

**INVENTORY MANAGEMENT: A CASE STUDY OF AVERY DENISSON
COMPANY BANGNA DISTRIBUTION CENTER**



**AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN
MANAGEMENT
INTERNATIONAL COLLEGE
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
2017
KMUTL-2017-IC-M-002-003**

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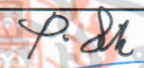

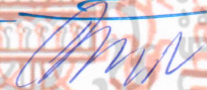
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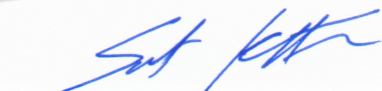
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Place: International College, 8th floor, 55th Anniversary Chalermprakit Building

KING MONKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG


(Assoc. Prof. Dr. Supat Kittiratsatcha)
Dean of International College
May 21st, 2017

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RESEARCH TITLE Inventory Management: A Case Study of Avery
Denisson Company Bangna Distribution Center

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DEGREE Master of Science

PROGRAMME Logistics and Supply Chain Management

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ABSTRACT

This independent study concerns to the inventory management in a case study of Avery Dennison Company. It aims to propose the guideline to set inventory level in order to minimize inventory costs, holding and ordering cost. The distribution center for Avery Denisson company has the excess inventory because an existing inventory control is not applicable to the operation and customer demand. In this work, three models were used to set order quantity, safety stock, and reorder for 61 items, used as examples in order to demonstrate the effectiveness of the proposed inventory control techniques.

The ABC categorized technique was employed to classify class of inventory so that an inventory manager can effectively use his/her resource to manage inventory. To set inventory control parameters, class A use the method of ordering batch size optimization with a reorder point. Class B use extension of the economic order quantity (EOQ) to fix order quantity and safety stock. Class C, it is used Min-Max model to find the safety stock, target stock level and order quantity. The calculation showed that inventory cost can be saved roughly at 22 percent of the total inventory costs.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my advisor Assistant Professor Dr. Wichitsawat Suksawat na Ayudhya who always guides and supports me with his encouragement throughout this research paper.

I would also like to thank all the professors for sharing their knowledge, giving encouragement, and providing very useful advice. I also want to thank all the staffs at International College @ KMITL for their assistance and motivation.

And special thanks to my parents, family and friends for the kind support and encourage me to complete in this independent study.

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Kwanchanok Nasok

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays inventory control is a part of every business because it has an impact on profits cash flow and which is generally a business's largest asset. Having too much inventory and or not having enough are considered to be primarily direct cause of business failures. To control the inventory is one of the principle factors that the top management has to consider closely. The customers demand become more diversified and customer behaviors change more rapidly. In order to satisfy customers demand a company who is able to serve fast-moving environment in a lower cost but at a faster speed will have more advantage in the marketplace.

Strong competitions within the market area of pressure sensitive labels (Label and Packaging Materials business) are more prevalent. The highly competitive race for market share is adjusted according to the conditions of market competition in terms of price, quality management, and after sales service to develop products and services to benefit and maintain customers. However, due to fluctuations in market demand, it is difficult to forecast the inventory level which results in imbalance between supply and demand. Hence inventory management is a major issue in the sector. Keeping a large amount of inventory which requires a large amount of space to store the inventory incurs carrying cost and storage cost are not always the best thing when trying to effectively manage the costs associated with the inventory. Since the market demand is a factor that cannot be controlled, monitoring inventory levels continued to reduce the loss of business opportunities and taking into the account the cost of proper storage is important. The store

stocks a wide variety of items may result in restrictions on the management. Setting the standard to reduce duplication and providing a role to support the preparation of standard components is decisive to be used in Avery Dennison Banana Distribution Center.

1.2 Statement of Problem

To gain market share and maintain service flexibility from competitors, Avery Dennison must have the products (mentioned herein SKUs items from Avery Dennison Malaysia and Rayong plant) that customers need on hand when the customers need them. The primary sources of finished goods come from Avery Dennison Malaysia and work in process (WIP) from Rayong plant. The product lines are Paper and Film. The products from both plants hold the largest sales volume. Bangna distribution center is holding such large volume of SKUs items on hand, which exceeds limit of its capacity storage, that it needs an external warehouse to store the inventory. Expenses included the rental cost and trucking cost when withdrawal the products from the external warehouse to the distribution center, where transportation is time-consuming and high risk of deterioration and obsolescence. There are a number of problems that cause chaos with the company's inventory management. In 2015, the company faced a problem with an excess inventory that turned into slow moving which was over the budget from falsely managing the inventory and as the result put all the cash flow at risk. Although the company has a high turnover ratio, it isn't well managed in buying and still having difficulty in managing inventory as well.

As mentioned above, Avery Dennison should have more concentration on inventory planning, in terms of products to meet customer needs and to minimize costs

resulting from obtaining and holding inventory with EOQ (Economic Order Quantity) planning implementation, Safety stock calculation for ROP (Reorder Point) in order to be able to plan the warehouse for more systematic and to be able to survive as a stand now and in the future.

1.3 Objectives of the Research

The objectives in this research are to study the purpose of determining the level of inventory and to expect the guidelines for improving inventory management as well as to define problems related to the Avery Dennison inventory of SKUs items from Avery Dennison Malaysia and Rayong plant at Avery Dennison Bangna Distribution Center as a principle of case study.

1. To deploy a mathematical technique for determining order quantities and safety stock levels for class A stock items.
2. To provide suggestions for improving the inventory management at the Avery Dennison Bangna Distribution Center

1.4 Scope of Study

The scope of this study concentrated on importing finished goods from Avery Dennison Malaysia and work in process from Rayong plant at Bangna Distribution Center. Historical inventory data were collected at least 10 months by retrieving company database.

1.5 Research Organization

The study report is organized into five parts. The contents of each can be briefly described as follows:

1. Chapter 1 is about the introduction and overview of the study.

2. Chapter 2 presents a review of literature relevant to the issues outlined in this introduction and research or theories that are related to the study. This includes a review on inventory management practices.

3. Chapter 3 provides a background of the company, Avery Dennison is in the context of this research, where method used for addressing the identified root causes and improvement in this study.

4. Chapter 4 shows analysis of data.

5. Chapter 5 provides conclusion of inventory reduction and recommendation as well as looks into the future study opportunities connected to the area of the advanced economic order.

1.6 Expected Contribution

The guidelines of inventory control that can help to reduce total inventory cost.

CHAPTER 2

LITERATURE REVIEW

1.1 Research Background

The intent of this chapter is to review the literatures that guides the methodology to improve the current inventory situation. First, it takes a look at the general topic of inventory management and then review related work to the topic of inventory management.

1.2 Logistics

Webster's New Encyclopedia Dictionary (1993) explained that the business logistics is a relatively new field of integrated management study in comparison to the traditional fields like finance, marketing and production. Logistics is "The branch of military science having to do with procuring, maintaining and transporting material, personnel and facilities".

John Coyle et.al. (2013) presented the US Field Manual 100-16-Operational Support defines logistics as the process of planning and executing the movement and sustainment of operating forces in the execution of military strategy and operations. It is the foundation of combat power – the bridge that connects the nation's industrial base to its operating forces.

Council of Logistics Management (CLM) defines logistics as process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw material, in-process inventory, finished goods and related

information from point of origin to point of consumption for the purpose of confirming customer requirements.

The process of anticipating customer needs and wants; acquiring the capital, materials, people, technologies, and information necessary to meet those needs and wants; optimizing the goods- or service-producing network to fulfill customer requests; and utilizing the network to fulfill customer requests in a timely manner

To conclude, logistics surround the overall flow of materials. From acquisition of the raw materials and purchased component parts to delivery of a finished product to the customer which involves two major operations:

1. Material management
2. Physical distribution management

Based on the idea of Andrew C. Gross, et al., 1998 the two operations can be illustrated in the following manner.

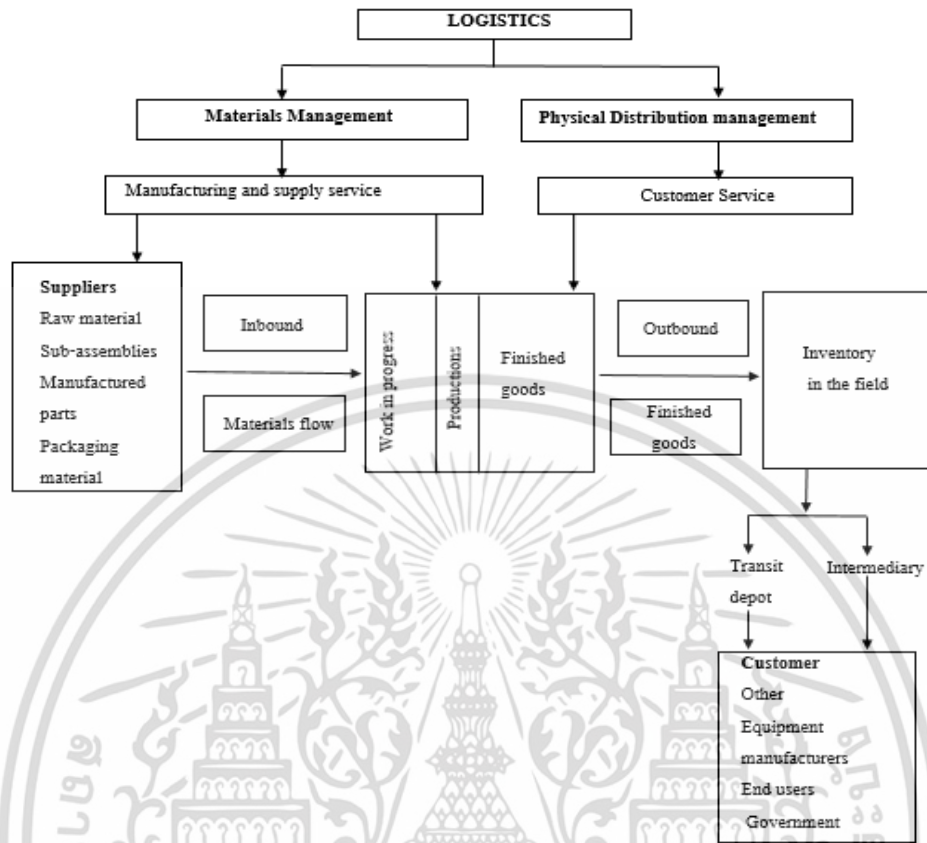


Figure 2.1 Modified from Component of Logistics (Basics of Distribution Management: A logistics Approach, 2004)

The term of logistics has long recognized that it owes origins to the military, which the logistics activities were the importance for national defense. It has become much more widely recognized in general public in the last 20 years from many channels such as television, advertising and radio. The customer sensitivity was also contributed to the recognition of the logistics service quality which has been increased and frequently mentioned about the logistics challenges.

2.2.1 Component of Logistic Costs

The total logistic costs are a sum of specific logistic costs, additional logistic costs and administrative costs:

1. Specific logistic costs are all cost of a performance station, a profit center or a company, which are caused by executing the operative logistic tasks transport, handling, storing and commissioning.

2. Additional logistic costs are caused by executing additional operative tasks which are directly connected with logistic tasks, such as packing, labeling, loading and unloading, and quality controlling.

3. Administrative logistic costs are costs for related administrative services, such as scheduling, quality management and controlling which go along with the execution of logistic performance and additional services.

Research and development, construction, production, assembling, marketing, sales and general administration also the costs for buying and procuring merchandise, parts, materials and equipment are not part of the logistic costs. The costs for packing sales units are production costs, whereas costs for packing materials, pallets, bins and load carriers are material costs of logistics.

1.3 Supply Chain Management

The supply chain management offers many tools and techniques that help business organization to verify the problems and also provide solutions of disruptions around the business environment.

Simichi-Levi et.al. (2003) described that the supply chain management activities cover almost everything such as from products to its development, logistics, sourcing and information system. It was defined as set of approaches

utilized to efficiently integrated suppliers, manufacturers, warehouses and stores, so that merchandise are produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize costs while satisfying service level requirements

2.3.1 Supply Chain Concept

The whole chain concept of supply chain is a single integrated flow across all the functions of the business. The flow of materials and flow of information across traditional functional boundaries within supply chain management are depicted as below figures.

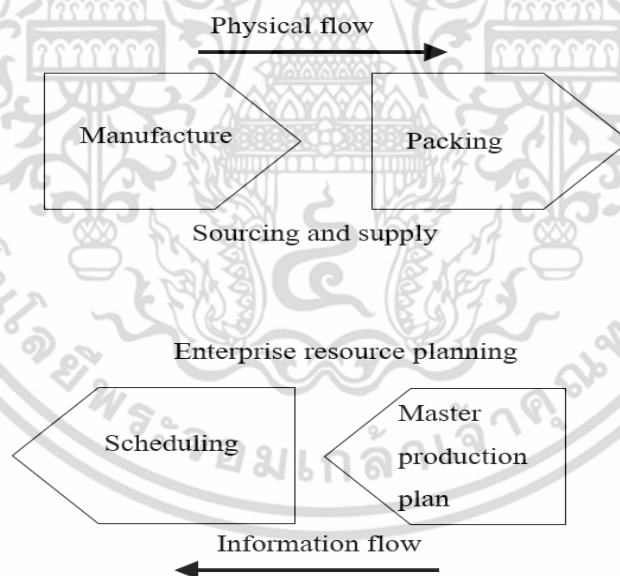


Figure 2.2 Supply chain management flow. Modified from Total Supply Chain Management (Ron Basu, K. Nevan Wright, 2008)

1.4 Inventory

The inventory is a supply of items by a firm to meet demand which come from both external customers and internal operations.

Swink (2001) explained that the inventory types are divided into Production inventories; raw materials, parts and components which are bought from supplier to use in the production. Work in process and semi-finished products in the production process and also final products in warehouse are regarded as inventories.

The inventory theory is used as a guideline for a management to satisfy customers demand or support the production of goods or services. High level of inventories is an expensive expense for a company and creates a pressure for operations and management personnel. Sometimes, the high inventory costs come from dis-economic of scales when a company orders a small lot and results in higher order costs. A key factor for successful supply chain management and inventory control systems is the effective inventory management, which mathematical models are applied. The main idea for keeping inventory is to serve customer demand while minimizing operations costs. The cost of keeping one unit in inventory for a given period of time is composed of physical holding cost (storage, handling, insurance opportunity, and interest cost, renting warehouse, electricity bill, etc.) and ordering costs (negotiation, preparation, custom clearance costs) or setup costs (changeover fixtures).

2.4.1 Types of inventory models

1. Independent Demand

Independent demand is consumed or needed in some general pattern and it is not dependent on any factors which would be considered as independent demand items. Items are those items that we sell to customers where judgment, forecasting, marketing, and economic analysis and various other techniques are used to decide on the quantity we will produce. Independent demand items are inventory that managed by multitude of factors that some forms of forecasting are involved to decide on quantities to produce or to have them available on hand. Independent demand items needed to be forecasted as far as feasible and meaningful. Many factors that are constantly changing are not feasible to forecast far into the future.

2. Dependent Demand

The dependent demand items are those items whose demand is determined by other items. Basically, determined by the relationship of the quantity needed with the end product and computed the quantities that need to be ordered and timing considerations. The number of dependent demand items are computed based on the bill of materials, the projected usage includes the planned production of all other products which require the item being planned. This is a purely computational process where judgment or forecasting is not needed. Dependent demand items are inventory whose demand can be computed from the quantities of the end item that needs them.

2.4.2 Inventory Costs

The inventory costs are a number of costs and expenses of a company. There are three main costs of operating inventory system which are ordering, holding and shortage costs.

2.4.2.1 Holding costs

Holding costs or carrying costs are the costs of holding one unit of an item in a period of time. These costs are varying with the level of inventory. They are consisted of capital cost, storage costs (building-own, land or rented). Holding costs are those costs that increase with the size of the inventory and are calculated, in baht per unit and per unit time, and by the product of the holding cost fraction and the unit costs. It is the cost of carrying items in inventory that comes from the holding cost rate multiply by unit cost.

Jacobs and Chase (2014) explained that Holding costs include the costs for storage facilities, handling, insurance, pilferage, breakage, obsolescence, depreciation, taxes, and the opportunity cost of capital. Obviously, high holding costs tend to favor low inventory level and frequent replenishment.

The holding cost can be measured from:

1. Capital cost: the money that invested in inventory and not accessible to use in other operations. This cost type focuses on the cost of capital tied up in inventory and the resulting lost opportunity from investing the capital. The capital cost is often the largest component of inventory holding costs.

2. Storage costs: this inventory belongs to the factory, not rented and leased so the storage cost depends on depreciation, property taxes, insurances, or utilities.

2.4.2.1 Ordering costs

Ordering cost is the processing costs that include all fixed costs (components of costs that do not vary with size of the order) this cost is always constant. It occurs from preparing to purchase order or production order until receiving of the items to storage. Ordering cost are the costs that increase with the number of orders placed and contain with these components of ordering costs all of the following:

1. Administration cost: is the cost of preparation of purchase requisition, preparation of purchase order, documentation formalities, email, telephone and telegraph.
2. Transportation cost: involved in transferring products to different places, which is passed on to consumers, often incurred regardless of the size of the orders.
3. Receiving cost: acquired the administrative work on receiving the order, the receiver will have to prepare the goods receive note, update the inventory records and make the essential check of the purchase order at the time of receipt.

2.4.2.3 Stockout costs

When a product is not enough to meet demand, the cost associated with not having product available will be occurred. Stockout might result in dissatisfied customers and can also include lost in sales. The costs can include the opportunity

cost of not making sales, loss of customers, incremental variable costs of processing and making the extra shipment, lateness charge, thus the loss of future profits and revenues from for the supplier. Stockout costs can be difficult to justify and identify the exact costs because of the uncertainty of future consequences.

2.4.2.4 Lead time

Lead time is the time between ordering goods or services and receiving them. The target inventory increases when the lead time increases. The longer the lead time is, the larger the inventory level is required.

2.4.2.5 Service level

The service level is the desired probability that a level of safety stock will not lead to a stock out.

2.4.3 Supplies

Supplies are items that are not used directly in production of independent demand items.

2.4.4 Components of Inventory Decision

Supply chain management have to make effective decisions to create most efficient and responsive process. Some of the important components that need to be considered are:

1. Cycle inventory is held to get benefits of economies of scales in the supply chain considering either production or purchases in lot size that are larger than those demanded by customers. Increase in lot also results in increase of holding costs.

2. Safety inventory is inventory carried for the purpose of satisfy demand that exceeds the amount of the forecast to fulfill the demand in uncertainty.

3. Seasonal inventory is built up to fulfill the expected variability in demand which carried for the time of a greater demand which is built up in the time of low demand. Determination of how much seasonal inventory to build is the cost of holding the additional seasonal inventory versus the cost of having a more flexible production rate.

4. Level of product availability

1.5 ABC Classification

Swink (2011) presented about how to manage an inventory effectively so that items can be classified by annual sales volume or annual item profits. A small percentage of items (frequently 10 to 20 percent) which accounts for a large percentage of sales (often 70-80 percent) may be classified as A items; moderate volume items as B items; and the low volume items as C items. Frequently, the B items are about 30 percent of the total and Cs are about 50 percent of the total number of items. As a result, the general procedure for a quantitative is:

1. Determine annual usage/sales for each item (units and/or value).
2. Determine the percentage of the total usage/sales by item.
3. Rank the items from highest to lowest percentage.

4. Classify the items into ABC categories.

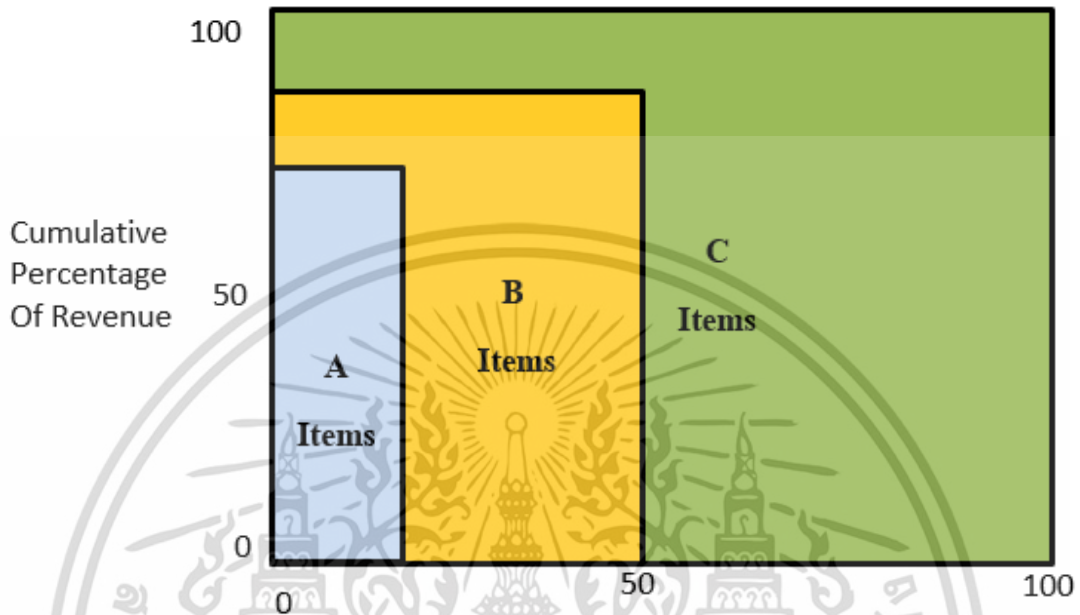


Figure 2.3 Cumulative Percentage of Items

Jay and Barry (2005) explained that ABC analysis is an inventory application of the Pareto principle. The Pareto principle which the idea is to establish inventory policies that focus resources on the few critical inventory parts and not the many trivial ones. To determine annual dollar volume for ABC analysis, measure the annual demand of each inventory item times the cost per unit. Class A items are the annual dollar volume is high. Although such items may represent only about 15% of the total inventory items, they represent 70% to 80% of the total dollar usage. Class B items are those inventory items of medium annual dollar volume. These items may represent about 30% of inventory items and 15% to 25% of the total value. Those with low annual dollar volume are Class C, which may represent only 5% of the annual dollar volume but about 55% of the total inventory items.

Pareto analysis is used for decision making of inventory control thinking and can be applied to minimize effort and to obtain best results. The Pareto curve is often called the “80-20 Rule”, the shape of the Pareto curve arises from the range of volumes and values combined in a statistical distribution. The most effort should be put into managing items which are most important for achieving, high stock value items need to be closely and tightly controlled whereas minor items do not need to be treated as carefully. The 80 percent of the total stock value is made up from 20 percent of the total stock items as stated. The other 80 percent of stock items contributes only 20 percent to the total inventory value.

1. A Class

Type A, has to be controlled strictly using systems likewise market expertise and product knowledge to sustain stock at the lowest appropriate level.

2. B Class

Type B is lower value, the inventory system should be applied on it such as EOQ system.

3. C Class

Type C, is simply controlled by the basic system, the control must be reliable and not result in stockout or large excess stock. This type is inexpensive but can greatly simplify the problems of controlling large numbers of stock lines. In real situation, the stock could have the control limits to avoid large inventory and proper stock cover range which can be set by the ABC inventory classes.

Nathanun (2012) focused on statistical analysis of management modules for spare parts of water purifier’s electronics to improve spare parts inventory

management policy. He studied the statistical analysis of probability distribution to define the uncertain delivery by lead time and quantity. He explained the classification of inventory to three classes by annual dollar value, called “ABC analysis”. Class “A” refers to most important items, Class “B” refers to moderate important items, and Class “C” refers to least important items. The amount of items in Class “A” accounts for 52.42 percent of an entire inventory cost. The total inventory cost equal to 82.67 percent. In his study, the simple exponential method is selected as the forecasting method to implement to a new model of ordering policy as it provides lowest inventory cost. The data on cumulative delivery quantity to order quantity ratio is used to generate the distribution probability and random number generation. The result found that the combination between A variable of 0.3029 and B variable of 0.4000 gives the lowest inventory cost.

1.6 Economic Order Quantity (EOQ)

Lynwood A. Johnson et.al. (1974) explained that although it is almost too simplistic for any real use, the EOQ model provides a useful initial sight into the tradeoffs and needed to balance costs arguing for either high or low inventories. Moreover; extension and variations of the models are numerous.

Wagner (1969) described periodic review variations of EOQ model can account for time of varying demand. These dynamic lot sizing problems are of special interest for MRP (Material Requirement Planning) based production planning and can be solved by dynamic programming or heuristic techniques based on properties of the EOQ model.

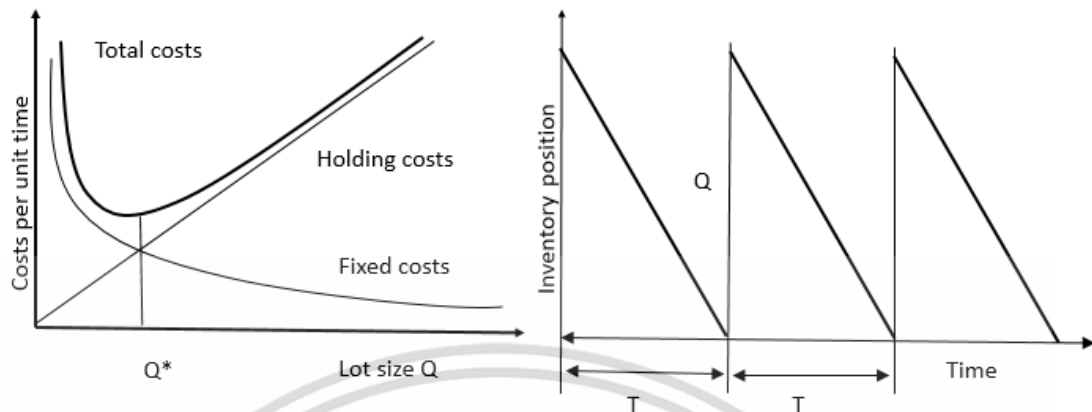


Figure 2.4 Total costs per unit time as a function of the lot size Q and time evolution of the inventory position for the EOQ model (Perret, 2007)

EOQ calculation:

1. Price per unit of product is constant.
2. Inventory holding cost is based on average inventory.
3. Ordering or setup costs are constant.
4. All demands for the product will be satisfied. (No backorders are allowed.)

$$\text{Annual carrying cost} = \frac{Q}{2} H \quad (2.1)$$

Where

Q = Order quantity in units

H = Holding (carrying) cost per unit per year

$$\text{Annual ordering cost} = \frac{D}{Q} S \quad (2.2)$$

Where

D = Demand, usually in units per year

S = Ordering cost per order

The optimal order quantity, can be obtained using Q^* . The result is the formula below.

$$Q^* = \sqrt{\frac{2DS}{H}} \quad (2.3)$$

The total annual cost (TC) associated with carrying and ordering inventory when Q units are ordered each time and it can be expressed by below formula.

$$TC = \text{Total carrying cost} + \text{Total ordering cost}$$

Where

$$TC = \frac{DS}{Q} + \frac{QH}{2} \quad (2.4)$$

D = Demand

S = Ordering cost

H = Holding cost

1.7 Reorder Point

The reorder point method is applicable for any type of storekeeping articles. Reorder point normally expresses in terms of when-to-order when the inventory level fall to this point and the inventory level at which an order should be placed.

The four consideration of the reorder point quantity:

1. Demand is variable
2. The lead time and standard deviation of demand
3. The average daily usage during the lead time
4. The degree of stockout risk is acceptable to management.

If demand and lead time are constant, the order point is:

$$ROP = \text{Expected demand during lead time} + z\sigma_{dLT}$$

Where

z = Number of standard deviations

σ_{dLT} = The standard deviation of lead time demand

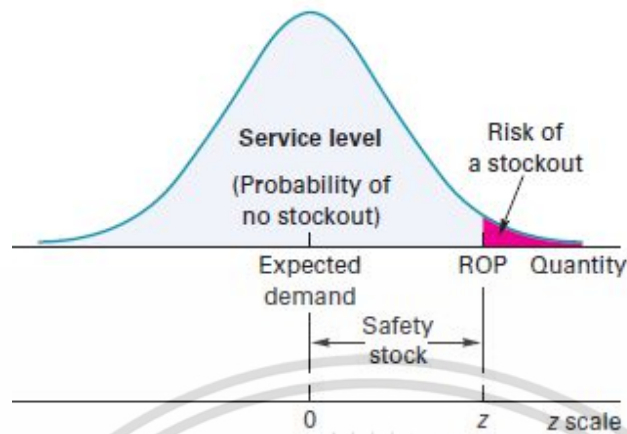


Figure 2.5 The ROP based on a normal distribution of lead time demand (Stevenson, 2012)

1.8 Safety Stock

Safety stock is the inventory to cover for the variability in demand and lead time such as supplier delivery delay. The level of safety stock is controllable in the sense that this investment is directly related to the desired level of customer service. Safety stock determinations are not intended to eliminate all stockouts but design for a higher service level which would result in fewer stockouts.

Edward and David (1998) described that safety stock are not needed when the future rate of demand and the length of time it takes to get a complete delivery of an order are known with certainty.

Chopra and Meind (2007) explained that the safety stock, which is necessary to ensure a required stock availability, is certain assumption calculated by probability theory.

Assuming that both demand and lead time are normal distributed around the mean, the formulas can be used to calculate safety stocks.

There are some factors that taken into an account when setting the amount of safety stock:

1. The average demand rate and average lead time
2. Demand and lead time variability
3. The desired service level

Safety stock calculation:

$$\text{Safety stock} = z\sigma_{dLT} \quad (2.5)$$

Where

d = Daily or weekly demand

$z\sigma_{dLT}$ = Standard deviation of lead time in days or weeks

Often times, customers do not provide information of their demands far enough in advance. If so, a safety stock is there to cover our inability to predict demand and to minimize the possibility of a stockout.

1.9 Min/Max inventory planning

A Min/Max inventory planning is a method to manage goods or materials in which the business sets a minimum limitation and maximum level of inventory to hold. The “Min” value represents a stock level that triggers a reorder and the “Max” value represents a new targeted stock level following the reorder.

1. Sum of the stock on hand plus the stock on order for every single SKU

2. When total stock reaches the Min value, a reorder is triggered.
3. The reorder quantity targets the Max value for the new total stock level

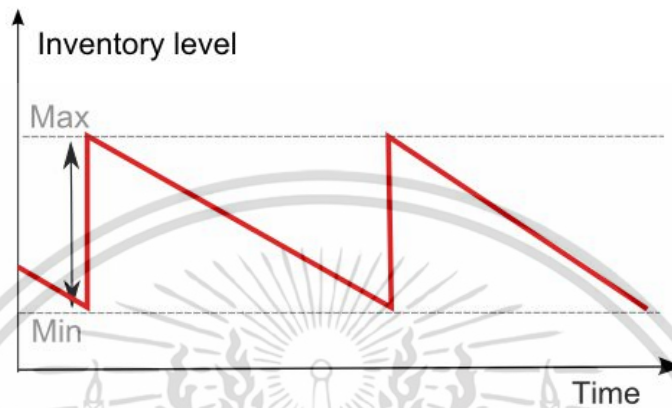


Figure 2.6 The Min/Max method of inventory replenishment (Heizer and Render, 2006)

1.10 The (r, Q) Inventory Policy

The (r, Q) inventory policy is also called *continuous review*. When the level of inventory declines to some determined reorder point, r, an order is placed for a lot size, Q. The order arrived to replenish the inventory after a lead time, LT. The values of r, Q are the decision variables to determine. The lead time is assumed to be known and constant. The main uncertainty is customer demand and customer demand is random and stationary. The inventory operating under (r, Q) policy is shown in figure 2.7.

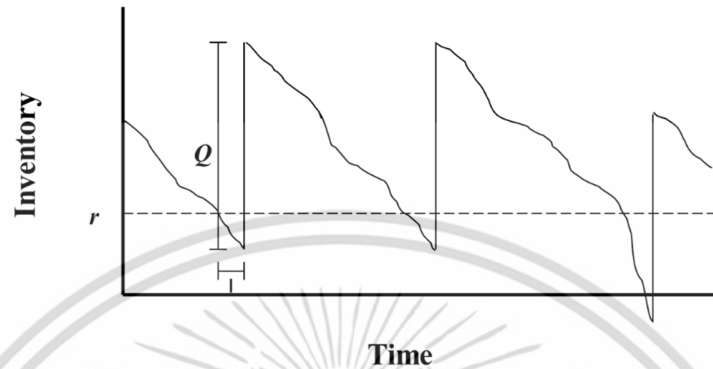


Figure 2.7 Inventory level under (r, Q) policy

The detail for proving the optimality and algorithm for (r, Q) policy is provided in Muckstadt and Sapro (2010). However, finding value of r, Q is briefly described here.

The expected total cost per unit time is $C(Q) = \text{Holding cost} + \text{Fixed cost} + \text{Shortage cost}$

$$C(Q) = H \left(\frac{Q}{2} + r - dLT \right) + S \frac{d}{Q} + p \frac{dn(r)}{Q} \quad (2.6)$$

Q^* and r^* can be determined by using following formula.

$$Q = \sqrt{\frac{2d[S + pn(r_i)]}{H}}, \quad F(r_i) = 1 + \frac{QH}{pd} \quad (2.7)$$

Where d is an expected demand per unit

p is stockout cost per unit

$n(r_i)$ is an expected shortage cost per cycle $n(r_i) = \sigma L(z)$

$L(z)$ is a standard loss function

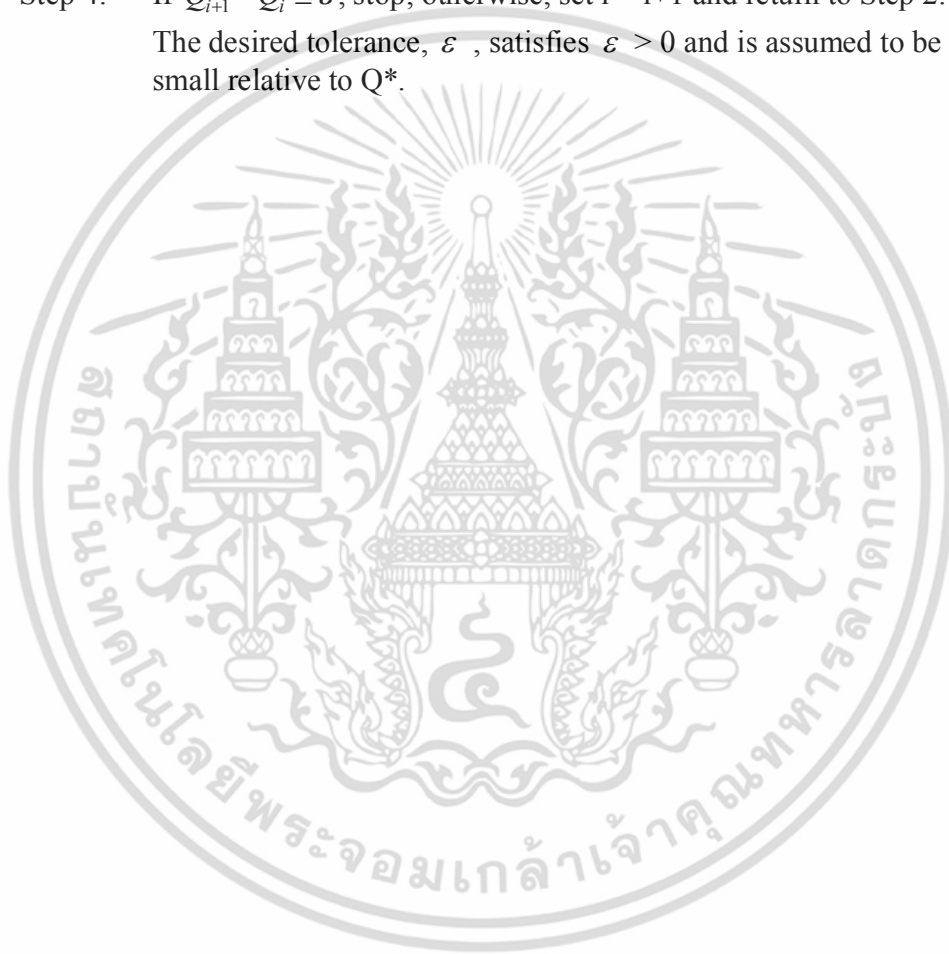
The following procedure can be employed to solve iteratively for Q^* and r^* value. **Algorithm for finding Q and r**

Step 1. $Q_0 = Q_{EOQ}$, $i = 1$

Step 2. Find r_i that satisfies $F(r_i) = 1 + \frac{QH}{pd}$

Step 3. Using r_i to compute for $Q_{i+1} = \sqrt{\frac{2d[S + pn(r_i)]}{H}}$

Step 4. If $Q_{i+1} - Q_i \leq \varepsilon$, stop; otherwise, set $i = i+1$ and return to Step 2.
The desired tolerance, ε , satisfies $\varepsilon > 0$ and is assumed to be small relative to Q^* .



CHAPTER 3

RESEARCH METHODOLOGY

1.1 Introduction

The Avery Dennison was originally established in Los Angeles, California, in 1935, a global leader in labeling and packaging materials and solution with the operations in more than 50 countries and has 25,000 employees worldwide. Rayong branch is the pressure-sensitive materials plant at the Eastern Seaboard Industrial Estate, which produces premier quality labeling, stock papers, films in roll for using in a variety of industries such as commercials, consumer applications products like self-stick postage stamps, industrial labels, retail tags, labeling systems, automotive dry-paint film laminates and medical-grade tapes. The distribution center is in Bangna which also imports finished goods from Avery Dennison affiliate plants.

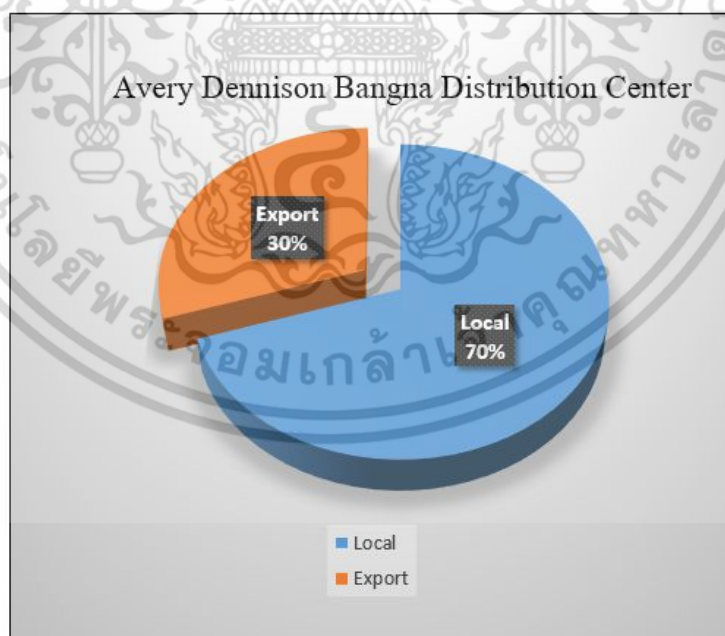


Figure 3.1 A percentage of the types of business

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 27 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

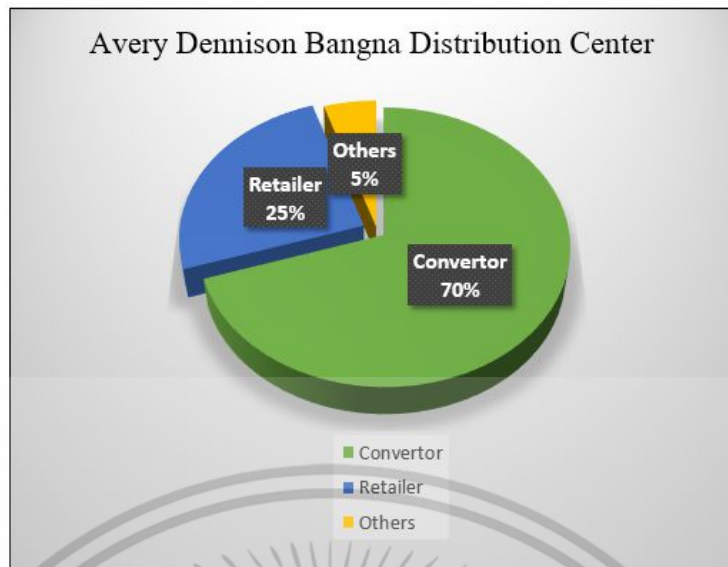


Figure 3.2 The percentage of local customers

Bangna Distribution Center provides label slitting in roll and supporting customer's order with the output of 40,000 square meters per day. The core Services are "Same day" (offering same day delivery of orders placed) and "EXACT" service (customers can order in precise roll width and length to match their required slit patterns – eliminating end wasted roll remainders and off cuts). The normal range of cutting output is 370,000 square meters to 400,000 square meter per day. Products are distributed to customers around Bangkok and Metropolitan area. The import shipments from Malaysia are more than 903,250 square meters per month and local production from Rayong plant is 274,500 square meters per week which create the complexity wider impact toward warehouse space. Warehouse management of the first goods purchased are assumed to be the first goods sold (FIFO). However, the inventory ties up capital, costs interest and it is also risky. The management often require inventory reduction and high turnover rates without considering the effect on the total costs and availability. On the other hand, stock often exceeds the necessary level. The company pays taxes on the inventory, and opportunity costs occur from the improper use of the funds that were

spent on the inventory which add cost to the carrying cost that now have an impact on company's operating income.

1.2 The system before improvement and its problems

The current process has been shown as on figure 3.3. The current ordering process of the company starts with sales department processed orders (done by customer service officer). The information of sales orders will be verified and extracted each SKU from database then each SKU is traced down into suppliers. The required SKU will be sent to the purchasing department to purchase each SKU according to their supply source. The logistics department uses the workers to count the amount of materials before issuing the purchase order and estimate the time when they should order from the rest of materials in stock. Every SKU is required to have stock of their own and is built up to look for the opportunity to be sold. Some items are at the warehouse for a long period of time without being used, and are considered excess inventory. After checking KPI of inventory management, company found the increase of excess materials in critical parts and exceed amount for most item at the end of the year. In this situation, the operators do not have the proper method to manage and control the inventory. Therefore, this study is aim to suggest the solutions so the company do not have to keep a large number of stocks.

For existing operation procedures, there is no guidelines for employees who perform the related tasks to control when and how much they should order for selling and keeping at appropriate stock level. Although the Min/Max is method is applied for all items, it is clearly not a good solution to control inventory cost and maintain the service level.

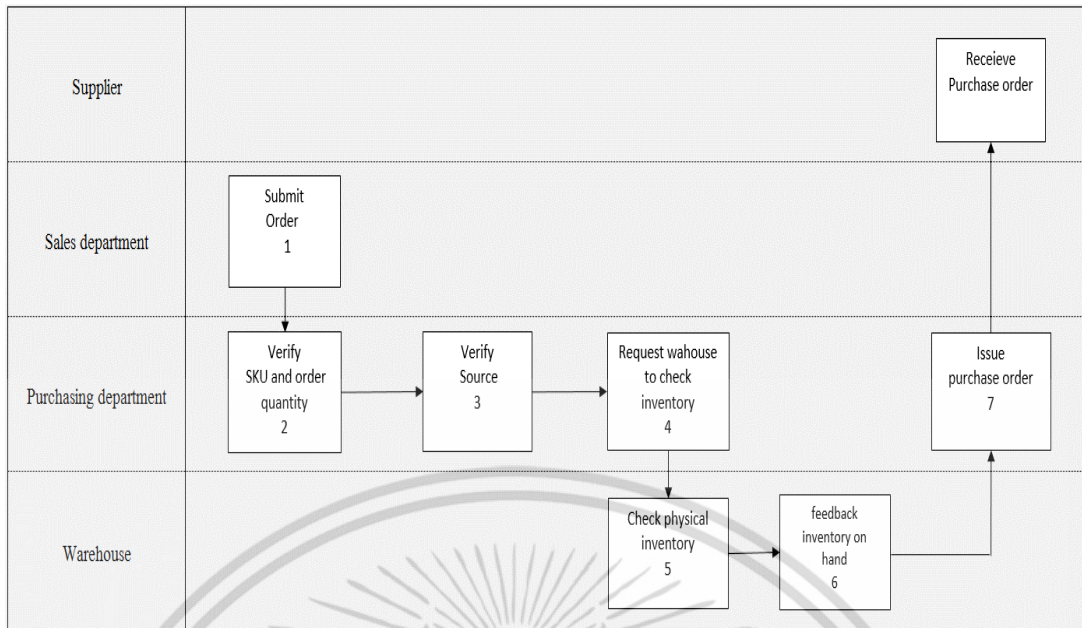


Figure 3.3 The current process

3.2.1 Materials

Material can divided into two groups of finished goods. Total 61 stock keeping units.

1. Stock keeping unit from Thailand 36 items
2. Stock keeping unit from Malaysia 25 items

The stocks manufactured in Thailand are pulled from the Rayong plant to replenish at Bangna Distribution Center in two containers every five days. The goods are carried in semi-trailer of 40-Foot height cube container with the carrying capacity of 100,000 square meters. The stocks from Malaysia are shipped in semi-trailer of 40-Foot height cube container truck with the carrying capacity of 137,250 square meters, which ten containers are shipped in every 21 days.

Table 3.1 Table of list of SKU 61 items

No.	Item	Type	Source
1	BW0146	Film	Malaysia
2	AW0331	Paper	Thailand
3	SY7022	Paper	Thailand
4	BW0174	Film	Malaysia
5	BW0227	Film	Malaysia
6	AW0271	Paper	Malaysia
7	SW7331	Paper	Malaysia
8	NW0035	Paper	Malaysia
9	AW0153	Paper	Malaysia
10	MW0066	Paper	Malaysia
11	BW0147	Film	Malaysia
12	BW0062	Film	Malaysia
13	NW0039	Paper	Malaysia
14	BW0183	Film	Malaysia
15	BW0243	Film	Thailand
16	AW0332	Paper	Thailand
17	AW0343N	Paper	Malaysia
18	NW0033	Paper	Malaysia
19	BW0062N	Film	Thailand
20	AW0326	Paper	Malaysia
21	BW0153	Film	Thailand
22	AW0344	Paper	Malaysia
23	AW0289	Paper	Thailand
24	SY7008	Film	Thailand
25	MZ0104	Film	Thailand
26	BW0064	Film	Thailand

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Table 3.1 Table of list of SKU 61 items (continued)

No.	Item	Type	Source
27	BW0184	Film	Malaysia
28	BW0112N	Film	Malaysia
29	BW9320	Film	Thailand
30	BW0226	Film	Thailand
31	BW0060	Film	Thailand
32	BW0237	Film	Malaysia
33	MZ0102	Film	Thailand
34	BW0230	Film	Thailand
35	SW7304	Paper	Thailand
36	MW0035N	Paper	Malaysia
37	BW0151	Film	Thailand
38	SY7054	Film	Malaysia
39	AW0333	Paper	Thailand
40	MZ0152	Film	Thailand
41	SW7045	Paper	Thailand
42	MZ0111N	Film	Thailand
43	SY7021	Paper	Thailand
44	BW0223	Film	Thailand
45	MZ0054	Film	Thailand
46	BW0233	Film	Thailand
47	SY7025N	Film	Malaysia
48	AW0362.1200	Paper	Thailand
49	MW0029N	Paper	Malaysia
50	AW0361.1200	Paper	Thailand
51	AW0321	Paper	Malaysia
52	AW0252	Paper	Thailand
53	BW0304	Film	Thailand

Table 3.1 Table of list of SKU 61 items (continued)

54	BW0148	Film	Thailand
55	MW0057P	Paper	Thailand
56	AW0253	Paper	Thailand
57	AW0312	Paper	Malaysia
58	BW0150	Film	Thailand
59	MW0052P	Paper	Thailand
60	AW0363.1200	Paper	Thailand
61	MW1616P	Paper	Thailand

1.3 Research Methodology

The methodology of this study consists of three phases, starting with the preliminary investigation, research and analysis, and future statement recommendation.

The selected research strategy is a case study. The objective is to analyze the cause of an excess inventory and to provide solution to improve and increase inventory management efficiency then compare the operation result the before and after.

3.3.1 The preliminary investigation

The historical data is gathered for twelve months from the company operation system, finished goods, and work in process are covered in this study. Products focused are film and paper products from Thailand and Malaysia plants. The data includes interviewing related parties on the issue related to the problems of existing work flow.

The author uses the interview in order to receive the information of existing business process. In term of sales processing, purchase processing and inventory management. The result came out with following flow charts which can explain the

3.3.2 Research and Analysis

The collected inventory data is reviewed in order to find out the causes for overstocking by use of a fishbone diagram, also known as cause-and-effect diagram. Then analyze the relation between the causes. The improvement measures will be proposed to increase efficiency and effectiveness of the company.

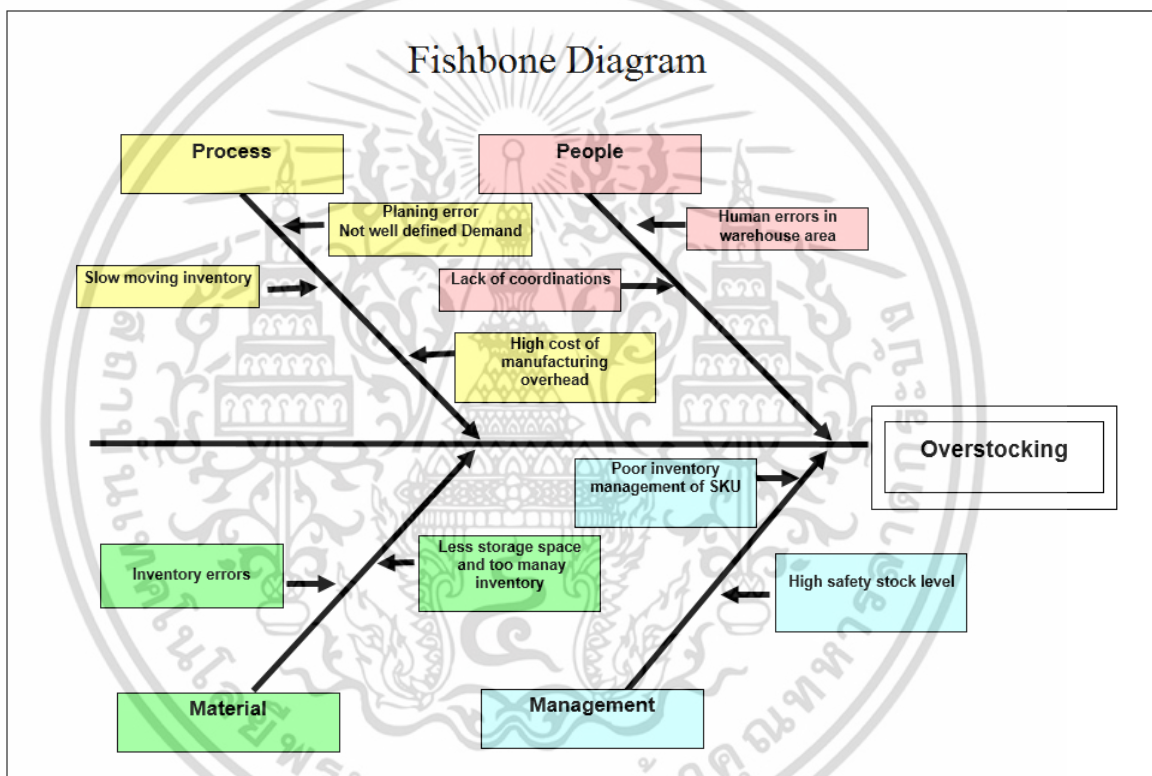


Figure 3.4 Fishbone diagram (cause-and-effect diagram)

1. Planning error: Do not know customers demand.

Measure: Set product level and determine unusual demand.

Proposal: Review the products with unusual demand corresponding with the history of purchase order and sales. Set the level of the product that makes its valuable to profit margin.

2. Slow moving inventory

Measure: Use discount sales.

Proposal: Analyze sales analytics data to see what impact those marketing changes have. Make a list of SKU which have not been sold in the past six months by using computer report and send the detailed report of excess stock to sales department to offer the price to customers.

3. High cost of manufacturing overhead

Measure: Overhead calculation

Proposal: Set up a standard overhead rate that can continue to use for multiple reporting period, based on long term expectation of how much overhead will be incurred and how many units will be purchased.

4. Human errors in the warehouse area

Measure: Review the system and operation control

Proposal: Implement the documentation control and risk management. Evaluate the individual performance, provide relevant training to make sure they understand how company works and what kind of products the company is selling.

5. Lack of coordination

Measure: Keep all parts of the organization at the same page

Proposal: Provide training to make the whole team work in coordination. The management team must pay special attention to issues related to coordination.

6. Inventory errors

Measure: Focus on cycle counts and make inventory numbers up to date.

Proposal: Make signs and labels to help warehouse officer find the inventory fast and easy. Then, ensure the products shipped out match the orders place and update the inventory numbers across all the systems.

7. Less storage space and too many inventory

Measure: Minimize on hand inventory by having real-time planning information for reordering the right stock and improving sales.

Proposal: Improve inventory management. Manage information on demand at all levels of supply chain which must be maintained in real-time and have only fast and medium moving products stored in the warehouse to clear away storage space.

8. Poor inventory management of SKU

Measure: Set up target SKU level.

Proposal: Apply ABC analysis method to divide inventory into categories based on cost per unit and quantity held in stock to prioritize control of high-priority inventory over inventory that has a lower impact to company bottom line.

9. High safety stock level

Measure: Calculate safety stock of each SKU and apply reorder point and ensure that unnecessary replenishment is avoid.

Proposal: Analyze the annual demand and order lead time and apply reorder point against variability in demand and lead time.

CHAPTER 4

ANALYSIS AND RESULTS

1.1 ABC Analysis and Classification

The company must determine the importance and the Thai Baht value of each individual inventory item. The ABC classification helps a company identify a small percentage of its items that account for a large percentage of the Thai Baht value of annual sales. These items are called Class A items. The company should have inventory investment in Class A, Class B items and focus on developing effective inventory control policies for these items which will create significantly savings.

Basically, the items are applied to classify the A, B and C classes. The step are as follows: Process of prioritization using ABC Analysis

1. Collect inventory data, details of annual demand, annual usage and unit price of each type of inventory.
2. Calculate total cost and unit price of each inventory items. Based on the available data, the usage quantity and unit price of 61 items in 2015 collected from the selected case study are applied to classify the A, B and C classes.
3. Compute the total cost of inventory items by multiply the usage quantity per year by the unit price.
4. Sort inventory in decreasing order of impact.
5. Calculate the accumulative impact of the list of inventory items by dividing item annual cost by total inventory annual usage.
6. Divide inventory into classes.

7. Analyze classed and make appropriate decisions

Table 4.1 Group by Thai baht annual usage

THB - Usage				
Category	No. of Item	% of Item	Baht usage	% of Usage
A	17	27.87	748,073,786	75.62
B	16	26.23	182,352,574	18.94
C	28	45.90	53,769,447	5.44
Total	61	100.00	989,195,806	100

Table 4.2 Number of items and percentage of items by sources

THB - Usage Category	No. of Item		% of Item	
	Thailand	Malaysia	Thailand	Malaysia
A	13	4	52	11.11
B	6	10	24	27.78
C	6	22	24	61.11
Total	25	36	100	100

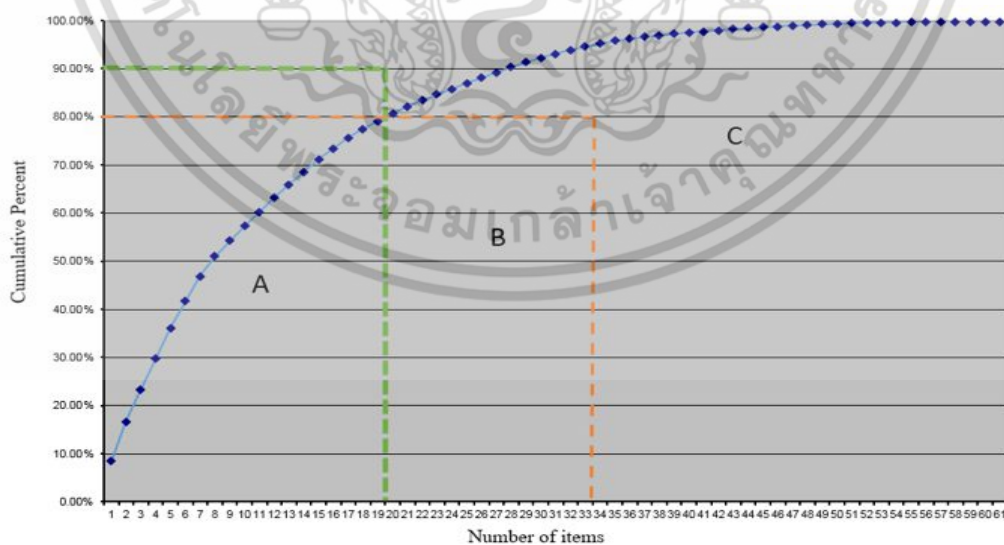


Figure 4.1 ABC Classification of inventory in year 2015

1.2 Implement the inventory system

Table 4.3 The result of ABC Analysis and Classification

No.	Item	Source	Unit price (m ² /THB)	Demand (m ² /year)	Convert into rolls	Usage (THB/year)	Total usage (%/year)	Cumulative (%)	Classification
1	BW0146	MALAYSIA	13.84	6,016,821	658	83,272,796	8.42%	8.42%	A
2	AW0331	THAILAND	7.46	10,976,190	1,200	81,866,353	8.28%	16.69%	A
3	SY7022	THAILAND	14.07	4,642,306	507	65,323,603	6.60%	23.30%	A
4	BW0174	MALAYSIA	12.87	4,992,611	546	64,254,906	6.50%	29.79%	A
5	BW0227	MALAYSIA	15.27	4,093,797	447	62,512,280	6.32%	36.11%	A
6	AW0271	MALAYSIA	9.80	5,609,600	613	54,950,186	5.56%	41.67%	A
7	SW7331	MALAYSIA	12.42	4,155,648	454	51,613,143	5.22%	46.89%	A
8	NW0035	MALAYSIA	12.96	3,174,179	347	41,137,357	4.16%	51.04%	A
9	AW0153	MALAYSIA	11.98	2,606,379	285	31,224,423	3.16%	54.20%	A
10	MW0066	MALAYSIA	10.35	2,921,371	319	30,236,189	3.06%	57.26%	A
11	BW0147	MALAYSIA	13.93	2,140,963	234	29,823,612	3.01%	60.27%	A
12	BW0062	MALAYSIA	12.92	2,246,170	245	29,020,520	2.93%	63.21%	A

Table 4.3 The result of ABC Analysis and Classification (continued)

No.	Item	Source	Unit price (m ² /THB)	Demand (m ² /year)	Convert into rolls	Usage (THB/year)	Total usage (%/year)	Cumulative (%)	Classification
13	NW0039	MALAYSIA	12.64	2,133,612	233	26,968,861	2.73%	65.93%	A
14	BW0183	MALAYSIA	15.42	1,687,650	184	26,023,566	2.63%	68.56%	A
15	BW0243	THAILAND	11.82	2,152,993	235	25,442,715	2.57%	71.14%	A
16	AW0332	THAILAND	7.69	2,914,007	318	22,395,514	2.26%	73.40%	A
17	AW0343N	MALAYSIA	9.26	2,376,648	260	22,007,762	2.22%	75.62%	A
18	NW0033	MALAYSIA	13.97	1,310,882	143	18,313,023	1.85%	77.48%	B
19	BW0062N	THAILAND	13.07	1,232,985	135	16,115,113	1.63%	79.10%	B
20	AW0326	MALAYSIA	9.88	1,601,936	175	15,827,125	1.60%	80.70%	B
21	BW0153	THAILAND	14.72	921,844	101	13,568,264	1.37%	82.08%	B
22	AW0344	MALAYSIA	10.18	1,289,163	141	13,123,680	1.33%	83.40%	B
23	AW0289	THAILAND	6.82	1,756,487	192	11,980,892	1.21%	84.61%	B
24	SY7008	THAILAND	13.52	865,265	95	11,702,391	1.18%	85.80%	B
25	MZ0104	THAILAND	29.02	394,855	43	11,457,581	1.16%	86.96%	B

Table 4.3 The result of ABC Analysis and Classification (continued)

No.	Item	Source	Unit price (m ² /THB)	Demand (m ² /year)	Convert into rolls	Usage (THB/year)	Total usage (%/year)	Cumulative (%)	Classification
26	BW0064	THAILAND	12.76	880,612	96	11,232,971	1.14%	88.09%	B
27	BW0184	MALAYSIA	16.48	658,248	72	10,847,924	1.10%	89.19%	B
28	BW0112N	MALAYSIA	7.93	1,367,905	149	10,847,489	1.10%	90.28%	B
29	BW9320	THAILAND	24.58	405,745	44	9,972,651	1.01%	91.29%	B
30	BW0226	THAILAND	6.75	1,374,276	150	9,276,324	0.94%	92.23%	B
31	BW0060	THAILAND	11.34	751,502	82	8,523,284	0.86%	93.09%	B
32	BW0237	MALAYSIA	14.26	536,251	59	7,646,937	0.77%	93.87%	B
33	MZ0102	THAILAND	24.39	283,621	31	6,916,924	0.70%	94.56%	B
34	BW0230	THAILAND	13.61	470,026	51	6,395,677	0.65%	95.21%	C
35	SW7304	THAILAND	14.40	375,954	41	5,415,015	0.55%	95.76%	C
36	MW0035N	MALAYSIA	11.51	397,727	43	4,577,835	0.46%	96.22%	C
37	BW0151	THAILAND	13.05	266,631	29	3,480,057	0.35%	96.57%	C
38	SY7054	MALAYSIA	9.96	348,742	38	3,473,467	0.35%	96.92%	C

Table 4.3 The result of ABC Analysis and Classification (continued)

No.	Item	Source	Unit price (m ² /T HB)	Demand (m ² /year)	Convert into rolls	Usage (THB/year)	Total usage (%/year)	Cumulative (%)	Classification
39	AW0333	THAILAND	7.52	432,727	47	3,253,174	0.33%	97.25%	C
40	MZ0152	THAILAND	21.77	111,925	12	2,436,465	0.25%	97.50%	C
41	SW7045	THAILAND	12.90	182,496	20	2,354,604	0.24%	97.74%	C
42	MZ0111N	THAILAND	17.33	135,696	15	2,351,440	0.24%	97.97%	C
43	SY7021	THAILAND	12.96	176,416	19	2,286,739	0.23%	98.21%	C
44	BW0223	THAILAND	13.08	158,602	17	2,074,920	0.21%	98.42%	C
45	MZ0054	THAILAND	35.21	53,285	6	1,876,094	0.19%	98.61%	C
46	BW0233	THAILAND	14.78	114,693	13	1,694,924	0.17%	98.78%	C
47	SY7025N	MALAYSIA	7.83	211,240	23	1,654,011	0.17%	98.94%	C
48	AW0362.1200	THAILAND	8.07	174,912	19	1,411,632	0.14%	99.09%	C
49	MW0029N	MALAYSIA	11.51	120,423	13	1,386,072	0.14%	99.23%	C
50	AW0361.1200	THAILAND	10.10	119,736	13	1,209,566	0.12%	99.35%	C
51	AW0321	MALAYSIA	9.54	124,000	14	1,182,955	0.12%	99.47%	C
52	AW0252	THAILAND	14.72	69,304	8	1,020,052	0.10%	99.57%	C
53	BW0304	THAILAND	13.64	68,698	8	936,990	0.09%	99.67%	C

Table 4.3 The result of ABC Analysis and Classification (continued)

No.	Item	Source	Unit price (m ² /TH B)	Demand (m ² /year)	Convert into rolls	Usage (THB/year)	Total usage (%/year)	Cumulative (%)	Classificatio n
54	BW0148	THAILAND	15.63	57,497	6	898,508	0.09%	99.76%	C
55	MW0057P	THAILAND	14.18	52,706	6	747,630	0.08%	99.83%	C
56	AW0253	THAILAND	12.63	41,017	4	518,065	0.05%	99.89%	C
57	AW0312	MALAYSIA	13.33	32,536	4	433,709	0.04%	99.93%	C
58	BW0150	THAILAND	11.97	30,924	3	370,150	0.04%	99.97%	C
59	MW0052P	THAILAND	9.39	28,786	3	270,297	0.03%	99.99%	C
60	AW0363.1200	THAILAND	7.18	6,993	1	50,185	0.01%	100.00%	C
61	MW1616P	THAILAND	9.40	980	1	9,214	0.00%	100.00%	C
		Total				989,195,80	100		
						6			

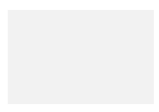
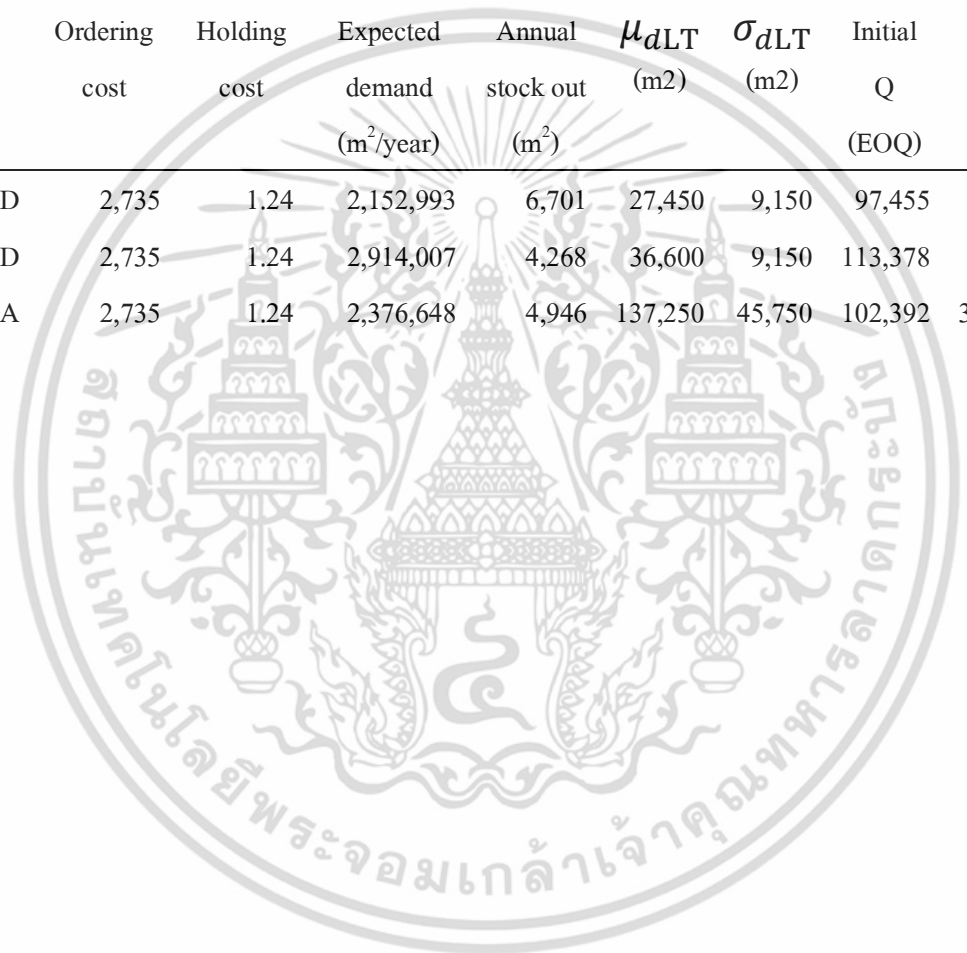
Remark: Data in 2015

Table 4.4 The (r, Q) calculation for class A

No.	Item	Source	Ordering cost	Holding cost	Expected demand (m ² /year)	Annual stock out (m ²)	μ_{dLT} (m ²)	σ_{dLT} (m ²)	Initial Q (EOQ)	r	Q	Convert into rolls
1	BW0146	MALAYSIA	2,735	1.24	6,016,821	7,560	347,700	73,200	162,917	671,441	178,802	20
2	AW0331	THAILAND	2,735	1.24	10,976,190	4,144	146,400	27,450	220,044	266,410	225,867	25
3	SY7022	THAILAND	2,735	1.24	4,642,306	7,874	64,050	9,150	143,103	104,500	145,015	16
4	BW0174	MALAYSIA	2,735	1.24	4,992,611	7,303	283,650	64,050	148,404	656,193	162,355	18
5	BW0227	MALAYSIA	2,735	1.24	4,093,797	8,455	228,750	54,900	134,384	470,695	146,287	16
6	AW0271	MALAYSIA	2,735	1.24	5,609,600	5,484	320,250	64,050	157,307	598,662	171,362	19
7	SW7331	MALAYSIA	2,735	1.24	4,155,648	6,529	237,900	54,900	135,395	476,838	147,427	16
8	NW0035	MALAYSIA	2,735	1.24	3,174,179	7,003	183,000	82,350	118,331	539,126	137,009	15
9	AW0153	MALAYSIA	2,735	1.24	2,606,379	6,303	146,400	36,600	107,226	303,628	115,288	13
10	MW0066	MALAYSIA	2,735	1.24	2,921,371	5,556	164,700	36,600	113,521	321,397	121,591	13
11	BW0147	MALAYSIA	2,735	1.24	2,140,963	7,645	118,950	36,600	97,182	276,887	105,241	12
12	BW0062	MALAYSIA	2,735	1.24	2,246,170	7,134	128,100	36,600	99,541	285,685	107,608	12
13	NW0039	MALAYSIA	2,735	1.24	2,133,612	6,840	118,950	91,500	97,015	509,041	118,543	13
14	BW0183	MALAYSIA	2,735	1.24	1,687,650	7,529	100,650	45,750	86,283	296,372	95,591	10

Table 4.4 The (r, Q) calculation for class A (continued)

No.	Item	Source	Ordering cost	Holding cost	Expected demand (m ² /year)	Annual stock out (m ²)	μ_{dLT} (m2)	σ_{dLT} (m2)	Initial Q (EOQ)	r	Q	Convert into rolls
15	BW0243	THAILAND	2,735	1.24	2,152,993	6,701	27,450	9,150	97,455	66,794	99,418	11
16	AW0332	THAILAND	2,735	1.24	2,914,007	4,268	36,600	9,150	113,378	75,337	115,364	13
17	AW0343N	MALAYSIA	2,735	1.24	2,376,648	4,946	137,250	45,750	102,392	330,593	112,725	12



4.2.1 Economic order quantity model (EOQ) for Class B

Class B is applied to economic order quantity (EOQ) model to determine the order quantity that will minimize the sum of the annual inventory holding cost and the annual ordering cost. The inventory in this class is moderately important and can be monitored. This class is used to define the ordering size, reorder point by Economic order quantity (EOQ) that manage continuously the stock level. When the stock depleted in the reorder point, the purchase order will be placed at the constant quantity. The formula is shown as below.

Table 4.5 Find economic order quantity of item NW0033

No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost
18	NW0033	MALAYSI A	1,310,882	13.97	2,735	1.24

$$Q^* = \sqrt{\frac{2(1,310,882)2,735}{1.24}}$$

$$= 76,044 \text{ m}^2$$

The optimal order quantity is 8 rolls.

*One roll is 9,150 square meters.

Table 4.6 Find economic order quantity of item BW0062N

No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost
19	BW0062 N	THAILAN D	1,232,985	13.07	2,735	1.24

$$Q^* = \sqrt{\frac{2(1,232,985)2,735}{1.24}}$$

$$= 73,750 \text{ m}^2$$

The optimal order quantity is 8 rolls.

*One roll is 9,150 square meters.

Table 4.7 Find economic order quantity of item AW0326

No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost
20	AW0326	MALAYSI A	1,601,936	9.88	2,735	1.24

$$Q^* = \sqrt{\frac{2(1,601,963)2,735}{1.24}}$$

$$= 84,063 \text{ m}^2$$

The optimal order quantity is 9 rolls.

*One roll is 9,150 square meters.

Table 4.8 Find economic order quantity of item BW0153

No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost
21	BW0153	THAILAN D	921,844	14.72	2,735	1.24

$$Q^* = \sqrt{\frac{2(921,844)2,735}{1.24}}$$

$$= 63,769 \text{ m}^2$$

The optimal order quantity is 7 rolls.

*One roll is 9,150 square meters.

4.2.2 Safety stock

To prevent stockout from the uncertainty demand and to improve the customer service level. The standard deviation computation is applied to find out how much the deviation of demand is. The company aims to achieve 95% of service level. This percentage is also required to compute the safety stock.

Table 4.9 Find safety stock of item NW0033

No.	Item	Source	Lead time (days)	σ_{dLT} (m ²)	$Z_{\text{Service level 95\%}}$
18	NW0033	MALAYSIA	21	19,853	1.65

$$SS = 1.65(19,853)$$

$$SS = 32,758 \text{ m}^2$$

The safety stock is 4 rolls.

*One roll is 9,150 square meters.

Table 4.10 Find safety stock of item BW0062N

No.	Item	Source	Lead time (days)	σ_{dLT} (m ²)	$Z_{\text{Service level 95\%}}$
19	BW0062N	THAILAND	5	2,572	1.65

$$SS = 1.65(2,572)$$

$$SS = 4,243 \text{ m}^2$$

The safety stock is 1 roll.

*One roll is 9,150 square meters.

Table 4.11 Find safety stock of item AW0326

No.	Item	Source	Lead time (days)	σ_{dLT} (m ²)	$Z_{\text{Service level 95\%}}$
20	AW0326	MALAYSIA	21	17,140	1.65

$$SS = 1.65(17,140)$$

$$SS = 28,281 \text{ m}^2$$

The safety stock is 3 rolls.

*One roll is 9,150 square meters.

Table 4.12 Find safety stock of item BW0153

No.	Item	Source	Lead time (days)	σ_{dLT} (m ²)	Z _{Service level 95%}
21	BW0153	THAILAND	5	2,476	1.65

$$SS = 1.65(2,476)$$

$$SS = 4,085 \text{ m}^2$$

The safety stock is 1 roll.

*One roll is 9,150 square meters.

4.2.3 Reorder point

The reorder point is applied for both sources and corresponded to reach 95% service level. The lead time of items in Thailand is 5 days and from Malaysia is 21 days. Daily demand is normally distributed with mean and standard deviation.

Table 4.13 Find reorder point of item NW0033

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	Z _{Service level 95%}	$z\sigma_{dLT}$ (m ²)
18	NW0033	MALAYSIA	21	2,486	75,404	19,853	1.65	32,758

$$ROP = 75,404 + 32,758$$

$$ROP = 108,162 \text{ m}^2 \text{ or } 12 \text{ rolls}$$

An order for 8 rolls is placed whenever the number of rolls remains in inventory drop to 12 rolls.

Table 4.14 Find reorder point of item BW0062N

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	$Z_{Service}$ level 95%	$z\sigma_{dLT}$ (m ²)
19	BW0062N	THAILAND	5	557	16,903	2,572	1.65	4,243

$$ROP = 16,903 + 4,243$$

$$ROP = 21,146 \text{ m}^2 \text{ or } 2 \text{ rolls}$$

An order for 8 rolls is placed whenever the number of rolls remains in inventory drop to 2 rolls.

Table 4.15 Find reorder point of item AW0326

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	$Z_{Service}$ level 95%	$z\sigma_{dLT}$ (m ²)
20	AW0326	MALAYSIA	21	3,046	92,389	17,140	1.65	28,281

$$ROP = 92,389 + 28,281$$

$$ROP = 120,670 \text{ m}^2 \text{ or } 13 \text{ rolls}$$

Table 4.16 Find reorder point of item AW0153

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	$Z_{Service}$ level 95%	$z\sigma_{dLT}$ (m ²)
21	AW0153	THAILAND	5	417	12,646	2,476	1.65	4,085

$$ROP = 12,646 + 4,085$$

$$\text{ROP} = 16,731 \text{ m}^2 \text{ or } 2 \text{ rolls}$$

An order for 7 rolls is placed whenever the number of rolls remains in inventory drop to 2 rolls.

The details of items listed for each group and calculations, the step are shown in Appendix B.

4.2.4 The Min-Max Inventory model

Class C is applied the Min-Max inventory ordering because it consists of the least valuable items with less aggressive goals. And the investment is lower than class A and B. To plan on how the Class C items should be purchased, it should be every four weeks. Step in doing the Min-Max are:

1. Determine the monthly sales to see the maximum and the minimum of demand
2. Use the graph to show the trend of usage in each month
3. Identify the minimum and maximum amount
4. Set minimum and maximum order quantity that company should order so that inventory on hand will reach an agreed maximum level when receiving the order.
5. Set the limit of stock per items

Table 4.17 Sales History of BW0230 in 2015

Item BW0230	Quantity (m ²)
January	43,361
February	25,934
March	56,893
April	23,349
May	46,308
June	51,467
July	40,264
August	30,559
September	46,869
October	52,779
November	21,704
December	30,539

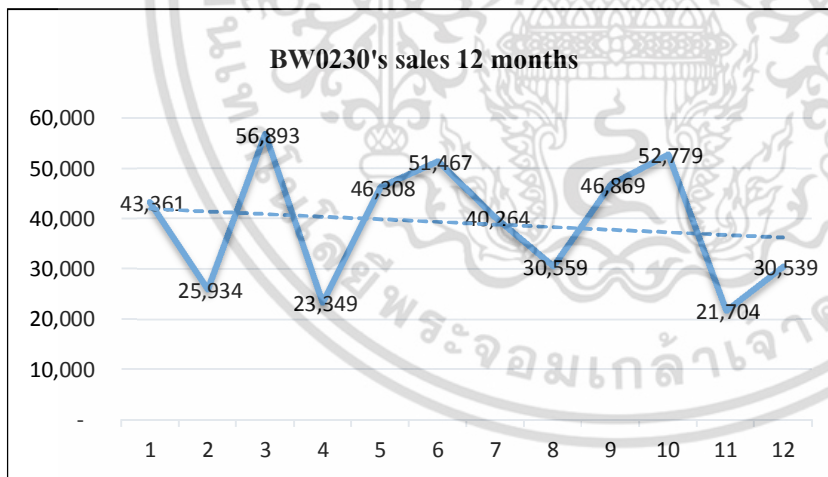


Figure 4.2 Usage of 12 months

BW0230 is classified as C class from ABC classification method.

$$\text{Min} = 21,704 \text{ m}^2$$

$$\text{Max} = 56,893 \text{ m}^2$$

$$\text{Average} = 39,169 \text{ m}^2$$

In this case, whenever the stock on hand goes below $39,169 \text{ m}^2$, it is time to place new order of $17,724 \text{ m}^2$ (2 rolls). This model can be further improved by reducing the max size.

1.3 Compare result before and after

To determine the current methods that the company is using and these guidelines of ABC analysis to classify and prioritize the items then apply (r, Q) model for class A. Apply EOQ methods, ROP for class B then Min-Max model for class C. These will help the company to see the difference between these two scenarios before and after by applying the total inventory cost formula to calculate the total. From the computation of all methods in each classes. The total inventory cost results in significant cost saving. Total inventory cost after applying the mathematical methods is 4,954,251 THB while the current methods is 6,385,275 THB.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This chapter provides conclusion and recommendation from the findings throughout this study. The key findings are summarized and the results are evaluated. The recommendations are provided to improve the inventory management of Avery Dennison Bangna Distribution Center. Finally, the future work is also discussed.

5.1 Conclusion

This research studied the improvement of an inventory control system of Avery Dennison Bangna Distribution Center. The objectives are to set the level of order quantity for each item as well as reorder points and safety stock while minimizing costs. To achieve these objectives, the inventory control calculation is based on a historical data in the year of 2015. The items are classified by using ABC analysis into three classes, A, B and C. Class A is the most important, Class B is moderate and Class C is the least important and then each group is applied to the inventory theory. The result is as described below.

1. Class A uses the method of ordering items by placing an order for a quantity of stock, called the lot size, at a point in time to minimize the average annual cost of operations and save the related ordering cost.

2. Class B are used fixed quantity model to find out the economic order quantity, safety stock and reorder point. Logistics department will order materials when material level falls to reorder point and order at a fixed quantity for each time. The result of each reorder point is shown in Appendix.

3. Class C is used Min/Max model to find out the target stock level, safety stock and order quantity. Logistics department will orders the materials when the stock is reaches its Min level and define the fixed quantity from the max level.

The total inventory cost of old method.

Class	Ordering cost (THB)	Holding cost (THB)	Total cost (THB)
A	557,940	3,350,116	3,908,056
B	525,120	807,631	1,332,751
C	918,960	225,508	1,144,468
Total	2,002,020	4,383,255	6,385,275

The total inventory cost of new method.

Class	Ordering cost (THB)	Holding cost (THB)	Total cost (THB)
A	1,226,891	1,429,406	2,656,297
B	632,540	632,540	1,265,079
C	714,702	318,173	1,032,875
Total	2,574,133	2,380,118	4,954,251

After applying the inventory guideline to improve inventory control, it can help company to save 1,431,024 THB or 22 percent of total inventory cost.

5.2 Recommendation for Future Study

The recommendations for the company are following;

1. A training course such as the material requirement planning (MRP) should be provided to the employees in order to gain knowledge, reduce the calculation time, and increase the performance in controlling the inventory.

2. Cooperation of Sales representatives and management team in making the decision and dispose the products that off-spec, non-saleable in order to have more warehouse space and working capital for inventory of the whole company.

The recommendations for the future study are following;

3. Advanced economic model formulation. The economic model formulation used in this study was quite simple. All costs were due to one-time capital investment. The benefits were only to reduce the inventory with an assumption of no other benefits such as labor saving, increasing system capacity and flexibility.

4. Non-Constant lead time has to be considered, analyzed throughout our developments and incorporate with Material Requirement Planning methodology. Because the true lead time of current capacity utilization only depends on the current workload and other factors. The lead time also may be considered as consequence of the production plan and the amount of inventory needed to satisfy customers.

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APPENDIX A



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Appendix A.1 Table of sales history of twelve months in 2015

No.	Item	Source	1	2	3	4	5	6	7	8	9	10	11	12
1	BW0146	MALAYSIA	385,796	438,931	662,059	318,504	576,232	605,185	519,064	424,673	529,376	606,749	375,804	574,448
2	AW0331	THAILAND	782,445	824,854	1,048,356	680,185	1,009,777	971,368	918,225	942,148	1,239,536	913,877	827,944	817,475
3	SY7022	THAILAND	389,482	348,585	458,225	309,504	397,208	403,422	353,899	327,769	521,374	340,186	347,827	444,825
4	BW0174	MALAYSIA	336,625	312,373	601,401	291,560	400,629	517,296	325,928	391,492	529,953	413,933	438,013	433,410
5	BW0227	MALAYSIA	316,494	304,432	496,232	261,379	354,622	339,363	313,029	335,444	441,102	269,099	272,686	389,915
6	AW0271	MALAYSIA	436,075	377,880	526,264	300,391	459,770	554,169	414,210	465,228	645,279	465,977	447,116	517,240
7	SW7331	MALAYSIA	440,820	296,760	435,040	171,264	358,717	418,525	289,565	260,593	347,648	289,123	432,717	414,874
8	NW0035	MALAYSIA	462,015	355,303	485,167	236,343	276,739	275,802	176,847	157,601	162,674	175,987	165,322	244,378
9	AW0153	MALAYSIA	212,889	223,390	352,798	153,783	234,815	255,979	242,976	197,735	184,641	181,098	196,823	169,453
10	MW0066	MALAYSIA	245,377	223,774	307,812	201,525	235,242	330,023	173,985	204,747	322,016	197,569	248,059	231,243
11	BW0147	MALAYSIA	110,201	159,589	257,917	173,232	210,635	236,135	120,464	146,354	229,844	157,420	151,364	187,807
12	BW0062	MALAYSIA	193,458	176,757	279,480	152,126	178,265	288,973	113,747	150,930	189,744	171,183	150,050	201,459
13	NW0039	MALAYSIA	488	775	90,843	82,419	98,238	243,166	177,598	261,341	342,758	175,505	257,427	403,053
14	BW0183	MALAYSIA	159,853	79,265	318,086	154,169	81,183	179,340	108,590	82,980	154,357	108,628	184,330	76,868
15	BW0243	THAILAND	162,539	179,720	192,656	122,973	193,289	181,803	162,031	140,681	252,002	143,315	225,548	196,434
16	AW0332	THAILAND	271,712	295,756	362,130	154,336	237,767	331,791	148,451	229,603	277,465	187,432	238,741	178,823
17	AW0343N	MALAYSIA	163,082	146,852	222,497	153,322	176,069	367,434	179,598	175,357	240,620	190,019	170,009	191,789
18	NW0033	MALAYSIA	143,283	102,514	142,146	43,178	109,432	129,782	123,207	71,328	127,389	94,992	115,692	107,938
19	BW0062N	THAILAND	85,156	96,082	116,854	88,921	76,794	113,864	96,626	98,922	116,482	102,324	109,057	131,902
20	AW0326	MALAYSIA	138,690	161,480	170,078	104,120	139,908	158,234	140,464	125,026	132,648	97,349	126,211	107,728
21	BW0153	THAILAND	76,271	74,704	81,321	57,295	69,576	73,269	56,317	76,155	101,129	65,276	99,657	90,873
22	AW0344	MALAYSIA	108,624	109,995	106,855	120,708	86,679	114,018	96,979	101,492	92,813	93,695	112,581	144,724

Appendix A.1 Table of sales history of twelve months in 2015(continued)

No.	Item	Source	1	2	3	4	5	6	7	8	9	10	11	12
23	AW0289	THAILAND	186,167	156,434	172,120	88,697	151,456	187,613	124,270	136,492	180,347	117,151	140,311	115,427
24	SY7008	THAILAND	34,337	31,254	106,007	64,571	50,207	65,367	40,596	75,922	120,474	123,470	105,660	47,401
25	MZ0104	THAILAND	38,848	39,511	45,419	18,003	30,639	30,867	26,433	31,127	43,414	30,663	36,146	23,785
26	BW0064	THAILAND	50,173	75,391	118,985	53,359	92,192	109,055	28,101	79,842	88,539	42,889	73,144	68,942
27	BW0184	MALAYSIA	45,821	41,220	90,817	41,036	44,159	102,994	36,773	43,219	38,393	68,306	46,073	59,436
28	BW0112N	MALAYSIA	119,560	97,088	150,237	122,928	118,306	120,662	71,331	99,874	116,134	79,416	75,175	197,195
29	BW9320	THAILAND	39,721	29,922	39,627	21,666	42,640	33,521	27,275	25,443	34,591	48,408	44,449	18,482
30	BW0226	THAILAND	77,444	88,940	195,540	76,410	130,391	113,317	77,938	112,273	151,881	96,549	125,825	127,770
31	BW0060	THAILAND	72,068	66,270	74,569	53,928	58,445	105,296	61,394	45,795	68,015	45,333	79,569	20,821
32	BW0237	MALAYSIA	43,648	40,130	28,774	72,011	64,563	46,485	40,255	39,009	61,702	33,325	32,749	33,598
33	MZ0102	THAILAND	27,282	18,757	21,516	21,468	22,383	29,246	19,985	18,277	29,021	19,615	17,519	38,552
34	BW0230	THAILAND	43,361	25,934	56,893	23,349	46,308	51,467	40,264	30,559	46,869	52,779	21,704	30,539
35	SW7304	THAILAND	64,030	2,000	66,355	4,475	66,719	67,227	10,590	72,324	8,890	5,240	1,543	6,563
36	MW0035N	MALAYSIA	94,861	128,784	110,874	13,845	3,454	11,034	3,739	9,608	5,160	4,956	5,122	6,289
37	BW0151	THAILAND	31,067	19,956	22,670	17,222	26,638	29,755	12,798	27,630	30,288	15,045	19,038	14,524
38	SY7054	MALAYSIA	39,418	35,620	54,049	22,993	27,260	24,729	19,118	20,537	27,895	32,798	20,642	23,683
39	AW0333	THAILAND	71,100	39,898	37,818	15,830	40,733	53,188	19,542	23,835	25,295	26,366	30,319	48,806
40	MZ0152	THAILAND	9,182	10,220	11,825	9,284	8,199	9,937	6,178	11,235	10,531	7,436	12,121	5,775
41	SW7045	THAILAND	18,994	24,914	19,009	11,005	14,321	9,560	15,281	2,914	14,677	22,580	9,064	20,177
42	MZ0111N	THAILAND	6,665	4,123	6,770	9,821	16,328	19,284	12,429	5,450	37,518	6,349	5,960	5,000
43	SY7021	THAILAND	18,396	24,837	24,690	16,482	16,150	19,127	17,362	21,820	12,553	1,500	1,000	2,500
44	BW0223	THAILAND	8,105	9,244	20,784	3,429	21,922	22,217	13,083	16,595	32,984	-	8,239	2,000
45	MZ0054	THAILAND	7,490	10,151	4,259	6,305	4,108	2,000	-	12,920	5,699	27	60	268

Appendix A.1 Table of sales history 2015 (continued)

No.	Item	Source	1	2	3	4	5	6	7	8	9	10	11	12
46	BW0233	THAILAND	12,876	9,961	14,403	9,504	8,420	11,450	8,865	9,500	6,887	6,900	8,500	7,428
47	SY7025N	MALAYSIA	763	2,180	23,315	18,917	19,401	23,535	21,781	20,771	28,709	20,345	13,139	18,386
48	AW0362.1200	THAILAND	36,600	14,146	10,775	34,035	14,650	5,694	13,100	5,316	14,052	6,678	5,016	14,850
49	MW0029N	MALAYSIA	35,807	24,099	31,648	6,813	22,056	-	-	-	-	-	-	-
50	AW0361.1200	THAILAND	8,873	5,670	5,800	11,800	9,227	17,320	11,080	5,560	11,200	20,400	6,306	6,500
51	AW0321	MALAYSIA	15,806	6,474	9,265	5,479	9,608	21,556	4,575	6,705	6,745	4,991	1,512	31,285
52	AW0252	THAILAND	22,319	8,007	11,450	450	-	5,071	500	-	14,557	-	5,000	1,950
53	BW0304	THAILAND	10,596	3,689	10,386	2,838	800	15,224	-	9,243	7,823	355	2,384	5,360
54	BW0148	THAILAND	7,377	6,852	6,609	3,822	4,583	8,405	8,384	1,522	2,864	6,005	1,074	-
55	MW0057P	THAILAND	-	106	5,961	2,688	1,024	6,595	3,258	9,678	2,994	8,518	7,364	4,519
56	AW0253	THAILAND	19,429	-	29	-	-	100	-	500	3,000	4,460	5,530	7,968
57	AW0312	MALAYSIA	3,813	1,607	6,440	763	3,902	-	4,575	2,288	6,863	-	763	1,525
58	BW0150	THAILAND	2,478	500	5,025	2,000	960	1,036	7,031	2,984	3,000	1,930	1,000	2,980
59	MW0052P	THAILAND	2,920	2,000	1,980	3,000	1,980	3,950	3,000	2,000	970	3,016	1,000	2,970
60	AW0363.1200	THAILAND	335	462	750	600	550	641	755	650	400	550	600	700
61	MW1616P	THAILAND	200	-	-	-	-	150	-	-	150	-	-	480
	Total		6,950,169	6,396,121	9,336,761	5,223,314	7,156,514	8,473,618	6,063,058	6,407,012	8,481,934	6,408,598	6,663,540	7,281,091

APPENDIX B



Appendix B.1: Table of demand during lead time of class A from January to December 2015

No.	Item	Source	Lead time	1	2	3	4	5	6	7	8	9	10	11	12
1	BW0146	MALAYSIA	21	261,345	329,198	448,491	222,953	390,351	423,630	351,624	297,271	370,564	411,023	263,063	389,142
2	AW0331	THAILAND	5	126,201	147,295	169,090	113,364	162,867	161,895	148,101	157,025	206,373	147,400	137,991	131,851
3	SY7022	THAILAND	5	62,820	62,247	73,907	51,428	64,066	67,237	57,080	54,628	86,896	54,869	57,971	71,746
4	BW0174	MALAYSIA	21	228,036	234,280	407,401	204,092	271,085	362,107	220,790	274,044	370,967	280,406	306,609	293,600
5	BW0227	MALAYSIA	21	214,399	211,859	336,157	167,598	240,228	237,554	197,178	234,811	308,771	182,293	190,880	264,136
6	AW0271	MALAYSIA	21	295,406	283,410	356,501	210,274	311,457	387,918	280,521	325,659	451,696	315,662	312,981	350,389
7	SW7331	MALAYSIA	21	298,620	222,570	294,705	119,885	243,002	292,968	196,157	182,415	243,354	195,858	302,902	281,043
8	NW0035	MALAYSIA	21	312,978	266,477	328,662	165,440	187,468	193,062	119,799	110,321	113,872	119,217	115,725	165,547
9	AW0153	MALAYSIA	21	144,215	167,542	239,001	107,648	159,068	179,185	164,597	138,414	129,249	122,679	137,776	114,791
10	MW0066	MALAYSIA	21	166,223	167,830	208,518	141,067	159,357	231,016	117,861	143,323	225,393	133,837	173,641	156,648
11	BW0147	MALAYSIA	21	74,653	115,173	174,718	121,263	142,688	165,295	77,523	102,448	160,891	106,640	105,955	127,224
12	BW0062	MALAYSIA	21	131,052	132,568	189,325	106,488	120,760	202,281	77,054	105,651	132,821	115,963	105,035	136,472
13	NW0039	MALAYSIA	21	331	582	61,539	57,694	66,548	170,216	120,309	182,939	239,931	118,891	180,199	273,036
14	BW0183	MALAYSIA	21	108,288	59,449	215,478	100,552	54,995	125,538	73,561	58,086	108,050	73,587	129,031	52,072
15	BW0243	THAILAND	5	24,794	32,093	31,074	17,556	31,176	28,831	24,712	23,447	42,000	23,115	37,591	30,261
16	AW0332	THAILAND	5	43,825	52,814	58,408	25,723	38,349	55,299	23,944	38,267	46,244	30,231	39,790	28,842
17	AW0343N	MALAYSIA	21	110,475	110,139	150,724	107,326	119,273	257,204	121,663	122,750	168,434	128,722	119,006	129,922

Appendix B.2: Table of economic order quantity for class B

No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost	Q*	Convert into rolls
18	NW0033	MALAYSIA	1,310,882	13.97	2,735	1.24	76,044	8
19	BW0062N	THAILAND	1,232,985	13.07	2,735	1.24	73,750	8
20	AW0326	MALAYSIA	1,601,936	9.88	2,735	1.24	84,063	9
21	BW0153	THAILAND	921,844	14.72	2,735	1.24	63,769	7
22	AW0344	MALAYSIA	1,289,163	10.18	2,735	1.24	75,411	8
23	AW0289	THAILAND	1,756,487	6.82	2,735	1.24	88,025	10
24	SY7008	THAILAND	865,265	13.52	2,735	1.24	61,781	7
25	MZ0104	THAILAND	394,855	29.02	2,735	1.24	41,735	5
26	BW0064	THAILAND	880,612	12.76	2,735	1.24	62,327	7
27	BW0184	MALAYSIA	658,248	16.48	2,735	1.24	53,886	6
28	BW0112N	MALAYSIA	1,367,905	7.93	2,735	1.24	77,680	8
29	BW9320	THAILAND	405,745	24.58	2,735	1.24	42,307	5

Appendix B.2: Table of economic order quantity for class B (continued)

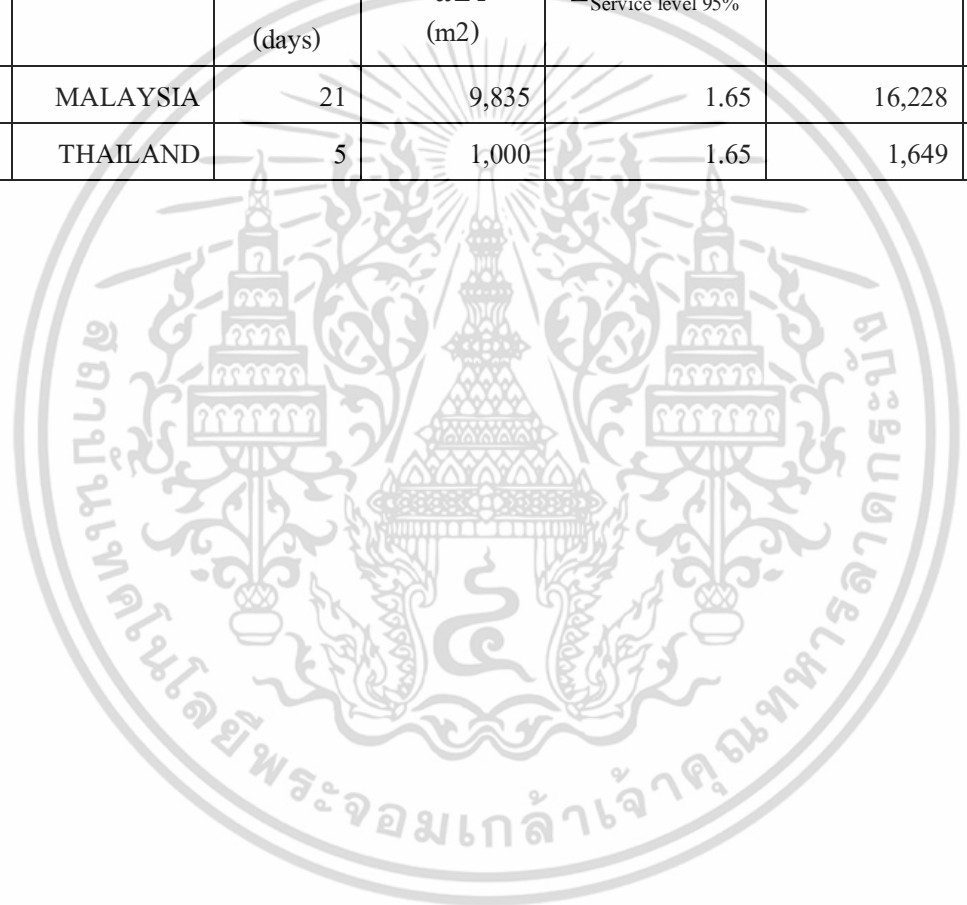
No	Item	Source	Demand (m ² /year)	Unit price (m ² /THB)	Ordering cost	Holding cost	Q*	Convert into rolls
30	BW0226	THAILAND	1,374,276	6.75	2,735	1.24	77,861	9
31	BW0060	THAILAND	751,502	11.34	2,735	1.24	57,577	6
32	BW0237	MALAYSIA	536,251	14.26	2,735	1.24	48,637	5
33	MZ0102	THAILAND	283,621	24.39	2,735	1.24	35,371	4

Appendix B.3: Table of safety stock calculation of class B

No.	Item	Source	Lead time (days)	σ_{dLT} (m2)	$Z_{\text{Service level 95\%}}$	Safety stock	Convert into rolls
18	NW0033	MALAYSIA	21	19,853	1.65	32,758	4
19	BW0062N	THAILAND	5	2,572	1.65	4,243	1
20	AW0326	MALAYSIA	21	17,140	1.65	28,281	3
21	BW0153	THAILAND	5	2,476	1.65	4,085	1
22	AW0344	MALAYSIA	21	11,043	1.65	18,221	2
23	AW0289	THAILAND	5	5,356	1.65	8,837	1
24	SY7008	THAILAND	5	5,516	1.65	9,102	1
25	MZ0104	THAILAND	5	1,384	1.65	2,284	1
26	BW0064	THAILAND	5	4,430	1.65	7,309	1
27	BW0184	MALAYSIA	21	14,803	1.65	24,426	3
28	BW0112N	MALAYSIA	21	23,137	1.65	38,176	4
29	BW9320	THAILAND	5	1,534	1.65	2,531	1
30	BW0226	THAILAND	5	5,661	1.65	9,340	1
31	BW0060	THAILAND	5	3,538	1.65	5,837	1

Appendix B.3: Table of safety stock calculation of class B (continued)

No.	Item	Source	Lead time (days)	σ_{dLT} (m2)	$Z_{\text{Service level 95\%}}$	Safety stock	Convert into rolls
32	BW0237	MALAYSIA	21	9,835	1.65	16,228	2
33	MZ0102	THAILAND	5	1,000	1.65	1,649	1



Appendix B.4: Table of reorder point calculation of class B

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	$Z_{\text{Service level}}$ 95%	$Z\sigma_{dLT}$ (m ²)	ROP	Convert into rolls
18	NW0033	MALAYSIA	21	2,486	75,404	19,853	1.65	32,758	108,162	12
19	BW0062N	THAILAND	5	557	16,903	2,572	1.65	4,243	21,146	2
20	AW0326	MALAYSIA	21	3,046	92,389	17,140	1.65	28,281	120,670	13
21	BW0153	THAILAND	5	417	12,646	2,476	1.65	4,085	16,731	2
22	AW0344	MALAYSIA	21	2,448	74,269	11,043	1.65	18,221	92,490	10
23	AW0289	THAILAND	5	795	24,101	5,356	1.65	8,837	32,938	4
24	SY7008	THAILAND	5	390	11,834	5,516	1.65	9,102	20,936	2
25	MZ0104	THAILAND	5	179	5,422	1,384	1.65	2,284	7,705	1
26	BW0064	THAILAND	5	399	12,090	4,430	1.65	7,309	19,399	2
27	BW0184	MALAYSIA	21	1,241	37,632	14,803	1.65	24,426	62,058	7
28	BW0112N	MALAYSIA	21	2,592	78,624	23,137	1.65	38,175	116,800	13
29	BW9320	THAILAND	5	180	5,475	1,534	1.65	2,531	8,006	1

Appendix B.4: Table of reorder point calculation of class B (continued)

No.	Item	Source	Lead time (days)	Expected demand during lead time (m ²)	d	σ_{dLT} (m ²)	$Z_{\text{Service level}}$ 95%	$Z\sigma_{dLT}$ (m ²)	ROP	Convert into rolls
30	BW0226	THAILAND	5	620	18,809	5,661	1.65	9,340	28,149	3
31	BW0060	THAILAND	5	341	10,333	3,538	1.65	5,837	16,170	2
32	BW0237	MALAYSIA	21	1,019	30,916	9,835	1.65	16,228	47,143	5
33	MZ0102	THAILAND	5	128	3,883	1,000	1.65	1,649	5,532	1

APPENDIX C



Appendix C.1: Table of Min-Max model for class C

No.	Item	Source	Min	Max	Average	Reorder quantity	Convert into rolls
34	BW0230	THAILAND	21,704	56,893	39,169	17,724	2
35	SW7304	THAILAND	1,543	72,324	31,329	40,994	4
36	MW0035N	MALAYSIA	3,454	128,784	33,144	95,640	10
37	BW0151	THAILAND	12,798	31,067	22,219	9,150	1
38	SY7054	MALAYSIA	19,118	54,049	29,062	24,987	3
39	AW0333	THAILAND	15,830	71,100	36,061	35,039	4
40	MZ0152	THAILAND	5,775	12,121	9,327	9,150	1
41	SW7045	THAILAND	2,914	24,914	15,208	9,706	1
42	MZ0111N	THAILAND	4,123	37,518	11,308	26,209	3
43	SY7021	THAILAND	1,000	24,837	14,701	10,136	1
44	BW0223	THAILAND	2,000	32,984	13,217	19,767	2
45	MZ0054	THAILAND	27	12,920	4,440	9,150	1
46	BW0233	THAILAND	6,887	14,403	9,558	9,150	1

Appendix C.1: Table of Min-Max model for class C

No.	Item	Source	Min	Max	Average	Reorder quantity	Convert into rolls
47	SY7025N	MALAYSIA	763	28,709	17,603	11,106	1
48	AW0362.1200	THAILAND	5,016	36,600	14,576	22,024	2
49	MW0029N	MALAYSIA	6,813	35,807	10,035	25,772	3
50	AW0361.1200	THAILAND	5,560	20,400	9,978	10,422	1
51	AW0321	MALAYSIA	1,512	31,285	10,333	20,952	2
52	AW0252	THAILAND	450	22,319	5,775	16,543	2
53	BW0304	THAILAND	355	15,224	5,725	9,499	1
54	BW0148	THAILAND	1,074	8,405	4,791	9,150	1
55	MW0057P	THAILAND	106	9,678	4,392	9,150	1
56	AW0253	THAILAND	29	19,429	3,418	16,011	2
57	AW0312	MALAYSIA	763	6,863	2,711	9150	1
58	BW0150	THAILAND	500	7,031	2,577	9150	1

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เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้