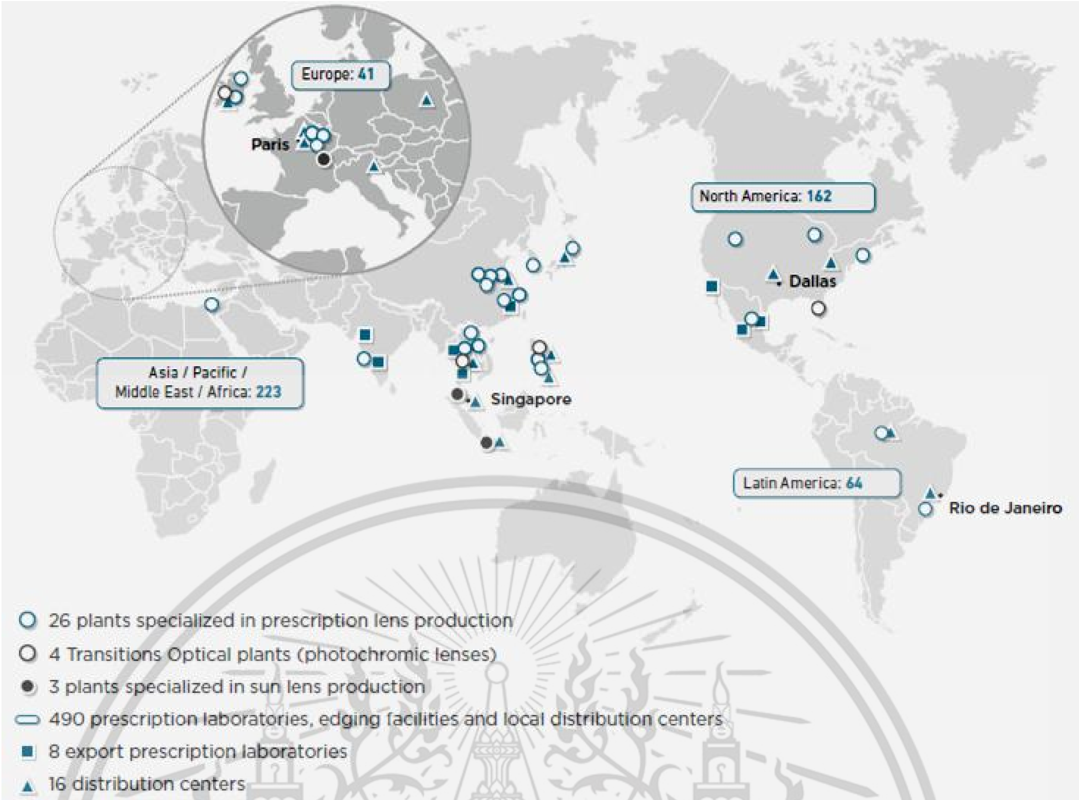


Figure 3.1 Geographical Essilor and partner distributions on December 31st, 2016
Source: Essilor Company

Essilor contributes the high lenses and offers a wide variety of products that can meet the customer needs including delivering the development of quality and technology. The world-famous lenses for the company are Varilux® lens, that is progressive lens offering a smooth transition from distance vision through intermediate vision to near vision, and Crizal® lens that is Polycarbonate lens with Hard multicoated and Anti-Reflection providing more comfortableness for all ages and give more benefit to customer satisfaction. Essilor international provides a number of product brands around 20 brands (Figure 3.2)

Figure 3.2 Essilor's Brands

Source: Essilor Company

The market share for this company is breakdown of revenue by business and geography. The Figure 3.7 explained that 87% was the biggest revenue in 2016 from lenses and optical instruments business in the company and biggest market region was North America 47%, Europe 28%, Asia Pacific, Middle East, Africa 18% and 7% was Latin America respectively.

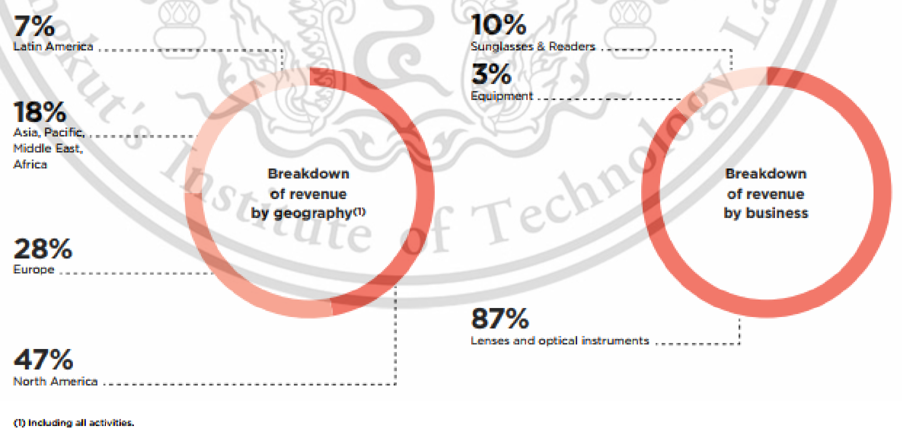


Figure 3.3 The company's revenue in 2016

Source: Essilor company

3.2 Company Overview

The company globally operates 33 lens production facilities including five in North America, two in Latin America, seven in Europe and nineteen in Asia / Middle East. The increased production volume over the year is driven by the growth in worldwide demand and the company continues to roll out its lean manufacturing program which helps delivering continued year-on-year operating performance gain at its production sites and further production cost saving.

However, the company has a number of the production sites and distribution centers all over the world. Therefore, the relationship of business process between each production and each distribution center in each country is different, the supply chain management regarding the limited of the legal restrictions, other constraint or the technology information is not improving. The company has been growing fast, since the organization has developed in terms of products and after-sales services while the goal is to reduce the inventory carrying cost. At present, the study company divides its inventory management into three major categories.

1. Make-To-Order
2. Make-To-Stock
3. Assembly-To-Order

Process and supply chain and logistics of enterprises

1. Production process

   The company has different product type per production area; each production is divided by product and process.

2. Inventory

   Inventory policy are: made to order and made to stock. There are three types; Raw material, Work in process and Finish goods.

3. Warehouse

The inventory management in warehouses is different type per China factory's strategy; each warehouse is divided by product and process.

4. Delivery

The company has delivery management such as delivery schedules of each area.

5. Sales and marketing

The customer in China factory is distribution centre or retailer of each area.

3.3 Company Product

The company's market is a comprehensive global market and could respond to the needs of its customers in all areas of demand. The types of lens are manufactured in four categories:

1. Lens type: the lens type is classified by the usage of product from subsidiaries and direct customer. There are two lens types; Semi-Finish lens (SF) and Finish lens (F).
2. Lens Index (Material): The refractive index or n value determined the raw materials used for producing the lens. The n value in the plastic lens market is currently between 1.50 and 1.74. This company has three segments:
    - Low Index (LI) or lens with a value of n not more than 1.50. The lens was not sticky enough to cut into a non-frame glasses fashion. Also, the lens was not UV protection. Some manufacturers had to add additive in production to meet the market demand.
    - Medium Index or call Polycarbonate lens (PC) or lens with a value of more than 1.50 but less than 1.60. The lens could be cut into non-frame glasses fashion. The materials used for preventing UV radiation so that

there was no need to add any additive in the production process. The n value was greater than the Low Index, also reduced the thickness of the lens. As a result, the total weight of the lens was reduced to be wore more comfortable.

- High Index (HI) or lens with a value of n from 1.60 up. Material was tougher than the Low and Medium index with UV protection. The lens's thickness was less than the Low and Medium Index. Therefore, it was lightest

3. Lens Design (Ophthalmic Surface): The design of each type of lens was intended to address various types of vision problems, including myopia, presbyopia, astigmatism and blurred vision with more than two visual impairments. Essilor's products were classified according to the type of vision defected into two groups as following:
    - Single Vision (SV) was a single lens divided into Two major types: Myopia as call Concave Lenses and Presbyopia as call Convex Lens
    - Multi-focal (PAL) was a lens that had many eyesight values. The lens was both short and long as call Progressive / Bifocal lens. The Progressive lens was a lens with more than one vision and seamless. The Bifocal lens was a lens with two vision and seam.
4. Coating (Surface Application): was the coating process adding a variety of features to the lens for general purpose use, maintenance and specific purpose. The products were divided according to the properties of the coating materials as following:
    - Uncoat (UNC) was a lens in organic material (plastic) used for correcting eyesight problems. It was manufactured from the curing of a

liquid raw material (monomer) in the mold which gave its final shape. It was uncoated product without tinting or coating. It was not a consumer lens, but an intermediate lens for further processing.

- Hard Coat (HC): was a coated lens to reduce the appearance of wrinkles and other damage caused by the use and cleaning of the face but there was still light reflection.
- Hard Multicoat (HMC): was a hard-coated lens and then coated the surface to cut off the light again in order to reduce reflection on the surface of the lens. It made the view through the lens clearer.
- Anti-Reflective coating (AR): it was a coated lens that would make the surface marks clearer.
- Transition (PHOTO): was a hard-coated lens, called photochromic lens that coated with special substances which would change color when exposed to UV light adjusting the light to suit the vision in different brightness, then coated the surface to cut off another layer. This process was specific in Transitions plant
- Tinting: was a dyed lens to reduce the intensity of light before reaching the eyes and eliminate radiation to destroy the eyes by dying pigment with multi-colors and multi-intensity. This would give you different features.

The attribute of each category is classified as the Table 3.1 following;

Table 3.1 The types of lens are manufactured

By Index	Low index			Medium Index			High Index		
Material	CR Series			Polycarbonate			MR Series		
Product Property	UV Protection by additional additive			Light weight, Strengh, UV Protection			Light weight, Strengh, UV Protection, Thin		
By Ophthalmic	LI Concave	LI Convex	LI Progressive	PC Concave	PC Concex	PC Progressive	HI Concave	HI Convex	HI Progressive
By Surface Application	LI Concave UNC	LI Convex UNC	LI PAL UNC	PC Concave UNC	PC Convex UNC		HI Concave UNC	HI Convex UNC	HI PAL UNC
	LI Concave HC	LI Convex HC	LI PAL HC	PC Concave HC	PC Convex HC	PC PAL HC	HI Concave HC	HI Convex HC	HI PAL HC
	LI Concave HMC/AR	LI Convex HMC/AR	LI PAL HMC/AR	PC Concave HMC/AR	PC Convex HMC/AR	PC PAL HMC/AR	HI Concave HMC/AR	HI Convex HMC/AR	HI PAL HMC/AR
	LI Concave Transition	LI Convex Transition	LI PAL Transition	PC Concave Transition	PC Convex Transition	PC PAL Transition	HI Concave Transition	HI Convex Transition	HI PAL Transition

Source: Essilor company

3.4 Business flow

The company structure has four distinct businesses. These businesses correspond to the processing stages of the product that is ordered by the consumer: raw material suppliers, lens manufacturers, prescription laboratories, edging centers, and retailers.

The business process starts with the manufacturer of a raw material for lenses, calls "Substrate" that are semi-finished lens and finished lens with three main lens indexes; low, medium and high index. This company has two manufacturers' types; independent manufacturers and integrated manufacturers. The independent manufacturers are chemical lens manufacturing, which is mass production in the factory and Integrated manufacturers are chemical lens manufacturing with included other process such as a cutting lens and assembled into eyeglass frame which is prescription production in Lab as the summary in Table 3.2

Table 3.2 The company structure

<table>
<tr><td>Raw materials suppliers</td><td colspan="3">Chemical companies and glass manufacturers</td></tr>
<tr><td>Lens manufacturers</td><td rowspan="2">Integrated manufacturers with laboratories
Essilor</td><td>Non-integrated manufacturers - Essilor</td><td></td></tr>
<tr><td>Lens finishers</td><td>Independent laboratories</td><td rowspan="2">Optical chains with integrated laboratories
Online distribution with integrated laboratories</td></tr>
<tr><td>Retailers</td><td colspan="2">Independent eye care professionals - Non-integrated chains - Online Distribution</td></tr>
<tr><td>End customer</td><td colspan="3">Consumers</td></tr>
</table>

Source: Essilor Company

The business flow starts to produce the substance for substrate lenses until providing the finished product to customer which is separated type of customer requirement; for independent manufacturing managed by distribution inventory by using the demand forecasting management, and integrated manufacturer managed by prescription order (Make-to-Order) from direct customer as explained in Figure 3.4

There are two important processes in the manufacturing:

1. Independent manufacturing: starts with producing the substance for substrate lens until coating-finishing-shipping process by mass production based on demand forecasting process.
2. Integrated manufacturing: starts with substrate lens until coating-edging mounting-finishing-shipping process by prescription from customer.

In the figure shows only one supplier and one customer, usually the process consists several manufacturers, lab, retailer, distribution centres and customer links in a supply/demand relationship.

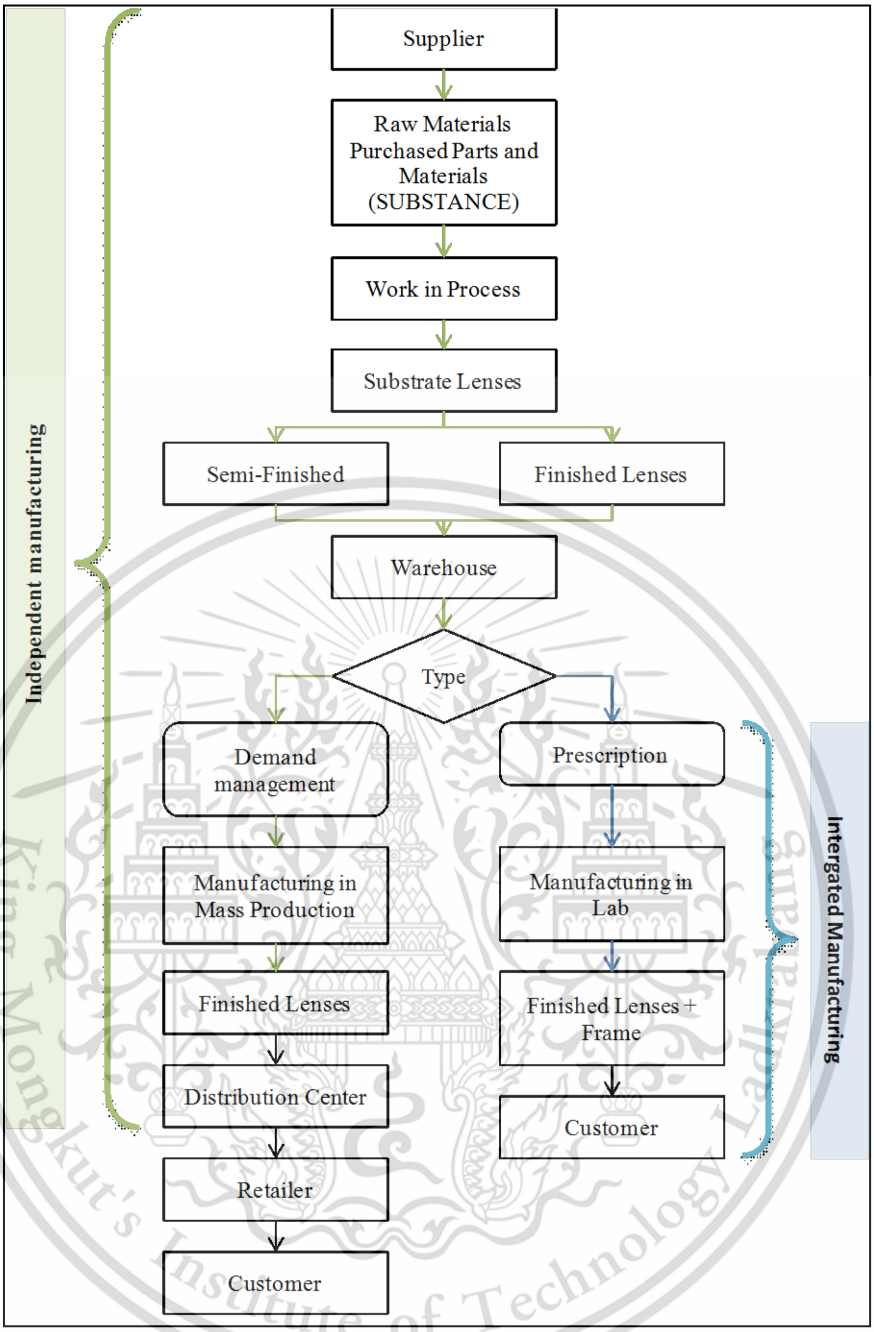


Figure 3.4 Business flow of manufacturing until distribution

Source: Essilor Company

However, the production process depends on the consumer needs and capabilities of China factory. Figure 3.5 explained the production process of independent manufacturers and integrated manufacturers. The process started with substrate lens or uncoated lens in the independent manufacturer or mass production which is the intermediate lens and keeps the substrate lens in the stock for further processing.

The attribute of each process is able to explain as the following;

1. The independent manufacturer starts producing the substrate lens and continuous process since tinting-finishing-stock, tinting-coating-finishing-stock/shipping and selling lenses to distribution center or direct customer or selling substrate lenses to the independent labs where a cutting lens and assembled into the frame including large retailers with their own labs as well as integrated manufacturer selling lens to the independent labs.
2. The integrated manufacturer starts from a prescription lens customer. Then proceeds by using the finish product or semi product from stock that made by independent manufacturer and then makes a tinting-coating process until cutting to achieve the shape of the frame.

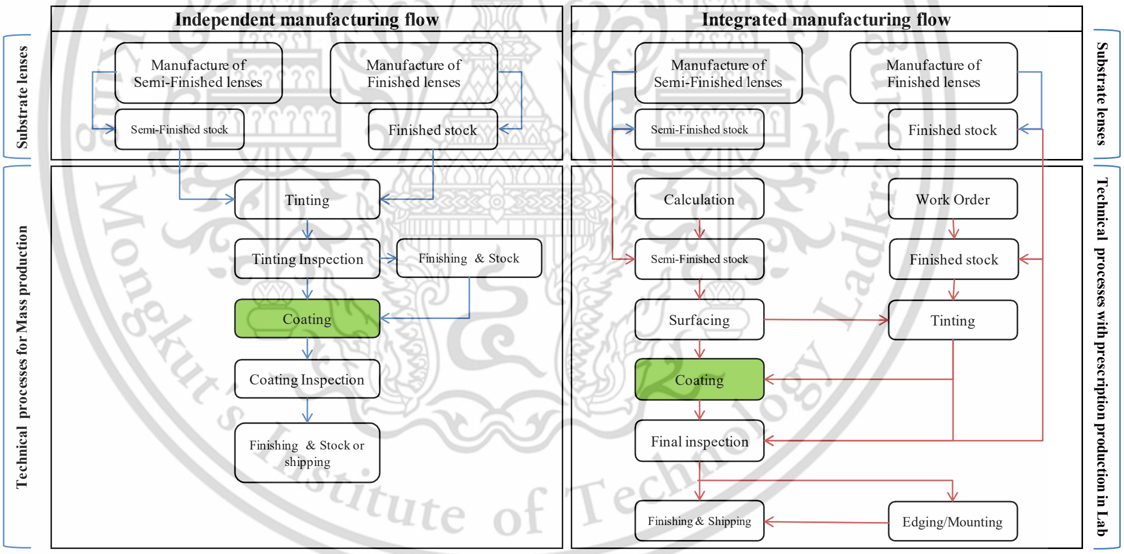


Figure 3.5 Production processes of Independent and Integrated manufacturers
Source: Essilor Company

Moreover, the coating process adds a variety of features to the lens regarding customer's need. Figure 3.6 showed each coating process of coated lens; uncoated lens, hard coated lens, photochromic lens, hard multi-coated lens and anti-reflective coated lens can be finished lens for selling to customers.

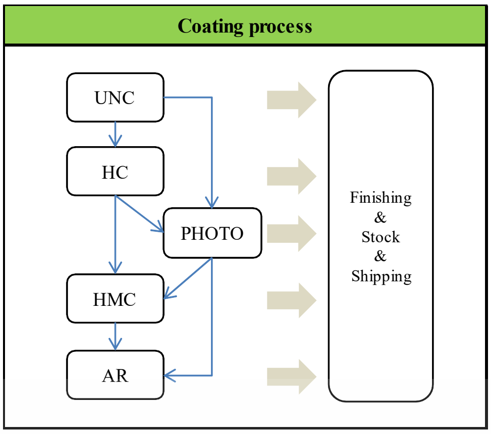


Figure 3.6 Coating processes of Independent and Integrated manufacturers
Source: Essilor Company

3.5 Global Supply chain

The global supply chain of the company covers all products and lens flows all over the world, from production plants to central logistics hubs, prescription labs and retail eye-care outlets. It offers the unrivalled ability to simultaneously manage the flows of both stock lenses (mainly single-vision finished lenses manufactured) and custom-finished prescription lenses (semi-finished lenses made in the production plants that were later surfaced and coated at a prescription laboratory).

Figure 3.7 explained the business process is designed as a complete network. The Group involves with every step from product manufacturing until delivering to the stores. It has a global network of plants, prescription laboratories, edging facilities and distribution centers serving eye care professionals (optical retailers and chains) worldwide.

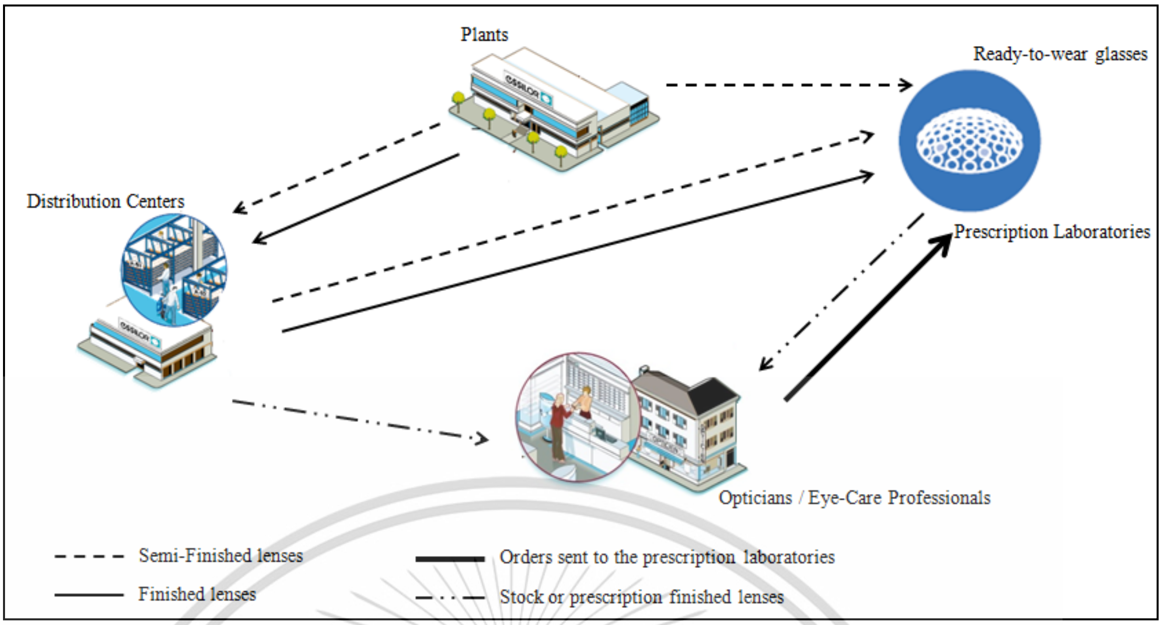


Figure 3.7 The company business process flow

Source: Essilor Company

There are three phases in the flow of supply chain in this company study. It has the important factors in the supply chain as showing in the Figure 3.8;

1. A supplier can be the same manufacturer and distribution centre.
2. A manufacturer can be the distribution centre to supply a product or service to a final customer
3. A customer can be a supplier to another customer, so the total chain can have a number of supplier/customer relationships.
4. While the distribution system can be direct from supplier to customer, depending on the product and markets, it can contain the intermediaries such as warehouse, retailer and wholesalers.

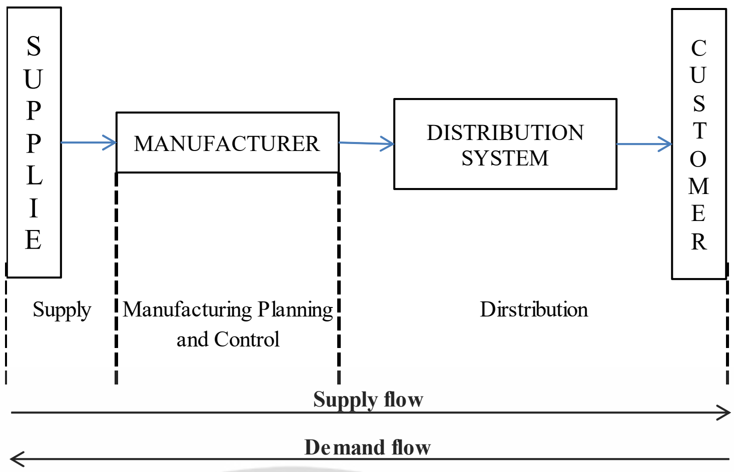


Figure 3.8 The company supply chain process

The company has several factories and distribution centers worldwide. Therefore, the process flow and logistics flow are depended on the consumer needs from the optical/eye-care professionals and types of each manufacturer; finished product that customer needs can be completed the process with the same factory or it needs to produce from other factories.

The company strategy in the business process is Make-to-Stock or Make-to-Order or Assembly-to-Order or Vender Manage Inventory. Figure 3.9 showed that each process can be the same or different manufacturer. Therefore, there are seven main models in the global supply chain depending on the customer's requirement.

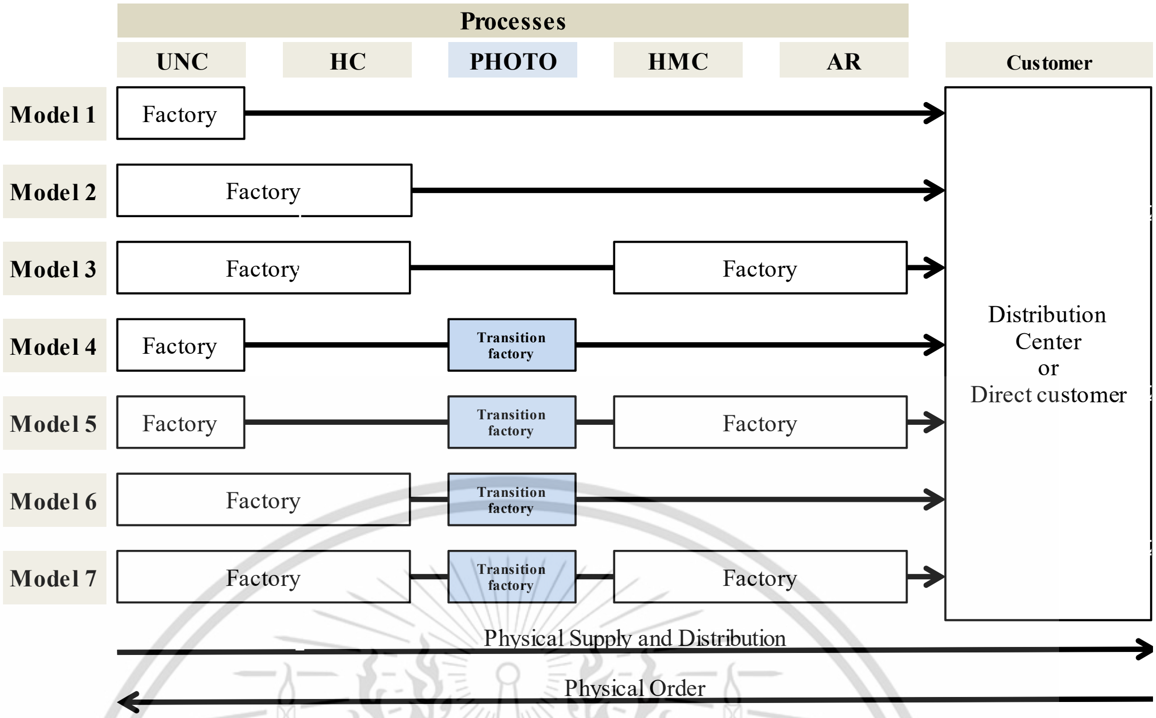


Figure 3.9 Global supply chain models in the company

Source: Essilor Company

3.6 Asia upstream supply chain

In Asia region of this company including the Pacific, Middle-East and Africa that are the main customers in Asia region call "AMERA" customer. The production is based in Asia continental where is located in Shanghai - China, Laguna and Mariveles - Philippines, Bangkok and Amphoe Phan Thong - Thailand and Savannaketh - Laos. In Figure 3.10 showed the seven manufacturers: one plant in China, three plants in Philippines (two Essilor plants and one Transitions plant), two plants in Thailand (one Essilor plant and one Transitions plants) and one plant in Laos.

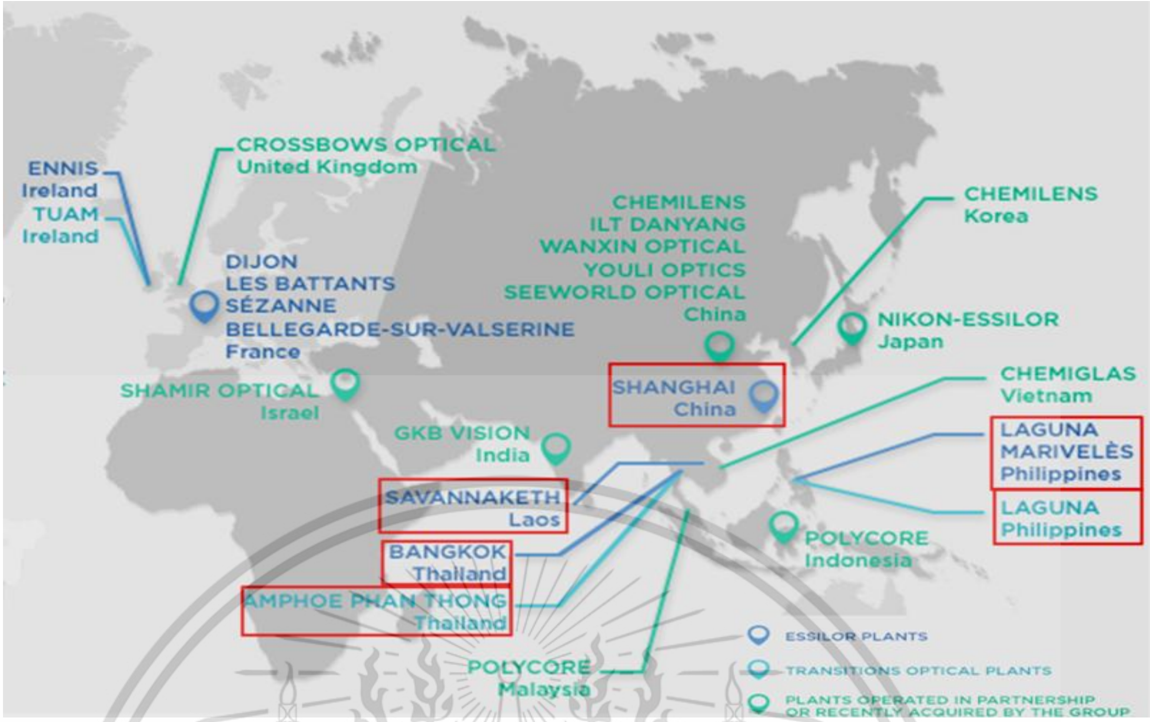


Figure 3.10 Essilors Asia geography

Source: Essilor Company

Each plant has different capability and quality in the production. Table 3.3 showed the current product category in China factory. The factories in China and Thailand produces three product categories; low, medium and high index. Philippines factory produces only two products categories; low and high index, and Laos factory produces only medium index for supporting the capacity for Thailand factory. Moreover, there is specific process related to two Transitions plants as the Photochromic coating process in Laguna – Philippines and Amphoe Phan Thong - Thailand.

Table 3.3 The types of lens were manufactured in Asia region

By Index		Low index				Medium Index				High Index			
Material		CR Series				Polycarbonate				MR Series			
Plants side		CH	PH	TH	LAO	CH	PH	TH	LAO	CH	PH	TH	LAO
By Surface Application	UNC	SV PAL	SV PAL	SV PAL		SV PAL		SV PAL	SV PAL	SV	SV	SV PAL	
	HC	SV	SV PAL	SV PAL		SV PAL		SV PAL	SV PAL		SV	SV PAL	
	HMC/AR	SV	SV	SV PAL		SV		SV PAL		SV	SV	SV PAL	
	Transitions		SV PAL	SV PAL				SV PAL			SV	SV PAL	

Source: Essilor Company

3.7 Validate flow related M&A theory

Related the Mergers and acquisitions (M&A's) practices were considered as a major strategy and commonly acknowledged by organizations that strove for the accomplishment in corporate profitability, diversity, and growth (Schweiger and Weber, 1989: Sinclair and Keller, 2017; J.P. Morgan, 2017). Worldwide deal making increased market share, but in the meantime providing the total costs when two organizations merged into one. A part of cost that considered in this research was the inventory carrying cost.

3.8 Diagnostic tools

The researcher identified steps how to select the product with interviewing the planner that would be implemented the new design and improved the demand forecasting and inventory management.

This section clarified the steps to classify the product in Asia region to improve the inventory level. There were 3 main steps to select the product and factory. First, validate the market sector in Essilor plants and Transitions plants. Second, validate the market sector and product categories in Essilor plants. Finally, validate the product categories and market sector in Transitions plants. The source of data from Asia Upstream supply chain, it was the actual supply to customer in 2015.

1. **Validate the market sector in Essilor and Transitions plants**

This section explained the markets in Essilor plants and Transitions plants in Asia region. Figure 3.11 showed that the highest numbers was US market (36%), followed by AMERA market (25%), Europe market and Import-Export flow in between Essilor plants or between Essilor plants and Transitions plants (17%) then followed by market in LATAM (3%) and other (2%).

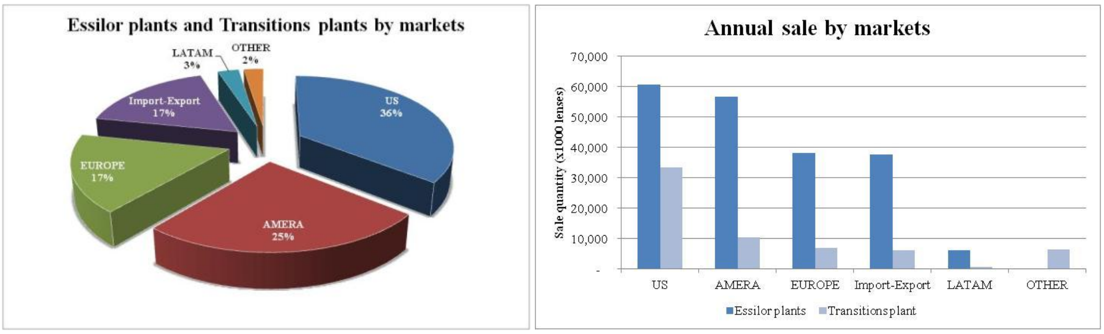


Figure 3.11 Annual sales in 2015 by market in Essilor and Transitions plants
Source: Essilor Company

2. **Validate the market sector and product categories in Essilor plants**

There were two steps for categorizing the products and plants. First, validate who was the biggest market in Essilor plants and what product was the best-selling. Figure 3.12 showed that US market was the biggest market in Asia plant and the best-selling product in US market was medium index with hard coat design (12%). Second, researcher focused the best-selling product that was medium index with hard coating and there were only two plants that was producing the medium index referring to the Figure 3.13, 36% was produced by China factory and 57% had sold to US market.

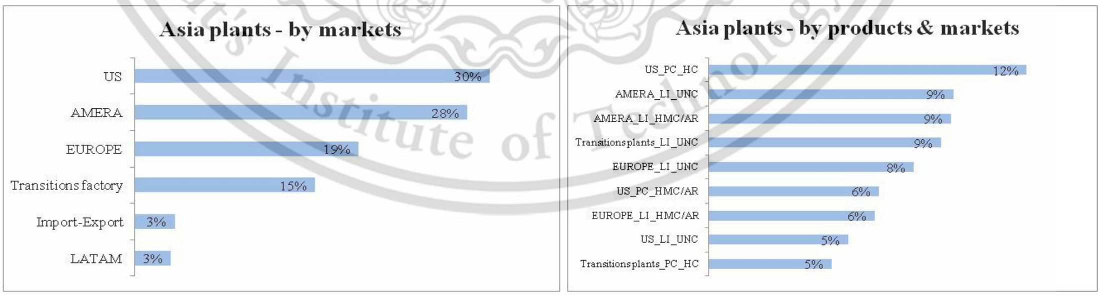


Figure 3.12 Categorized by products and markets

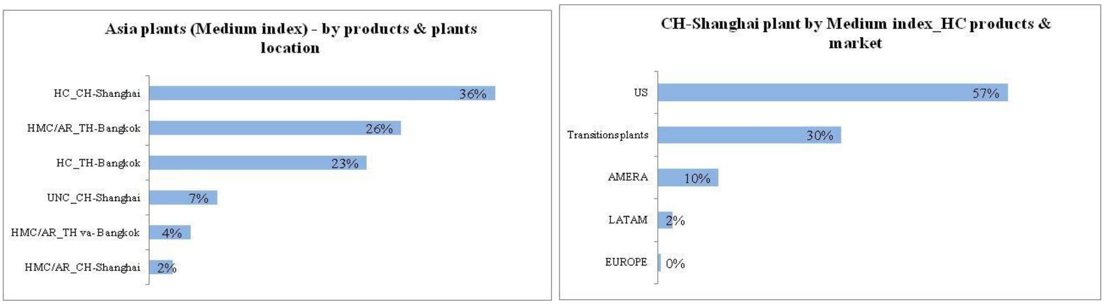


Figure 3.13 Categorized by products and plants locations
Source: Essilor Company

3. **Validate the market sector and product categories in Transitions plants**

Since, Transitions Company had been recently merged with Essilor Group. Therefore, there were many products that Transitions plants buy from Essilor plants or other suppliers must be considered since the cost of inventory on hand had been included. However, business and process management had not been changed in the currently. Transition plants had two locations in Asia region; Laguna – Philippines and Amphoe Phan Thong – Thailand.

There were three steps for categorizing the products, market and supplier. First, validate who was the biggest market and what product had sold to market in the Transitions plants. Figure 3.14 showed that US market (52%) was the biggest market and the highest products had sold to US market was medium index with hard coat design (26%). Accordingly, Transitions plants could not produce substrate lens by themselves. Therefore, Transitions plants needed to buy the substrate lens from Essilor plants or other suppliers. The second, validate who was the biggest supplier. Figure 3.15 showed that 68% was Asia plants and the biggest factory was Laguna – Philippines plant 46%, followed by Shanghai – China plant 32%. However, when consider the highest selling volume by product, which was medium index with hard coating, the only two factories had produced the medium index were Bangkok-Thailand plant and Shanghai – China plant. Final step, validate the products and customers that related to both plants. Figure 3.16 focused on medium index in Bangkok-Thailand plant and Shanghai – China plant and it showed that the biggest factory to produce the medium index with hard coating was Shanghai – China plant 67% and the biggest customer was US market 88%

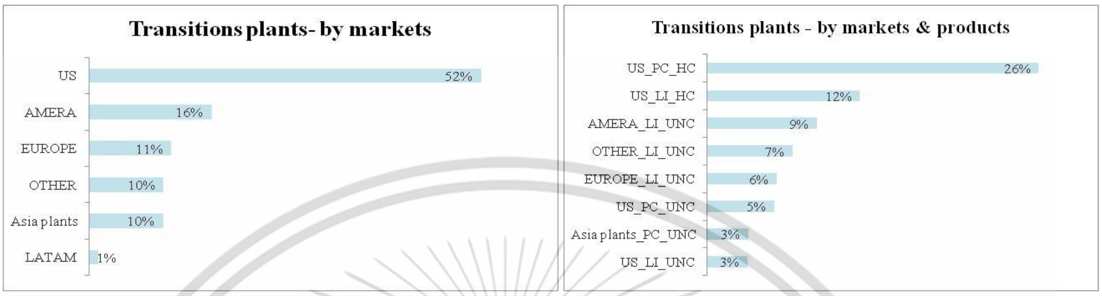


Figure 3.14 Categorized by markets and products

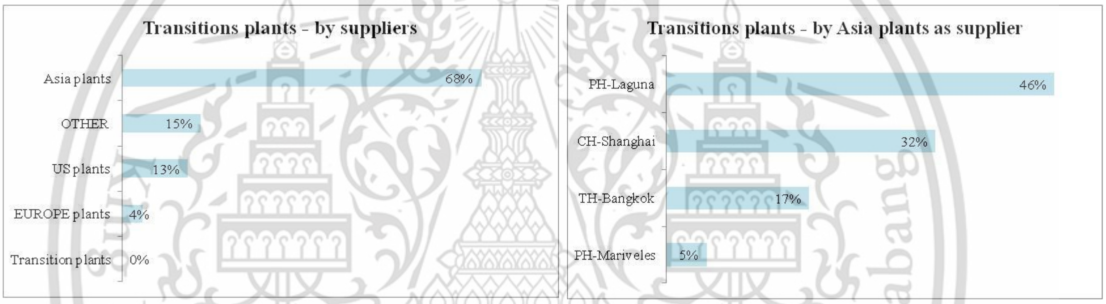


Figure 3.15 Categorized by suppliers

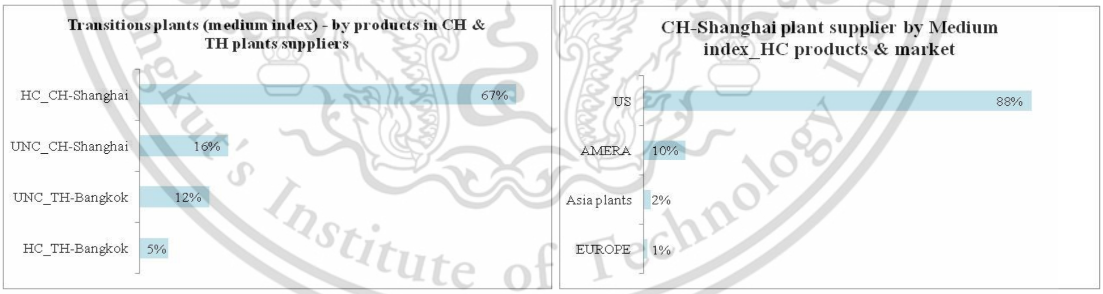


Figure 3.16 Categorized of medium product by supplier and markets
Source: Essilor Company

As above classified steps, the highest selling quantity was US market and this market mainly bought medium index with hard coating lens called “PC HC”. The manufacturer to supply this type of lens was Transitions factory that needed the substrate lens from China factory. Therefore, the customer of China factory was Transitions factory while the customer of Transitions factory was US market.

The study of current flow for the selected product and factory with identifying the problem and proposing the new design would be explained in detail in next chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

This section discussed about the current stage with identifying the problem for selected product and factory included the current inventory management process, and providing the new proposal for improving the inventory level.

4.1 Study the current flow

For this study, selected the medium index or PC with hard coated lenses that was produced by China factory which was mass production. The products in this factory were Semi-Finish Multi-focal lens (SFPAL), Semi-Finish Single Vision lens (SFSV) and Finish Single Vision lens (FSV). Figure 4.1 showed the best-selling products in China factory was Semi-Finish Single Vision lens (SFSV). The biggest customer was US market in both of China plant and Transitions plant as 43% and 83% respectively. Moreover, China plant's market was Transitions plant for the value-added product.

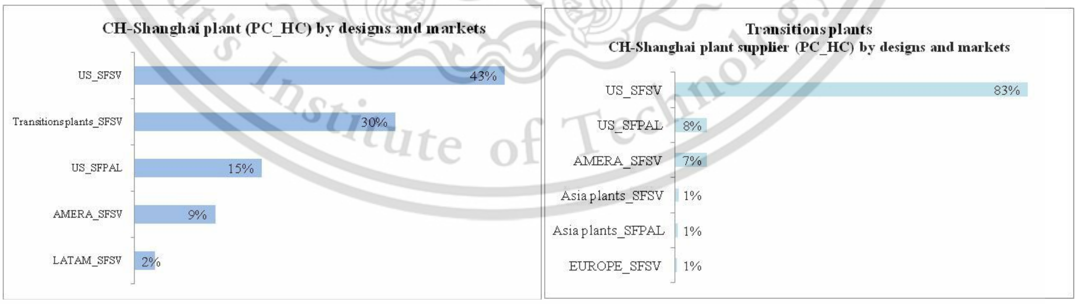


Figure 4.1 Categorized by designs of medium index with hard coated products and markets in China plant (manufacturer and supplier)

Source: Essilor Company

There were 3 functions to review the current process,

4.1.1 Review the selected factory model and strategy

Currently, the SFSV PC HC product in this factory applied the manufacturing strategy by Make-to-Stock (MTS) for AMERA market. For value-added lens would sell to Transitions factory which was managed the manufacturing strategy by Vender Management Inventory. VMI was currently used to monitor factories' inventory replenishment. However, the integration of VMI implied consequences on the collaboration process that linked the different planning processes of China factory. Figure 4.2 explained the current flow for this product from China factory until distributed to customers that was separated by three main models from the seven global models as the following;

Model: China factory → Customer

It was the model 2 in global models. The strategy of this routing was Make-to-Stock between China factory and customer.

Model: China factory → Transitions factory → Customer

It was the model 6 in global models. The strategy of this routing was VMI between China factory, Transitions factory and Make-to-Order between Transitions factory and customer.

Model: China factory → Transitions factory → TH-va factory → Customer

It was the model 6 in global models. The strategy of this routing was VMI between China factory, Transitions factory and Make-to-Order between Transitions factory and TH-va factory that the plant was managed by MTO.

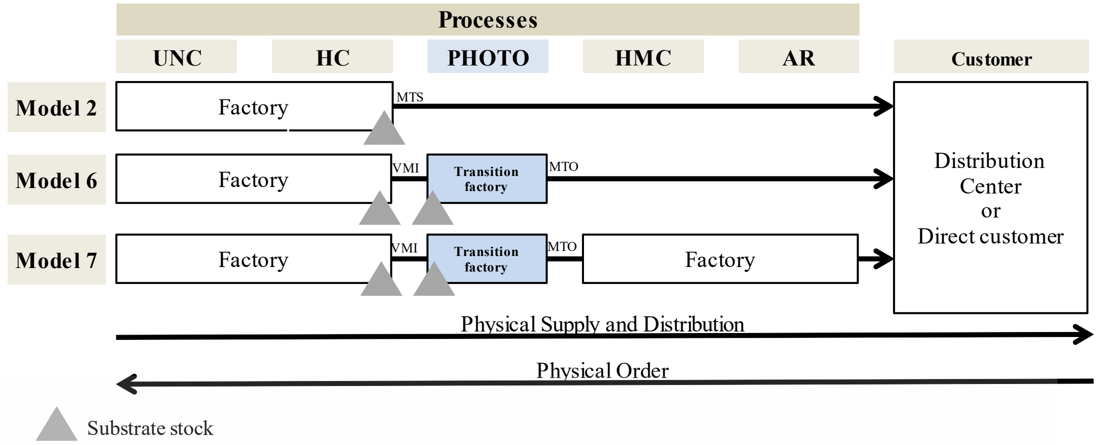


Figure 4.2 Supply chain flow between factory to customers or distribution centres
Source: Essilor Company

The highest sales were US market, in model 2, and followed by model 6, while model 7 was very small sales to US market. Table 4.1 showed that 50% was selling to US market with directly supplied by China factory and 35% was selling to Transitions plants that their biggest market was US.

Table 4.1 Classified the products by markets

Products	CH-Shanghai plant	Transitions plants	TH-Bangkok plant	Market zone	Model
	UNC/HC	PHOTO coating	HMC/AR coating		
SFSV PC HC	50%			US	Model 2
SFSV PC HC Trans		90%		US	Model 6
SFSV PC HC Trans	35%	8%		AMERA	Model 6
SFSV PC HC Trans		1%		EUROPE	Model 6
SFSV PC HMC Trans		1%	100%	US	Model 7
SFSV PC HC	11%			AMERA	Model 2
SFSV PC HC	3%			LATAM	Model 2
SFSV PC HC	0%			EUROPE	Model 2
	100%	**100%**	**100%**		

Source: Essilor Company

The researcher selected the flow between China factory and Transitions factory to improve the process because the stock management in between both plants had different product that was sold directly from China factory.

4.1.2 Review the current process flow

China factory was responsible to calculate the stock level by using the Microsoft excel to replenish the stock on hand with control the inventory level in between Min-Max which was provided by Transitions factory. Therefore, the important process was efficient communication to control the inventory level. Figure 4.3 explained the current process between China factory and Transitions factory. Starting the planner in Transitions factory provided the Min-Target-Max calculation by excel and it was updated every quarter. Then, planner in China factory used the target to control the stock level and consider whether the product should be produced if it was under target. After product completed and validated by quality control then it would put on shelf. It was rolling process to continue the production activity. Therefore, the products would be distributed to Transitions factory, when the stock on hand was under target level. Every step needed to collaborate and communicate since planning team checked with warehouse team for the stock availability, then alerted customer service to release the invoice when the product was ready to ship.

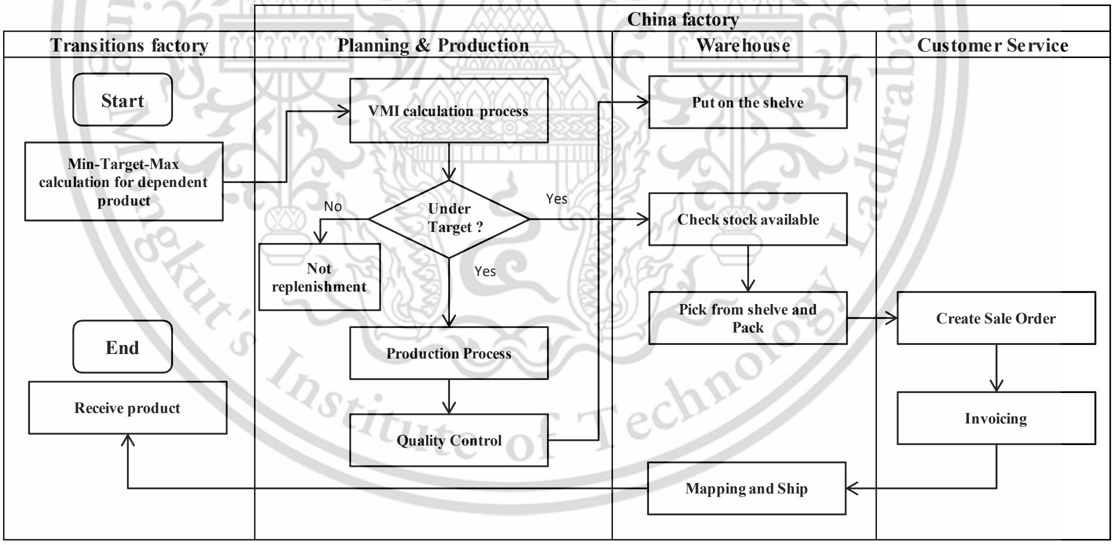


Figure 4.3 The current process flow

Source: Essilor Company

4.1.3 Review existing inventory system

The existing system was reviewed to identify the activities related to the fulfillment of customer's order. The activities reviewed including MIN-MAX-TARGET management.

The investigation of the existing system would provide the parameters about the problems inherent in the existing system.

1. Demand forecasting

The current process, there was no demand forecasting process in the activity of this flow regarding China factory managed the stock on hand by using the Microsoft Excel which was keeping the quantity on hand in-between a minimum (MIN) and maximum (MAX) as the strategy of Vender Management Inventory (VMI) in order to control stock replenishment. The MIN-TARGET-MAX had provided by Transitions factory and defines at the SKU level. Hence, the planner's China factory no visibility the actual demand that Transitions factory sale to customer.

The equation for the MIN-MAX was shown as follow.

$$MIN = \frac{Yt\text{-}1+Yt\text{-}2+\ldots+Yn}{n} \times LTr \tag{4.1}$$

$$MAX = MIN + \text{Lot size} \tag{4.2}$$

The Target defined as a midpoint between MIN and MAX.

$$\sum MIN < \text{YEAR END TARGET} < \sum MAX. \tag{4.3}$$

Where

MIN = min-max minimum quantity

MAX = min-max maximum quantity

Y_t = actual value of Finish product in time period t

n = number of periods 0 be average

For a six-month moving average had n = 6

LT_r = replenishment Lead Time

For production lead time in Finish product had $LT_r = 1$

Lot size = China factory capacity per SKU

2. Stock replenishment control

The visibility of China factory to calculate the stock replenishment, the planner's experience was only the Microsoft excel tool. The replenishment had been controlled by the midpoint between MIN and MAX based on the replenishment lead time (week), order frequency (week) and defines at the SKU level.

The equation for the fulfillment was shown as follow:

$$\text{Replenishment quantity} = \text{QOH} - \text{Weekly requirement} < \text{Target} \quad (4.4)$$

$$\text{Weekly requirement} = \frac{\text{MIN}}{\text{Week}} \times \text{LT PTF} \quad (4.5)$$

For a three-weeks Planning Time France (PTF) lead time = 6

Where,

$$\text{QOH} = \text{Ending inventory quantity} + \text{In Transit quantity} \quad (4.6)$$

Target = the midpoint between MIN and MAX

The box quantity minimum = 30 units/Box

Thus,

The QOH was considered to be replenished when $QOH < Target$.

The QOH was considered to be in excess when $QOH > MAX$.

The product was considered to be endangered when its QOH went below the critical level, equivalent to $QOH \leq {}^{MIN}/_{2}$

A shortage occurred when a substrate in Transitions factory was not available to be launched in production.

<u>Example</u>

The ending quantity on hand were 500 units and In-transit were 200 units in 3 weeks of transportation lead time in current system. If MIN equaled 400 units or 1-month coverage, MAX (200 units/lot size) equaled 800 units or 1.8-month coverage and Target equaled 720 units or 1.7-month coverage. The product fulfilment was shown as follow:

Replenishment quantity = (500 units + 200 units – 300 units) – 800 units = -400 units

Regarding the minimum of units per batch equaled 30 units,

Replenishment quantity = ${}^{-400}/_{30}$ = - 13.33 boxes or 420 units

Thus, when inventory level was less than Target quantity or 800 units; planner would release the shipment plan to ship the product to Transitions factory.

4.2 Identify the Problem

Given the above examination of existing system, the key problem could be summarized related to inventory management encountered by the case company.

4.2.1 Stock day

Referring to the Processing Lead Time at China factory was around 5 days and Transportation Lead Time to Transitions factory equaled 20 days by Sea shipment freight. Thus, the total of Lead Time between China factory to Transitions factory was 25 days. In Transitions factory, the Processing Lead Time for make-to-order for final process equaled 3 days. The equation for the stock days was shown as follow:

$$\text{Stock days} = \frac{\text{Actual sale per month}}{\text{Beginning on hand per month}} \times 30 \qquad (4.7)$$

Figure 4.4 showed the comparison between actual sales from China factory to Transitions factory versus the ending inventory on hand in both plants. Therefore, the average of stock days was around 71 days for selecting product from 2014- Aug 2016; 93 days, 66 days and 52 days respectively. Figure 4.5 explained the longest stock days was the SFSV PC HC 2, around 267 days, the SFSV PC HC 1, around 97 days, and 48 days for the SFSV PC HC 3

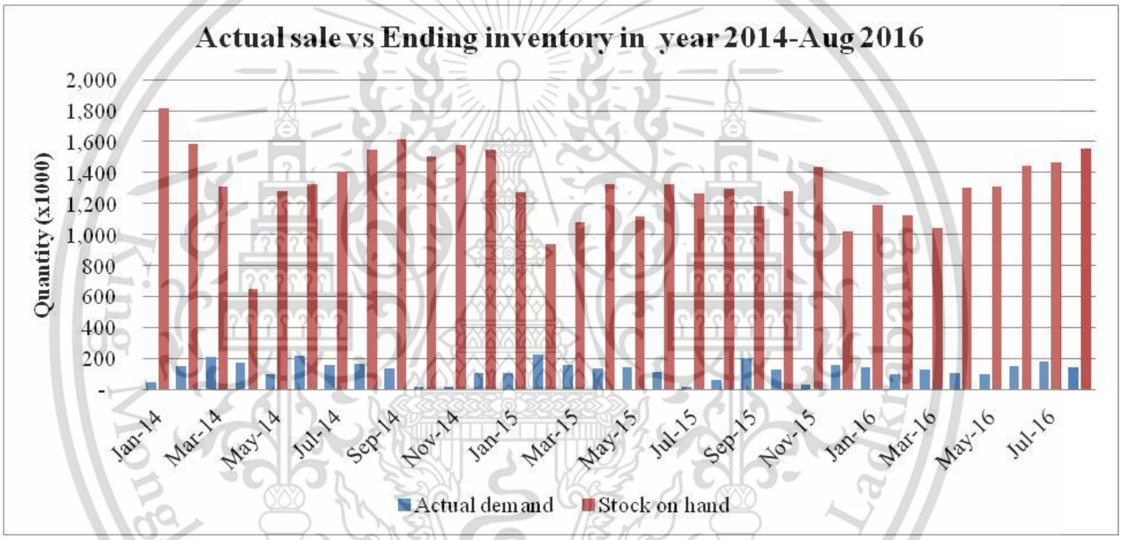
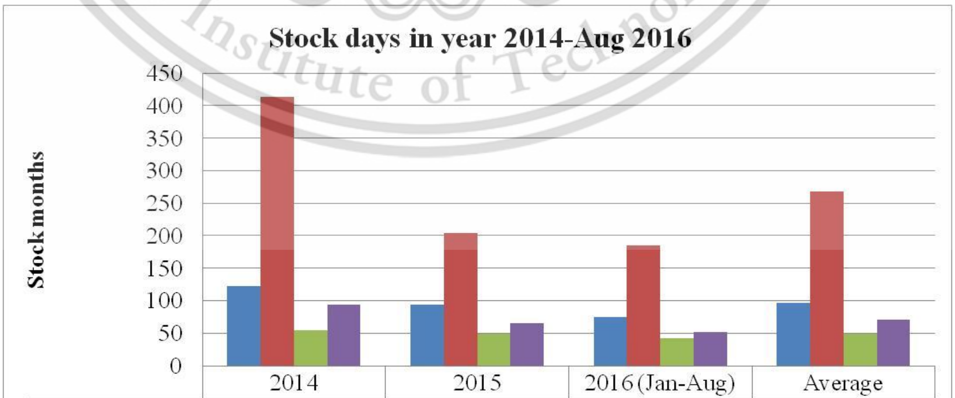


Figure 4.4 Comparison of actual sales vs ending inventory from 2014-Aug 2016
Source: Essilor Company



	2014	2015	2016 (Jan-Aug)	Average
SFSV PC HC 1	122	93	75	97
SFSV PC HC 2	413	205	184	267
SFSV PC HC 3	54	49	42	48
Total average	93	66	52	71

Figure 4.5 Comparison of Stock Days from 2014-Aug 2016
Source: Essilor Company

4.2.2 Demand forecasting

The current process, the planner's Transitions factory provided the purchasing forecast to China factory for only the capacity plan, but the actual shipment to Transitions factory was fulfilled by the product in the midpoint of MIN and MAX.

4.3 Design a new proposal

This section explain the process adapted to design a new demand planning system and an inventory system to cope with the stated problems.

4.3.1 New flow of demand forecasting process and ordering process

The demand forecasting was changed the business process in order to connect the forecasting process since the customer could be the distribution centre in the chain.

Therefore, the new organization of demand forecasting process and Ordering Process had been implemented. Figure 4.6 explained that both processes needed to be linked together in order to prevent the inventory excess or shortage, but provide the good service level.

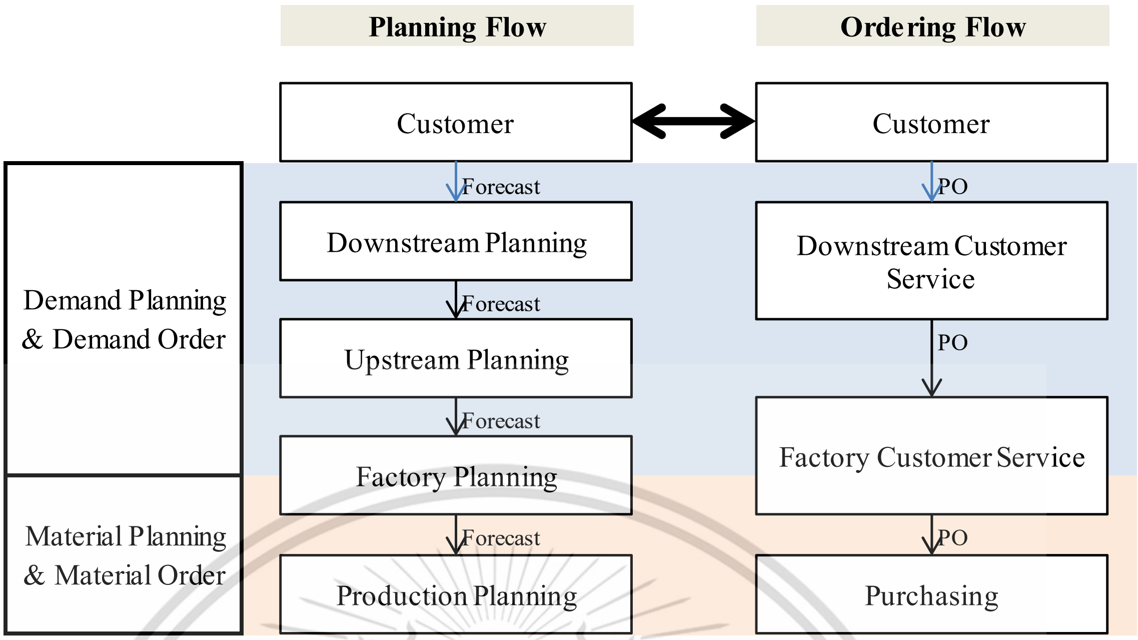


Figure 4.6 The proposed processes of demand forecasting & ordering process flow

4.3.2 Demand forecasting system

The researcher had collected monthly demand information for each sample product from January 2014 to August 2016. The analysis was used to select an appropriate forecast technique, it was necessary to analyze the demand patterns that related to the behavior of planner.

As reviewed with planner, the simple analysis should be implemented as the first step since the planner lacked of experience in the forecasting process with the complicated analysis. Therefore, to analyze the sample historical demand over a relatively long period in order to investigate the patterns of demand, the data and product family would be reviewed monthly. Thus, the complicated forecast technique was unnecessary to use and the demand was short-term planning hence the appropriated forecast technique was Moving-Average forecasting. In conclusion, to prove this technique, it needed to verify the forecast accuracy by evaluating from forecast error value. There were three types of measurement for forecast accuracy;

MAD, MSE and MAPE. Since each measure provided the same results, thus, this research selected to use MAD (Mean Absolute Deviation) to evaluate the accuracy.

4.3.3 Safety Stock (ROP)

The researcher proposed the safety stock control to prevent any variation of both fluctuations of demand and ordering lead-time, there was certainly a need to maintain amount of safety stock to protect the factory against uncertainties. Safety stock calculation would be performed in the following step:

1. Define an appropriate service level for each item
2. Calculate safety stock based on historical of actual demand

4.3.4 Distribution requirement planning system

The researcher proposed the DRP system to forecast the requirement between the China factory, Transitions factory and the company's distribution centers. The system gave central supply and factory had opportunity to plan for the product that would actually be needed and when. It was able both to respond to customer's demand and coordinate planning and control.

The system translated the logic of material requirement planning to the distribution system. The definitions of system overview for this company study were following;

1. Demand forecasting system
2. Forecast Consumption
3. Master Demand Scheduling
4. Distribution Requirement Planning

The system used the result from the demand forecasting system which was planned by family level therefore the company had another tool called "Distribution Key (DK)". It had calculated the percentage per SKU level by using the historical sales backwards 13 weeks per customer. The equation for the stock days was shown as follow:

$$\text{SKU ratio} = \frac{\textit{Historical sales 13 weeks per items level per customer}}{\textit{Historical sales 13 weeks per family level per customer}} \qquad (4.2)$$

Example that there were historical sales per customer by family level equaled 10,000 pieces and there were 3 SKUs in the family that had different actual demand per each SKUs. The SKU1 equaled 5,600 pieces, SKU2 equaled 2,000 pieces and SKU3 equaled 2,400 pieces. Therefore, the ration of SKU1, SKU2 and SKU3 were equal to 56%, 20% and 24% respectively.

Figure 4.7 showed the system schematic and definitions of each step from the demand forecasting process until DRP released the planned order for the factory master production schedule.

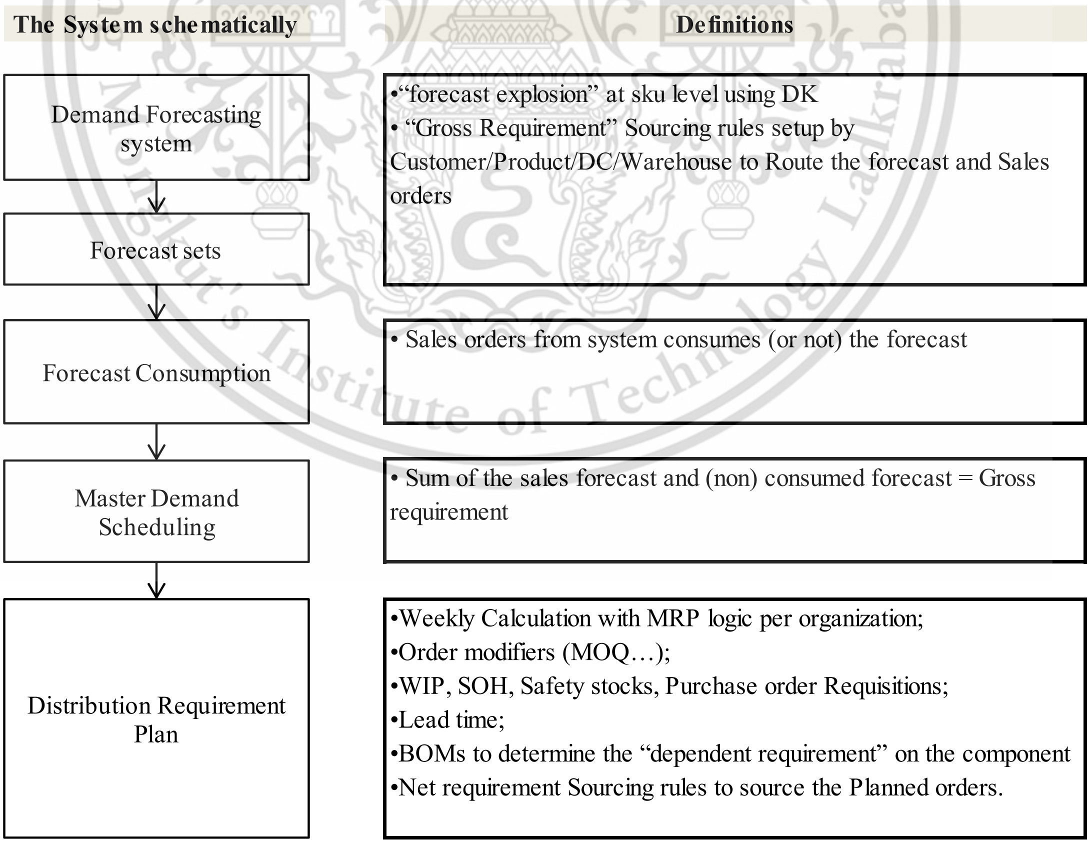


Figure 4.7 The system overview for Distribution Requirement Plan

4.4 The result

4.4.1 New flow chart

After implemented the DRP tools to compute the planned order releasing to production and it automatically generated the shipment plan to determine the ship-to destination as well as it automatically created the Sale Order after closed the pallet and ready to ship out. Figure 4.8 showed the new activity in China factory, started the planning team analyzing the demand consumption based on DRP calculation. In the meantime, if the DRP suggested wrong calculation one way or another, planners in China factory needed to manual re-calculate the correct planned order and release it to production process due to the only 1-day planning lead time in order to continue production rolling time which could not wait the DRP refreshed. After finished production process and completed validation by quality control, the system would consider the product prioritization based on DRP determination of the ship-to destination, when the label was scanned, then put on the pallet, and close the pallet once it was full. After that, the sale order and invoice would be automatically created and finally shipped the product to Transition factory.

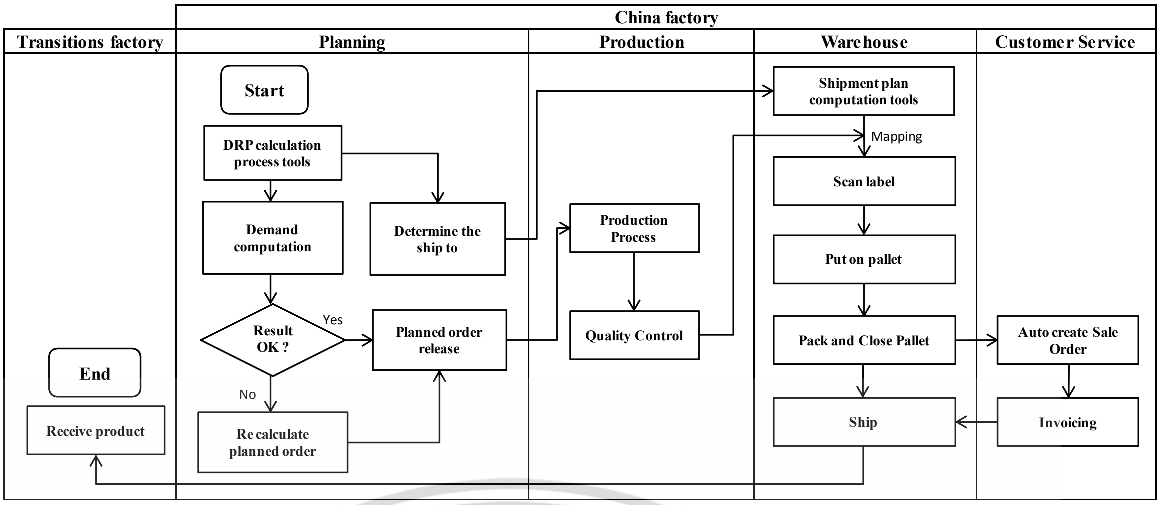


Figure 4.8 The new process flow

4.4.2 Demand forecasting

The previous state, there was no forecasting method since factory managed the inventory by VMI. This model required other healthy stock to control the stock on hand in Transitions factory. This model also lacked of information about the actual demand that Transitions factory sold to customer.

The proposed method of demand forecast for the selected items would be discussed through the following steps.

1. Data selection

The total of product study had 3 product families, and 32 SKU items had been sold to Transitions factory. The researcher consolidated the selling history by product family to categorize and identify the requirement that could be improved the inventory control. The products in inventory were classified by listing the annual usage from 2014- Aug 2016 according to quantity volume.

2. Historical demand review

To select a forecast technique, it needed to firstly investigate the demand patterns of each item, then select an appropriate technique that matched to actual demand pattern. This research acquired historical demand data from January 2014 to

August 2016 of three selected product families to investigate the demand pattern and the performance of the resulting system was assessed by simulating the situation under the new system against the actual operational data experienced. The historical demands of three product families were shown in Table 4.2 to 4.4 respectively.

Table 4.2 The usage volume for the selected products in 2014

Family code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total 2014
PC SFSV 1	46	149	208	170	142	226	158	163	134	19	19	105	1,539
PC SFSV 2	49	63	53	27	8	22	19	13	8	18	18	28	328
PC SFSV 3	425	346	354	358	351	334	328	330	365	225	175	407	3,998
Total	520	559	615	555	502	581	505	506	508	262	212	539	5,864

Unit : x1000 lens

Table 4.3 The usage volume for the selected products in 2015

Family code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total 2015
PC SFSV 1	108	224	161	135	140	113	20	62	205	130	34	161	1,494
PC SFSV 2	19	36	35	5	45	29	72	18	24	10	3	10	306
PC SFSV 3	364	503	395	356	555	436	419	315	557	409	180	569	5,058
Total	491	763	591	496	740	577	511	396	786	549	217	740	6,858

Unit : x1000 lens

Table 4.4 The usage volume for the selected products from January 2016 – August 2016

Family code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Jan - Aug 2016
PC SFSV 1	144	102	127	107	95	149	181	141	1,377
PC SFSV 2	9	13	18	16	45	20	22	36	313
PC SFSV 3	523	423	634	608	615	568	731	661	6,634
Total	675	538	779	730	755	737	934	838	8,324

Unit : x1000 lens

The historical monthly demand during 2014 to August 2016 of the three selected product families illustrated in Figure 4.9

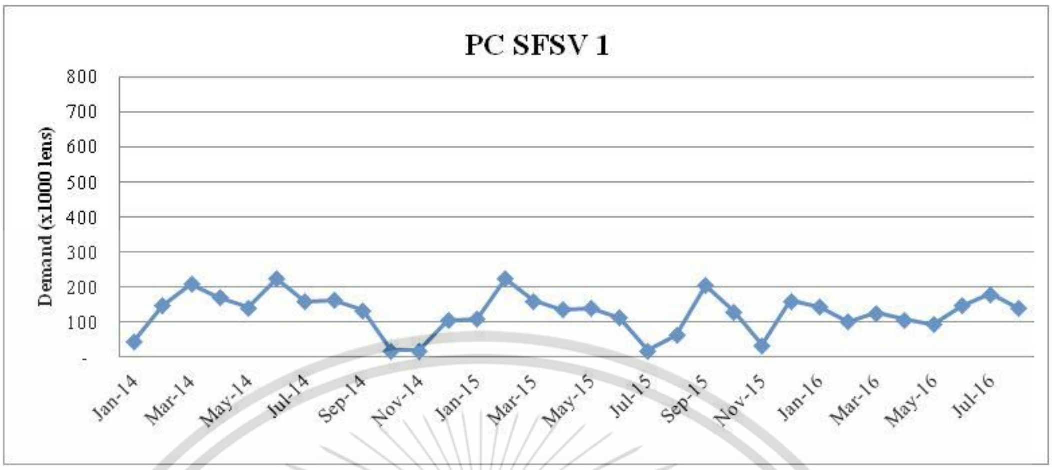


Figure 4.9 (a)

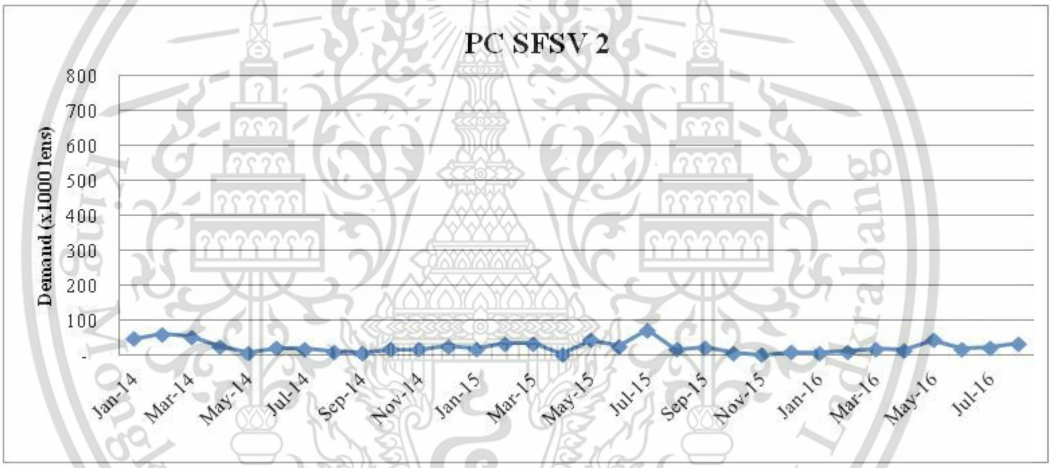


Figure 4.9 (b)

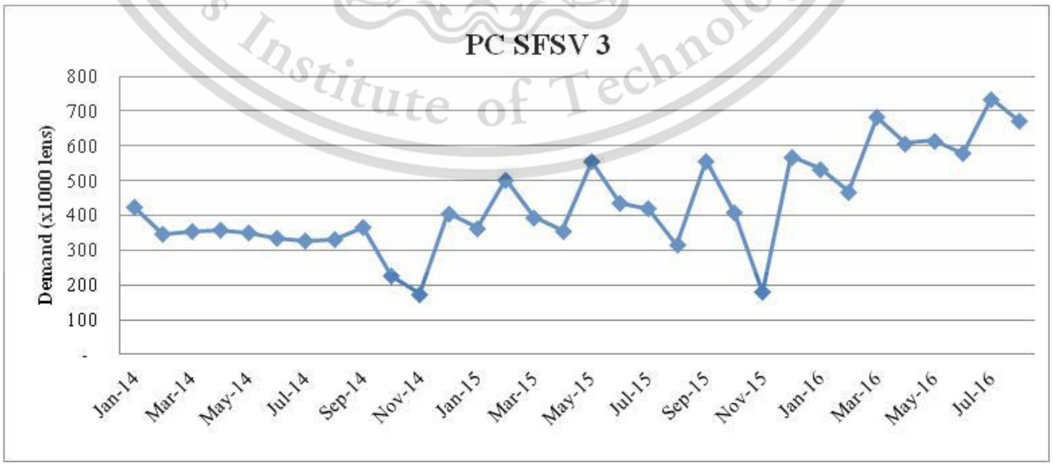


Figure 4.9 (c)

Figure 4.9 Historical demand patterns of sample data from 2014 to August 2016

Above figures showed that three product families of Figure 4.9(a), 4.9(b), and 4.9(c) had irregular pattern, one product of Figure 4.9(c) was not consistent as the actual demand was variable and the healthy stock control as Target had changed by every quarter that was impacted to the stock uncertainty.

Since the planners of China factory had no experience in demand forecasting process and the current method had been transferred from VMI method to use the demand forecast. Meantime, to provide the good deliver to customer with the good capacity therefore needed to connect the net requirement from the end customer to factory by using DRP.

4.4.3 Inventory management

The new proposed method for inventory management would determine and review under the distribution requirement planning system which was working by pushing method in order to make the delivery of goods more efficient by determining which goods, in what quantities, and at what location were required to meet anticipated demand. The concerned data used to analyze in side of DRP consisted as follow.

1. Order quantity
2. Safety Stock and Reorder Point
3. Lead Time

1. **Order Quantity**

The current order quantity of the case study company had managed by production planner regarding the quantity would be replenished in the middle of the MIN-MAX as the vender inventory management system that produced goods, lacked of the demand visibility forecasting, and actual demand from Transitions factory that always faced the problem of shortage or excess inventory.

It was a cost of operating. Normally, the order quantity based on the quantity on hand availability in the warehouse and ready to ship with full pallet was around 5640 pieces/pallet that the warehouse guy would count the quantity from the shelves and put on the pallet, pack and load in the truck in order to ship. Thus, the ordering process started from Warehouse staff informing the quantity that would be shipped to the production customer service staff via e-mail. Then, the customer service staffs proceeded invoice. The frequency of this activity was around 1 times/week.

The new proposed inventory management system had considered the order quantity as the requirement from DRP calculation with pushing system. The system would automatically generate the work order for production based on the quantity prioritization in DRP and the order quantity that should be shipped to distribution centres. However, the DRP helped identifying only the shipment plan which depended on the constraint of the production capacity.

2. **Safety Stock (ROP)**

As before, the China factory managed the stock by using the Min-Target-Max control. The new method proposing to control the stock was a safety stock calculation that based on the theory of Reorder Point. It was calculated by dividing the order quantity by the annual demand and multiplying by the number of days in the year. Reorder point, Inventory level which initiated an order

$$\text{Reorder Point} = \text{Lead Time Demand} + \text{Safety Stock} \qquad (4.9)$$

3. **Distribution requirement planning system**

To organize the delivery requirement efficiently from time to time, the DRP system proposed the reorder point in the weekly basic. The parameter determined in the system as follow:

1. The demand forecast quantity as the moving average demand
2. The safety stock as related the safety theory
3. The actual order opened from end customer of Finished lens
4. WIP quantity in the China factory
5. Quantity on hand in Transitions factory
6. In-Transit quantity delivered from China factory to Transitions factory
7. There was BOM set up in between Finished lens to Substrate lens to provide the dependent demand.
8. The net requirement from Transition factory to China factory

Figure 4.10 showed the weekly the net horizontal requirement between Transitions factory and China factory. It was providing the weekly basic of real requirement from the finished lens and China got the real dependent demand from Transitions factory. As the company target minimized the inventory on hand thus the concept was to keep the inventory on hand of substrate lens only one side where was Transitions warehouse therefore no need to have the safety stock to manage in DRP of China warehouse.

Finished lens - Transitions factory

Production Lead Time: 1 week

Week	1	2	3	4	6	7	8	9	10	11	12
Order Quantity	10	5									
Forecast	5	5	5	5	5	5	5	5	5	5	5
Current forecast				5	5	5	5	5	5	5	5
Gross Requirement	10	5	5	5	5	5	5	5	5	5	5
Beginning on hand	15										
Projected on hand	10	10	10	10	10	10	10	10	10	10	10
WIP	5										
Safety Stock	10	10	10	10	10	10	10	10	10	10	10
Planned Order Release	0	5	5	5	5	5	5	5	5	5	5

BOM

Substrate lens - Transitions factory

Lead Time in transportation: 4 weeks

Week	1	2	3	4	6	7	8	9	10	11
Dependent demand	5	5	5	5	5	5	5	5	5	5
Forecast	10	10	10	10	10	10	10	10	10	10
Gross Requirement	15	15	15	15	15	15	15	15	15	15
Beginning on hand	50									
Projected on hand	75	60	45	40	40	40	40	40	40	40
Scheduled receipts	40									
Safety Stock	40	40	40	40	40	40	40	40	40	40
Planned Order receipts	0	0	0	10	15	15	15	15	15	15

Substrate lens - Transitions factory

Lead time in production: 1 week

Week	1	2	3	4	5	5	5	5	5	5
Dependent demand	25	15	15	15	15	15	0	0	0	0
Beginning on hand	0									
WIP	10									
Safety Stock	0	0	0	0	0	0	0	0	0	0
Planned Order Release	15	15	15	15	15	15	0	0	0	0

Figure 4.10 DRP system coherence between China and Transitions factory

4.5 Discussion and Evaluation

4.5.1 Forecast accuracy

After deployed the new forecast method by the moving average, the researcher analyzed and followed up the actual demand month by month to forecast the further demand. The researcher analyzed the October demand forecasting rotation with summarizing in three product families, and then calculated the new forecast by moving average method as showed in the Table 4.5

Table 4.5 Forecast error of selected products from September 2016 – December 2017

	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	MAR-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Total
Demand forecasting	660	617	836	797	786	776	982	854	914	1,001	1,032	1,045	1,041	1,065	-
Actual demand	686	544	747	933	735	654	930	922	1,025	956	1,060	1,026	1,127	1,012	-
Absolute deviation	26	73	89	136	50	122	52	68	111	45	29	19	85	53	959

Unit : x1000 lens

Source: Essilor company

As above table could measure the forecast error through the Mean Absolute Deviation (MAD)

$$\text{MAD}=\frac{\sum|\text{errors}|}{\text{Number of periods}}=\frac{959}{15}=64\ (\times 1000 \text{ pieces}) \qquad (4.10)$$

Measurement of the forecast error was important because it indicated the relative cost of different levels of customer service.

Figure 4.11 showed the result of the forecast error from September 2016 until October 2017. It could summarize that in total of 15 months since implemented the demand forecasting process, the forecast error was found around 64,000 pieces or 8% of the total demand.

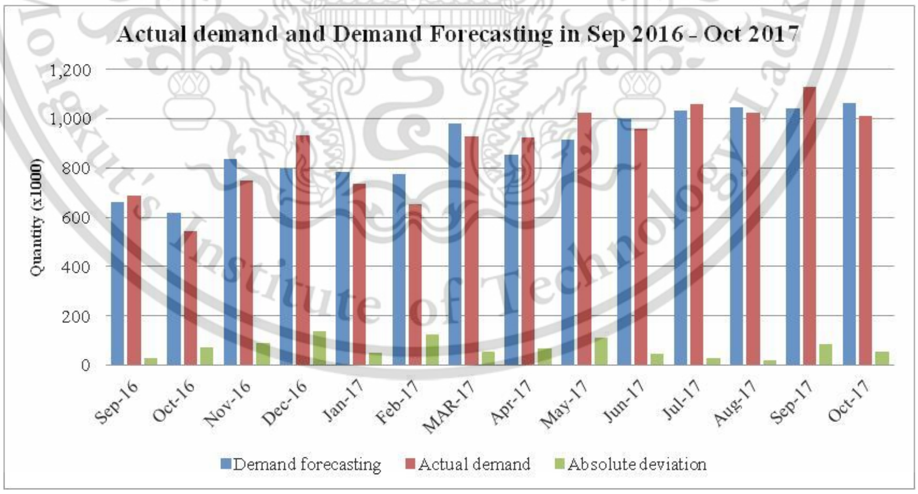


Figure 4.11 The demand accuracy from September 2016 – October 2017

Even there was the forecast error in the factory, it still could provide the customer level in total 99.6% which was good situation to continue the forecasting process and put it in the DRP system in order to see the real demand from Transitions factory's needs. Table 4.6 showed the percentage of customer level from China factory providing the good substrate lens to Transitions factory.

Table 4.6 Service level between both factories from September 2016 – October 2017

	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	MAR-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Total
Demand forecasting	660	617	836	797	786	776	982	854	914	1,001	1,032	1,045	1,041	1,065	12,405
Actual demand	686	544	747	933	735	654	930	922	1,025	956	1,060	1,026	1,127	1,012	12,356
Absolute deviation	26	(73)	(89)	136	(50)	(122)	(52)	68	111	(45)	29	(19)	85	(53)	(49)
Service level target	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Service level	104.0%	88.2%	89.3%	117.1%	93.6%	84.3%	94.7%	108.0%	112.1%	95.5%	102.8%	98.1%	108.2%	95.1%	99.6%

Source: Essilor company

As above table could measure the service level was defined as follow:

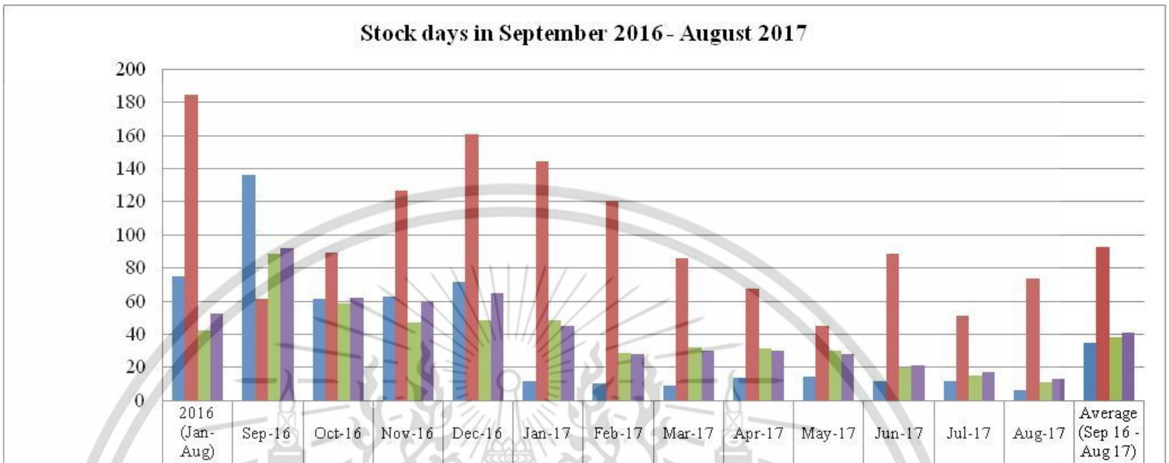
$$\text{Service level} = \frac{\text{Actual demand}}{\text{Demand forecasting}} \times 100 = \frac{12{,}356}{12{,}405} \times 100 = 99.6\% \qquad (4.11)$$

The demand forecasting defined as the real net requirement needs from the Transitions factory suggested by DRP system while actual demand was equal the actual shipped from China factory to Transitions factory.

However, there was small gap of variation of forecast error, but it could improve the forecast accuracy with better forecasting method.

4.5.2 Stock days

The stock day had decreased since the new forecast method was implemented and used in DRP system to get the real net demand. Figure 4.12 showed the stock days per each product comparing before (January to August 2016) and after (September 2016 to August 2017), the stock days decreased from 75 days to 35 days for SFSV PC HC 1, decreased from 184 days to 93 days for SFSV PC HC 2 and decreased from 42 days to 38 days for SFSV PC HC 3. Therefore, the total average day for three product families decreased from 52 days to 41 days. Figure 4.13 explained that the average for three product families about 68 days by removed the outliner of October 2014, November 2014 and November 2015 due to the actual demand in these months very dropped as the ordering flow issue. After implemented the demand forecasting process the average stock days was decreased from 68 days to 38 days.



	2016 (Jan-Aug)	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Average (Sep 16 - Aug 17)
SFSV PC HC 1	75	136	61	63	72	11	10	9	14	15	12	12	6	35
SFSV PC HC 2	184	61	89	127	161	145	121	86	68	45	89	51	74	93
SFSV PC HC 3	42	89	58	47	49	48	29	32	31	30	20	15	11	38
Total average	52	92	62	60	65	45	28	30	30	28	21	17	13	41

Figure 4.12 Stock days from September 2016 – August 2017

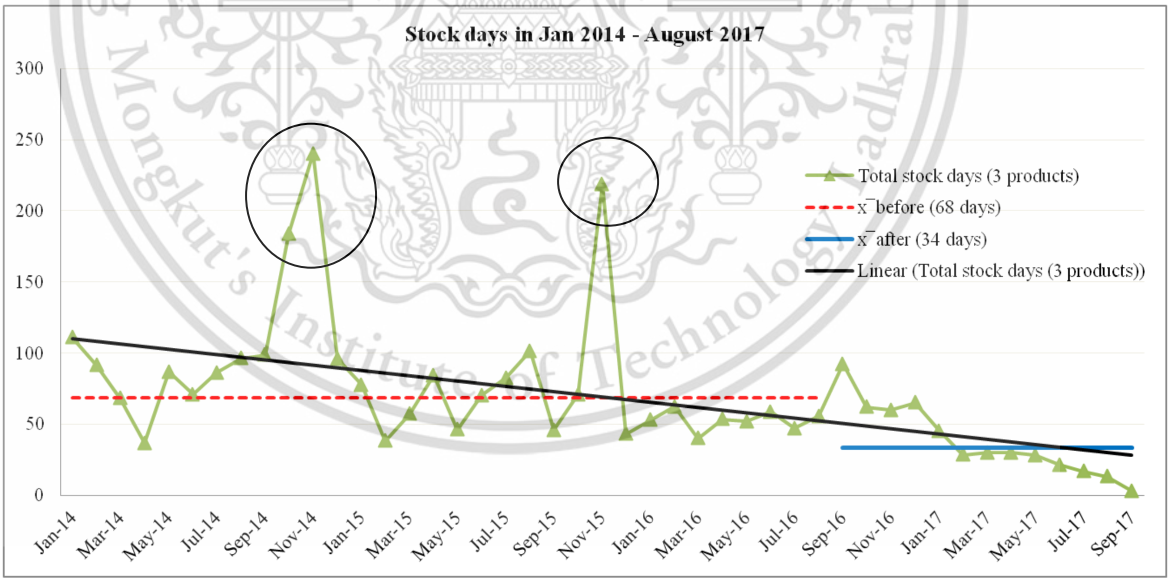


Figure 4.13 Stock days from January 2014 – August 2017

Consideration per product families in Table 4.7, SFSV PC HC 1 and SFSV PC HC 2 extremely improved the stock days around 53% and 50% respectively. While SFSV PC HC 3 slightly improved only 9% due to small demand and supply. The total improvement for the average day from January – August 2016 was 52 days to 41 days from September 2016 to August 2017. It was improved around 21 % or decreased from the previous system around 11 days.

Table 4.7 Comparison of stock days level between the current and proposed system

Family code	Avg days (Jan-Aug'16)	Avg days (Sep'16 - Aug'17)	Avg days decreased	% Improvement
SFSV PC HC 1	75	35	40	53%
SFSV PC HC 2	184	93	91	50%
SFSV PC HC 3	42	38	4	9%
Total average	52	41	11	21%

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Chapter 1 explained the key problem of the company which was the problem of planning and inventory control of made to stock. It was one important factor because it associated with inventory and responded to customer's needs. The process of inventory planning would help the company reducing costs and meeting customer's needs more efficiently. Impact from the problem of planning and inventory control would result in the cost of penalty due to the delay of delivery to customers, cost from the loss of selling opportunity, expenditure from the loss of goodwill and opportunity to use available or necessary resources to apply to others that could give a greater return. Therefore, it's vital to improve planning, inventory control to be more efficiently solving such problems.

Chapter 2 explained the tools, content or methods that could enhance the analysis in this case study.

Chapter 3 explained the problems that occurred in the case study company such invisibility demand in China factory, because they managed the inventory level as VMI flow with manual process, and also controlled the stock level with the Target or Periodic system. Regarding, Essilor Company had been merged together with Transitions Company resulting the cost increase, one of the cost was inventory carrying cost, which was importance factor needed to consider. Thus, the company had the problem on the inventory increasing immediately. Therefore, the objective of this study was to optimize the inventory on hand for the substrate product that was the standard component to Transitions factory. But the first step that could improve the inventory was to propose the demand forecasting method to planner, who had less experience in demand forecasting process. Therefore, to avoid any inconvenience caused to the planner, the researcher started implementing the Moving-Average forecast method and calculating by product families. Meantime, there was other system controlling the average demand by items. The new purposes also implemented the safety stock calculation and integrated all parameters into the DRP in order to support the weekly basic demand from time to time. It helped planner analyzing the requirement faster with authoring the real demand in the finished goods level.

Chapter 4 explained the current process of selected product and factory and found that the DRP tools could support the inventory level, as the stock days was large decreased around 50% for two product families and 9% for one product family. After implemented the demand forecasting, the result showed that there was small forecast error but still provided the good customer service level.

5.2 Problem and Barrier

The need of data research was the secret of the organization establishment and the decision depended on the executive, since the disclosure was necessary to ask for permission and approval from the executive or head company. Although the company gave them full cooperation, it had been formally agreed not to disclose the information of the company.

Personnel in each department of the company also had the concept of each work. Employees tried to plan and practice to measure their own departments' accomplishment.

5.3 Recommendation

1. The forecasting method needed to practice more and analyze to select the good model for this specific product.
2. A company should practice the ABC analysis model in order to avoid the uncertainty by items level
3. A company should control product family 1 and 2 inventory closely since the stock days could be more improved.
4. The DRP tools could support the production weekly basis, but it was systematic that could find some problems if the data input was incorrect and unstable. Meaning that affected the production to produce wrong quantity.

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