INVENTORY MANAGEMENT OF A RICE DISTRIBUTOR COMPANY

By

JANSUDA WAREESAENGTHIP

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
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Martin de Tours School of Management
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Bangkok, Thailand

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I, Jansuda Wareesaengthip
declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

Inventory Management of A Rice Distributor Company

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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

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(Asst. Prof. Dr. Withichai Wongthatsanekorn)

Date December 9, 2011

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Finally, and most important, my greatest debts of gratitude are reserved for my beloved family. I would like to dedicate this paper to my parents for their continuous encouragement and inspiration throughout my life.

Jansuda Wareesaengthip

Assumption University

November 2011

ABSTRACT

In this study, the company faces an inventory problem. Since inventory management is one of the most significant functions that help the company reduce its operational cost, the purpose of this study is to employ the economic order quantity concept for managing a product and respond to the research question "What are the appropriate quantity and time to reduce the total inventory cost of ABC Company? “

A rice distributor company's products were categorized, based on annual cost volume usage, into three groups, set A, set B, and set C. The most important product, Product AA was selected as the ABC inventory control. Then, the consumption pattern was analyzed by using variability coefficient (VC) in order to determine whether the consumption pattern conform to the economic order quantity's assumption which states that demand must be constant throughout the considered period. The results show that the consumption pattern of product AA has low variability which means the demand is constant. Therefore, economic order quantity can be applied. Since the product AA is used in the all warehouses, all inventory related costs e.g., ordering cost, and carrying cost were estimated separately before determining the economic order quantity (EOQ), reorder point (ROP) and safety stock (SS) for each warehouse Then, this study used economic order quantity (EOQ); reorder point (ROP) and safety stock (SS) to simulate the ordering process. Finally, total inventory costs were compared between the current ordering process and the economic order quantity for all warehouses. The results indicated that economic order quantity is appropriate since it incurs less total inventory cost for product AA when compared with the current ordering process. The total inventory cost in 2010 can be reduced by approximately 59.94 percent when economic order quantity is applied.

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Signed

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Date: 7 / 12 / 2011

CHAPTER I

GENERALITIES OF THE STUDY

There are many important issues for every business to concentrate on, but the most exclusive and vital asset for all business is inventory since it requires ordering cost and physical holding cost management (Render, Stair, & Hanna, 2008). Although, inventory has to deal with cost, it cannot be eliminated from any business. Because inventory is positive, it can maintain or increase customer satisfaction when the demands from customers are increasing. Nowadays there is highly competitive business environment, so every business needs to work successfully. They should verify the suitability of inventory volume so as to reduce the total inventory cost.

Therefore, every business should discover an appropriate theory and methodology to control inventory. It is concerned with the target of active inventory management. It would be an advantage for a company to decrease its total inventory cost by identifying the appropriate quantity and time to order.

To reduce the total cost, the company has to verify the total cost of inventory, based on the ordering cost and physical holding cost. So it is essential for every business to focus on ordering to enhance its suitability.

This chapter contains a brief company outline and the significance problem which the company faces. Then, the proposed objective of this research and analysis of the root cause of the problem will be presented. Next, the scope and expected benefits of this research are presented. Finally, the related definition terms will be specified at the end of this chapter.

1.1 Background of the Study

ABC Company runs a rice business with five customers in a competitive market in Thailand. Rice is a significant product which many business find it essential to purchase as their core product. Thus, it is necessary for ABC to supply sufficient products to its main five customers as these customers are also running a rice business as their main concern. Therefore, inventory has become a vital function to avoid any shortage problems. ABC decides to keep inventory in order to maintain customers' satisfaction, but it is more than ABC can accept. ABC has five products, classified by type as AA, BB, CC, DD, and EE.

Three purchasing members control the purchase process in each warehouse, so they are separately working in each process. They are responsible for issuing orders. and control the inventory volume in each warehouse in order to support customer requirements. They cannot accept any stock-out, so no stock-out problems exist in warehouse.

ABC categorizes its products by separating them into three warehouses, as the warehouse no. 1 no. 2 and no. 3. All warehouses do not have the same total area and their capacities are different. ABC needs to take responsibility for warehouse management to gain more benefits for the company.

Thus, ABC has a policy which emphasizes control of inventory based on the warehouse capacity. There is only 50 percent of the total warehouse capacity that the company controls, since it has allocated the other 50 percent of warehouse capacity for customer rental. The capacity of each warehouse is shown in Table.1.1.

ABC is a pseudonym

Table 1.1: Capacity of Each Warehouse in 2010

roduc	Warehouse No (Tons)	archo se No (Tons	Warehouse o (Tons)
	100	200	300
	100	200	300
	100	200	300
	100	200	300
	100	200	300
:Total	500	1,000	1,500
Acceptable J	250	500	750

Source: Constructed from Company Data

For lead time, the supplier needs a total lead time of approximately 30 days. But the acceptable lead time fixed for their customers is only 14 days. Table 1.2 shows the processing lead time between ABC and customers. It starts when ABC issues an order to the supplier in the first week, and receives the product around the fourth week. On the other hand, they receive order from the customers around the second week, and the customers also require delivery of the product in the fourth week.

Table 1.2: Processing Lead Time of ABC and Customers

Processin Lead Time		week	Wee	Week:	week
ABC	Issues order to manufacturers			Lead time = 30 days	
	Receives products				A
Customers	Issues order to ABC		A	Lead time = 14 days	
	Receives products				A

Source: Constructed from Company's Data

Table 1.2 shows that processing lead time of the ABC and customers are different It lead to a focus on inventory in order to supply the customer requirements and prevent any stock-out problem. So this is the important factor which is the explanation for keeping inventory in ABC.

1.2 Statement of the Problem

The capacity of warehouse no. 1 was only 250 tons but the average inventory of all products in warehouse no. 1 in 2010, mentioned in Figure 1.1, was 266.49 tons. So it would be in opposition to their policy.

Figure 1.1: The Average Inventory of All Products in Warehouse No. 1 In 2010

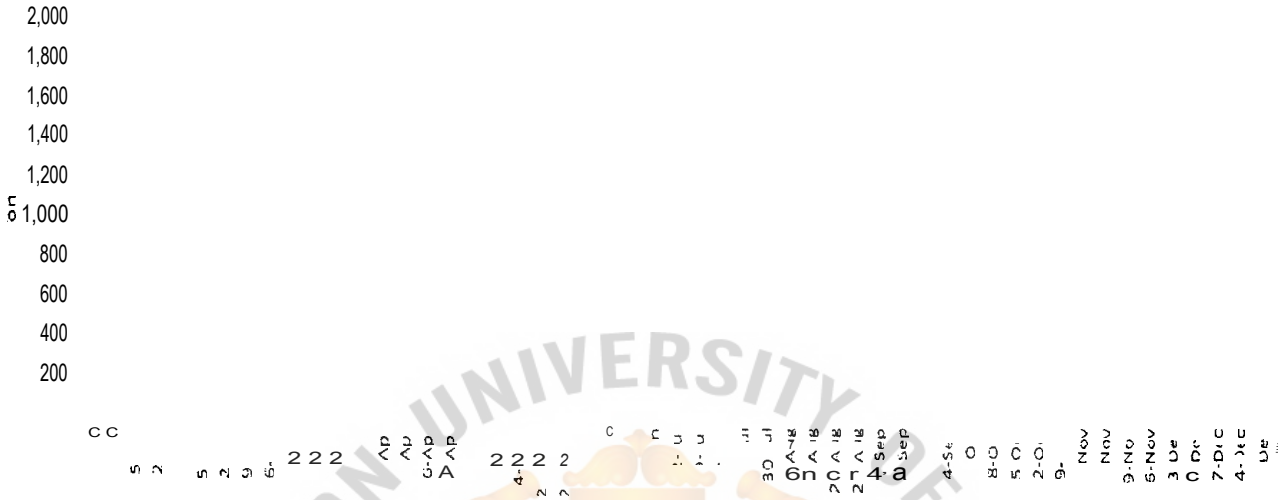
Remarks: – – The acceptable volume line

The average inventory line

Source: constructed from company data

Warehouse no. 2 was also over the acceptable volume because it can accept only 500 tons. It was shown in Figure no. 1.2 that the average inventory of all products in warehouse no. 2 in 2010 was 950.55 tons. So it was exactly in opposition to the policy also.

Figure 1.2: The Average Inventory of All Products in Warehouse No. 2 In 2010



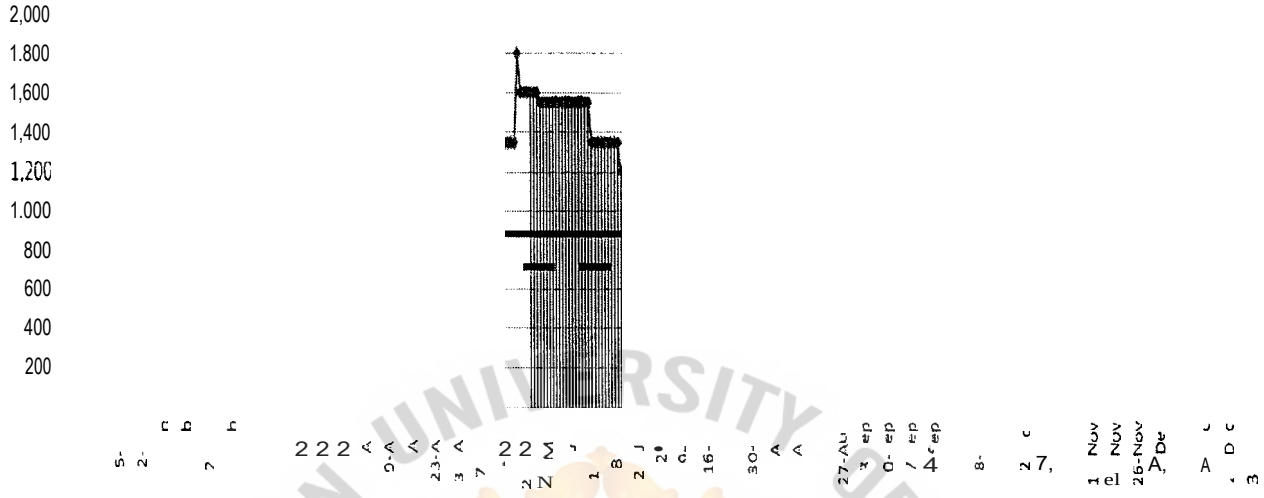
Remarks: – – The acceptable volume line

The average inventory line

Source: constructed from company data

Furthermore, warehouse no. 3 was also in opposition to the policy because the average inventory of all products in warehouse no. 3 in 2010 was 829.59 tons but they can accept only around 750 tons, as shown in Figure 1.3.

Figure 1.3: The Average Inventory of All Products in Warehouse No. 3 In 2010



Source: Constructed from company data

Remarks: – – The acceptable volume line
— The average inventory line

Moreover, ABC faced a high total inventory situation from 2008 to 2010 as their significant problem. And in 2010, it was still over the maximum volume which they could accept according to their policy. It should not be over 50 percent of warehouse capacity, as shown in Table.1.1.

So it is really serious for ABC because this problem would lead to a high total cost and it completely nullifies the efficiency of their inventory turnover. Where average amount of inventory is high, it illustrates that the inventory turnover has decreased. It becomes a critical situation for ABC because it means that the company took a long period to obtain cash from their customers, according to Table.1.3.

Table 1.3: The Inventory Turnover of All Products in 2008 – 2010

			2008			
Product	**AA**	**BB**	**CC**	**DD**	**EE**	**TOTAL'08**
Cost of Goods Sold	19,080,000.00	5,342,000.00	4,960,000.00	3,012,500.00	3,030,000.00	35,424,500.00
Average Inventory	4,042,500.00	2,100,000.00	2,125,000.00	1,367,500.00	739,500.00	10,374,500.00
Inventory Turnover	**4.72**	**2.54**	**2.33**	**2.20**	**4.10**	**3.41**
			2009			
Product	**AA**	**BB**	**CC**	**DD**	**EE**	**TOTAL'09**
Cost of Goods Sold	19,145,000.00	5,412,500.00	5,040,000.00	3,077,500.00	3,120,000.00	35,795,000.00
Average Inventory	**4,117,500.00**	2,700,000.00	2,200,000.00	1,442,500.00	830,000.00	11,290,000.00
Inventory Turnover	**4.65**	**2.00**	**2.29**	**2.13**	**3.76**	**3.17**
			,2010			
	AA	**BB**	**CC**	**DD**	**EE**	**TOTAL'10**
Cost of Goods Sold	19,650,000.00	6,112,500.00	5,690,000.00	3,982,500.00	3,475,000.00	38,910,000.00
Average Inventory	4,567,500.00	3,350,000.00	2,800,000.00	2,242,500.00	1,480,000.00	14,456,709.85
Inventory Turnover	**4.30**	**1.82**	**2.03**	**1.78**	**2.35**	**2.69**

1.3 Research Objectives

Establishing the appropriate inventory management that decreases the total inventory cost for ABC company is the main purpose of this research. There are four objectives of the study:

1. To categorize the most important product for ABC inventory control.
2. To analyze the variable volume of usage by variability coefficient.
3. To determine economic order quantity to solve the high total inventory cost problem.
4. To simulate the total cost after applying economic order quantity by Microsoft Excel 2010.

1.4 Scope of the Research

As there are five products purchased by ABC, this research will focus on ABC inventory control in order to find out the most vital product. Moreover, it will calculate the variability coefficient (VC) to ensure the possibility of applying the economic order quantity (EOQ).

Data will be collected which is related to a selected product in 2010, to evaluate the total inventory cost between the current situation and the proposed economic order quantity (EOQ).

1.5 Significance of the Research

It is useful for ABC to reduce the total inventory cost of the selected product because it can identify the appropriate quantity and time for ordering based on the inventory cost of the selected product. It should increase the inventory turnover of the selected product and it would be convenient to apply this technique to other products also.

1.6 Limitations of the Research

The three limitations in this study:

1. It is impossible to collect past data which is more than five years old.
2. There is a high turnover rate of the purchasing staff.
3. It can focus on only the quantitative factor because it is difficult to discuss qualitative factors with the operations staff.

1.7 Definition of Terms

ABC Inventory Control	The necessary theory for classifying important products. It is calculated by product price and annual consumption (Edward, 2009).
Carrying Cost	It consists of two components which are opportunity cost and physical inventory cost (Ballard, 1996).

Economic Order Quantity (EOQ)	The theory manages inventory by focusing on how much to order by calculating the amount which is able to minimize the total ordering and carrying cost (Hariga, 1994).
Inventory	All products which are contained in all warehouses to support requirement of customers (Peterson & Silver 1979).
Reorder Point (ROP)	The reorder point for replenishment of stock occurs when the level of inventory drops down to zero. In instantaneous replenishment of stock the level of inventory jumps to the original level from zero level (Jon, 2001).
Rice Distributor Company	A company whose business is rice, and the main purpose is delivering the product from their warehouse to the customers (Weiss & Mark, 1989).
Total Inventory Cost	The total cost includes the purchase cost, order cost, and carrying cost (Ballard, 1996).
Variability Coefficient (VC)	The methodology for evaluating how much of the usage is variable (Peterson & Silver 1979).

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter explains the source of inventory, importance of inventory, related costs of inventory, and inventory management. This is followed by an explanation of the concept of ABC inventory control, variability coefficient, just-in-time, and economic order quantity. Interesting studies related to this research are also presented.

2.1 Source of Inventory

Wisner, Keong, and Tan (2008) stated that there are four basic source of inventory;

- Raw Materials are the most basic materials that industries require in the production of their final goods
- Work-in processes (WIP) means products still in process but not yet completed.
- Finished Goods Inventory means the completed products awaiting sale.
- Maintenance, Repairing, and Operating Supplies (MRO) are materials used in producing the products. However, these materials are not part of the finished products.

2.2 Importance of Inventory

Edward (2009) declared that in this rapidly changing business and competitive environment, inventory that is kept in the warehouse has a significant effect on the daily business operation. Inventory control involves many levels of the organization, from the shop floor workers to the top management commitment. Therefore, it encounters various problems in implementation. However, there are three basic reasons for keeping an inventory, as follows:

- Time: Lead Time

  Uncertainty: Fluctuation

- Economies of scale: Price

All these above reasons can apply in the real business world and would lead to high total cost of inventory.

2.3 **Related Cost with Inventory**

Piasecki (2009) mentioned that when companies are involved with the three reasons in 2.2, they have three important related inventory costs:

2.3.1 Purchase Cost

The purchase cost is the unit price when purchase from outside the firm.

2.3.2 Order Cost

The order cost is incurred when an inventory replacement order is placed.

2.3.3 Carrying Costs

There are two components in the inventory carrying costs, which are opportunity costs and physical inventory costs as detailed below;

The cost of capital only one part of inventory carrying cost. There are other costs related to carrying cost in order to keep inventories, for both the rental warehouse expenses and owned warehouse cost. This is defined as physical holding cost.

In conclusion, the physical and opportunity costs of inventory will be calculated together. Thus, how to calculate the total inventory carrying costs can be answered by the following equation:

$$\mathbf{H} = (h + r)\, C \qquad (2.1)$$

Where;

Total unit inventory carrying cost

Opportunity cost of holding

Physical cost of holding

Cost of purchase

2.4 Inventory Management

Edward (2009) mentioned that even though there are many products in the business, there are only two questions which the company should answer to decide how to manage or control the inventory.

- What is the appropriate quantity that the company should order?
- When is the appropriate time that the company should order?

Krishna (2007) declared that the scope of inventory management concerns the issues of replenishment lead time, carrying cost, asset management, forecasting, inventory valuation, future inventory price forecasting, physical inventory, and available physical space for inventory, quality management, replenishment, returns and defective goods and demand forecasting.

2.5 ABC Inventory Control

Wisner (2008) mentioned that the ABC inventory control is the technique which classifies inventory items into three sets according to the annual cost volume usage. The annual cost volume usage for an inventory item is computed by using the following equation:

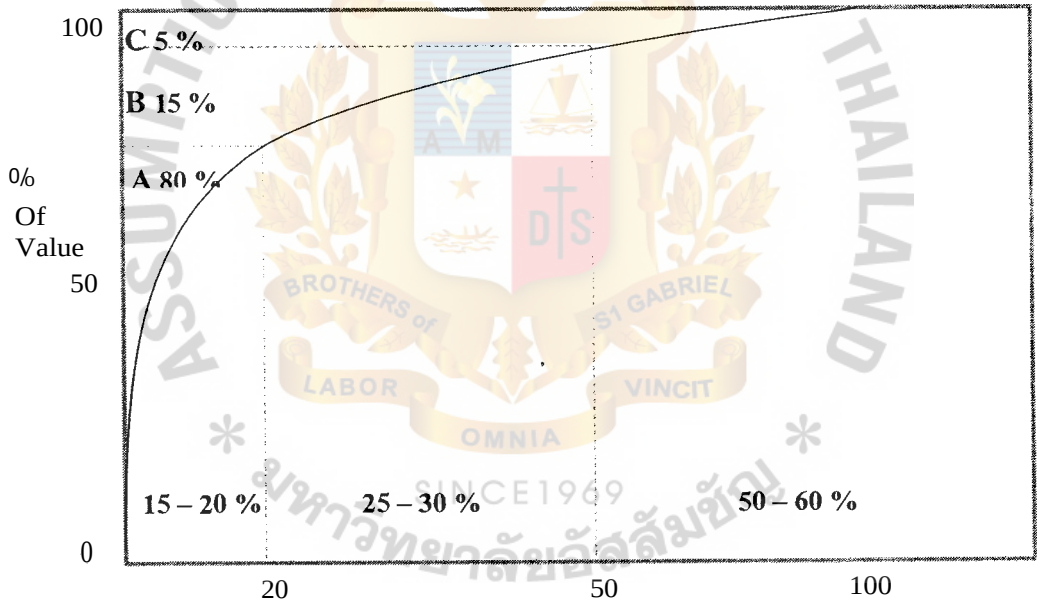
$$\text{Annual cost volume usage} = \text{Unit cost} * \text{Annual usage} \quad (2.2)$$

Inventory can be classified by annual cost volume. The ABC inventory classification control technique can be explained as follows;

- Set A : High annual cost volume usage with total annual cost volume usage around 80 percent, matched by total inventory items of about 20 percent.
- Set B : Intermediate annual cost with total annual cost volume usage around 15 percent, matched by total inventory items of about 40 percent.
- Set C : Low annual cost with total annual cost volume usage around 5 percent, matched by total inventory items of about 40 percent.

Clarification is in Figure 2.1

Figure 2.1: Ratio of ABC Inventory Control



Source: Wisner et al. (2008)

2.6 Variability Coefficient (VC)

Variability Coefficient (VC), has two different settings necessary to be calculated: analyzing a single variable and taking a model. The standard formulation of the VC, the ratio of the standard deviation to the mean, applies in the single variable setting. In the modeling setting, the VC is calculated as the ratio of the root mean squared error (RMSE) to the mean of the dependent variable. In both settings, the VC is regularly presented as the given ratio multiplied by 100.

The VC for a single variable aims to define the dispersion of the variable in a way that does not depend on the variable's measurement unit. The VC for a model aims to define the model fit in terms of the relative sizes of the squared residuals and outcome values. The lower the VC is, the smaller the residuals relative to the predicted value. This is suggestive of a good model fit.

2.7 Possibility to Apply Economic Order Quantity (EOQ)

Krishna (2007) stated that according to the economic order quantity assumption, the economic order quantity technique would be advantageous if the demand is constant and known.

However, Peterson and Silver (1979) mentioned that there are various factors which cause varied demand. Thus, they proposed a vital tool to indicate the variability of a demand pattern by using the variability coefficient. These equations are calculated as follows:

$$d = \qquad d_i \tag{2.3}$$

$$\text{Est. var } D = \frac{1}{n} E n_{i=1} d_i^2 \quad \bar{d}^2 \tag{2.4}$$

$$VC = \frac{\text{Est.var } D}{d^2} \tag{2.5}$$

Where;

d_i = demand in period i

n = Number of period

In order to determine whether a demand pattern has high variability or not, it is necessary to consider the value of VC. If VC is less than 0.25(<0.25), then a simple economic order quantity technique can be applied. In contrast, if VC is greater than 0.25(>0.25), it means that demand has high variability, and therefore, economic order quantity cannot be applied.

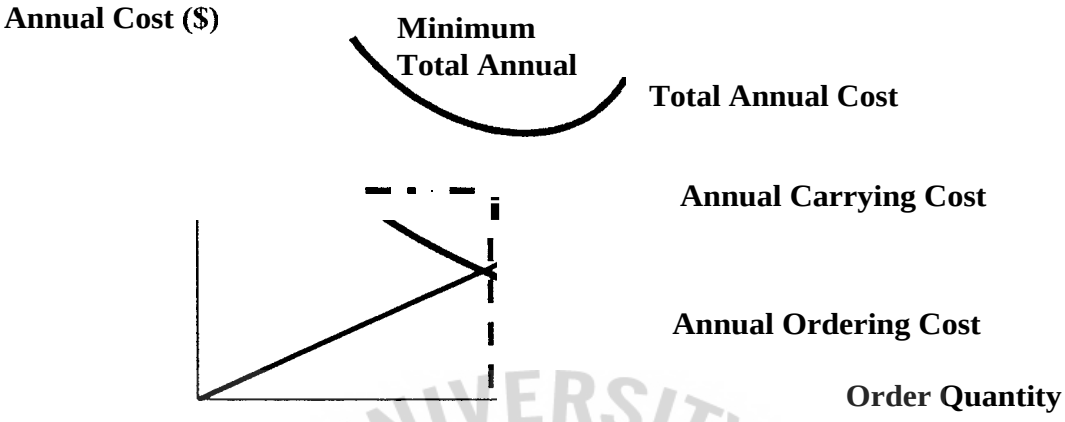
2.8 Economic Order Quantity (EOQ)

Hariga (1994) stated that economic order quantity (EOQ) is the level of inventory which reduces the total inventory holding cost and ordering cost. It is the one of oldest standard production scheduling models. It is a very convenient and easy model, and is based on the following significant assumptions:

1. Demand has to be known and stable. A variable demand situation cannot use economic order quantity.
2. The replenishment lead time should be known and stable also.
3. Purchase cost for the inventory is invariable.
4. The inventory carrying and ordering costs should be known and invariable.
5. There should not be the possibility of stock outs.

The main purpose for managing inventory is how to minimize the total inventory management cost. The economic order quantity hypothesis will be involved with the total inventory cost which is calculated together with the inventory ordering cost and inventory carrying cost. Therefore, the company has to consider minimizing the sum of these related costs in order to minimize the total inventory management cost.

Figure 2.2: Minimize the Total Inventory Cost



Source: Wisner et al. (2008)

Thus, when the annual ordering cost equals the annual holding cost, the total annual inventory management cost is minimized, as follows:

$$\left[\frac{D}{Q}\right]S = \left[\frac{Q}{2}\right](r+h)C \tag{2.6}$$

$$2DS = Q2(r+h)C \tag{2.7}$$

$$2DS = Q2(r+h)C \tag{2.8}$$

This optimal ordered quantity is indicated by Q*. Therefore, the economic order quantity is expressed by the formula below:

$$EOQ = Q = \sqrt{\frac{2DS}{(r+h)C}} \tag{2.9}$$

When a company orders inventory at Q*, the company incurs the least annual inventory management cost, as:

$$TC\,min = \frac{SD}{Q^*} + \left[\frac{Q^*(r+h)C}{2}\right] + CD \quad (2.10)$$

$$\text{Annual ordering cost} = \left[\frac{D}{Q^*}\right] \quad (2.11)$$

$$\text{Annual carrying cost} = \left[\frac{Q^*}{2}\right](r+h)C \quad (2.12)$$

$$\text{Annual order frequency cost} = \frac{}{Q^*} \quad (2.13)$$

Where;

Annual demand

- Cost when issuing an order
- Opportunity cost of holding
- Physical cost
- Cost of purchase

2.9 Reorder Point (ROP)

The reorder point for replenishment of stock occurs when the level of inventory drops down to zero. In view of instantaneous replenishment of stock the level of inventory jumps to the original level from zero level. It is based on the two factors as the average demand per unit of time, average replenishment lead time, and safety stock. (Edward, 2009). The ROP is shown in Figure 2.3:

$$ROP = d \times LT + SS \quad (2.14)$$

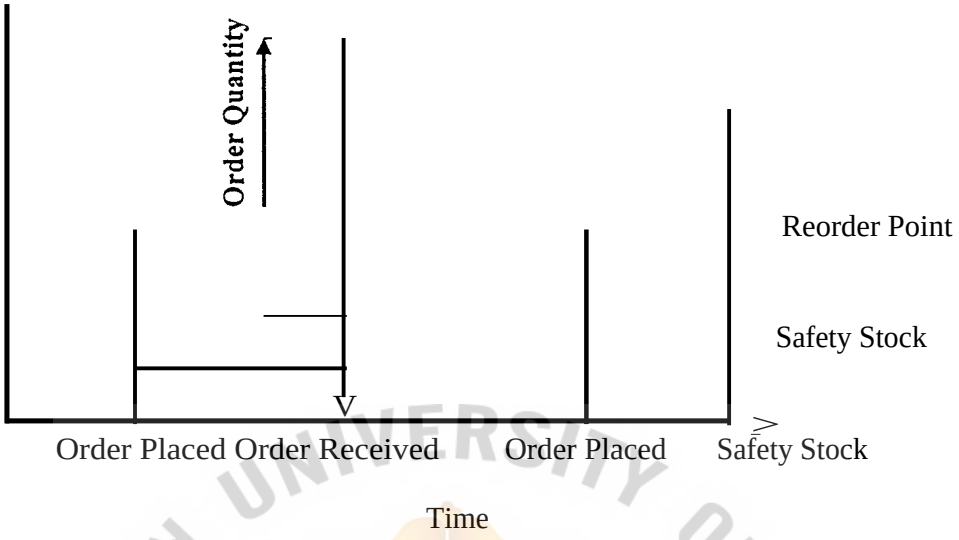
Where;

- Average demand per unit of time

LT = Average replenishment lead time

SS = Safety stock

Figure 2.3: The Reorder Point



Source: Wisner et al. (2008)

2.10 Related Research

Other researchers who have studied economic order quantity, are reported and discussed now, in order to further understand the concept of economic order quantity.

Hariga (1994) stresses that inventory means "Piles of Money" on the shelf and profit for the company. However, he noticed that 30 percent of the inventory of most retail shops is dead. He further elaborates two types of inventory calculation that determine the inventory level required for profitability. The two calculations are based on "cost to order" and "cost to keep."

Evan (1985) explains how inventory can best be monitored and measured in the warehouse. He mentions that inventory control is treated as a management function, whereas the monitoring of stock is regarded as a supervisory function. However, he highlights that the monitoring and measurement process is often overlooked and thus results in unreliability of the data for the management decision-making.

2.12 Summary

All the theories and case studies that are analyzed above provide important information to prepare an appropriate methodology for order process improvement and for dealing with inventory troubles. Each theory provides a useful technique to manage several problems that resulted from unsuitable inventory management at ABC. The key point of this problem is inventory cost which is because of inappropriate quantity and time to order.

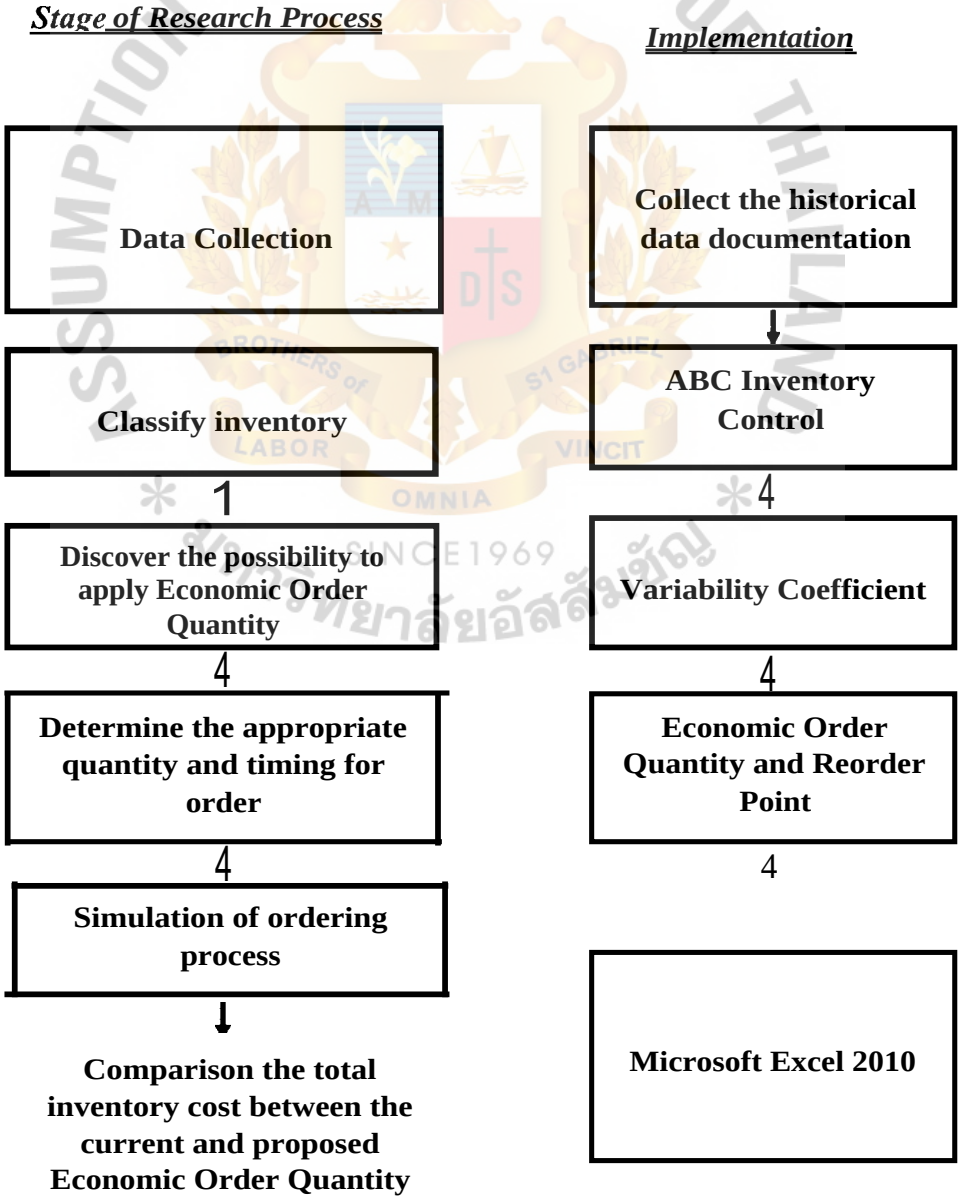
Therefore, the initial step is to organize a suitable inventory level for ABC inventory control. Moreover, economic order quantity (EOQ) and reorder point (ROP) are the most attractive strategies that can answer the research question as to what are the appropriate quantity and time to reduce the total inventory cost of company. We are able to calculate the appropriate quantity and time by considering the lead time and constant annual consumption. Thus, variability coefficient (VC) is relevant to investigate the variability of demand before applying EOQ.

CHAPTER III

RESEARCH METHODOLOGY

This study attempts to find an appropriate quantity and also a suitable timing for ABC, in order to reduce the total inventory cost. This research will use and analyze the relevant data of 2010 based on the historical demand data and purchased data for analysis. The methodologies, to establish suitable order quantity and time to issue order for the selected product, are as follows.

Figure 3.1: Stages of the Research Process and Implementation



3.1 Data Collection

This study is involved with the performance of three purchasers. It is important to collect the essential data from the three purchasers in each warehouse. The related documentation will be reviewed, such as purchase order of each warehouse, invoice of each warehouse, inventory report of each warehouse, and purchasing expense report of each warehouse. It is necessary to collect the data as follows:

The annual consumption volume for each product in 2010

- The average price for each product in 2010
- The inventory ordering cost for selected product in 2010
- The inventory carrying cost for selected product in 2010

3.2 Classify Inventory by Applying ABC Inventory Control

From collecting product data for 2010 of ABC, the products are various so it is inconvenient to make a decision for inventory management for all the products. Moreover, it is also inappropriate to improve every product. Therefore, this research will try to find the main product item by applying ABC inventory control. Then, it will select the product that has the highest annual cost volume. The steps of ABC inventory control are:

3.2.1. Collect the Average Price and Annual Consumption Volume for Each Product in 2010.

What will be collected is the annual consumption of each product from January 2010 until December 2010, as explained in Table 3.1

Table 3.1: The Average Annual Consumption and Average Price of Each Product in 2010

No.	Product	Average Price	Average Annual Consumptions	Average Annual Cost (Baht)
1	AA	23,000.00	985.50	22,666,500.00
2	BB	19,000.00	319.00	6,061,000.00
3	CC	15,000.00	402.00	6,030,000.00
4	DD	12,000.00	397.00	4,764,000.00
5	EE	8,000.00	527.50	4,220,000.00
Total			2,631.00	43,741,500.00

Source: Computed by Using Company Data

3.2.2. Calculate the Annual Cost Volume of Each Product in 2010

It is calculated by multiplying the average annual consumption with the average price per ton, as illustrated in Example 3.1

Example 3.1 Annual cost volume usage calculation for product AA

Average Annual Consumption in Year 2010 = 985.50 Tons

Average Price in Year 2010 = 23,000 Baht per ton

Thus, the average annual cost volume usage of product AA is calculated as follows:

985.50 Tons X 23,000 Baht per ton = Baht 22,666,500.

Furthermore, average annual cost volume usage is approximately 51.82 percent.

The percentage of each product is summarized as in Table 3.2

Table 3.2: The Percentage of Each Product in 2010

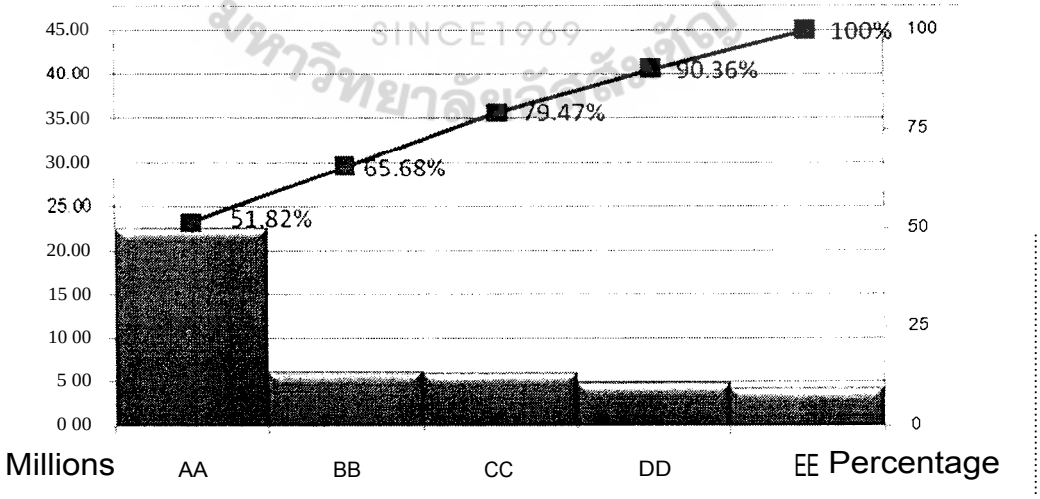
No.	roduc	Verage Price IA	Average Annual onsumpti n)	Average Annual Cost lit	Percentage
1	AA	23,000.00	985.50	22,666,500.00	51.82%
2	BB	19,000.00	319.00	6,061,000.00	13.86%
3	CC	15,000.00	402.00	6,030,000.00	13.79%
4	DD	12,000.00	397.00	4,764,000.00	10.89%
5	EE	8,000.00	527.50	4,220,000.00	9.65%
	Total		2,631.00	43,741,500.00	100.00%

Source: Computed by Using Company Data

3.2.3. Arrange the Annual Cost Volume of Each Product

Figure 3.2 mentions the ABC category of each product in group A, B and C

Figure 3.2: The ABC Category of Each Product



Source: Constructed by Company Data

3.2.4. Select the Most Important Product

According to Figure 3.2, product AA is the highest cost volume product which had annual cost volume usage of baht 22,666,500.00, which accounts for 51.82 percent of total annual cost volume usage. Therefore, this study selects product AA as the pilot project to develop an inventory management system for the ABC company.

3.3 Discover the Possibility to Apply Economic Order Quantity

Peterson and Silver (1979) mentioned that there are various factors which cause variation in demand. Thus, they proposed a vital tool for indicating the variability of a demand pattern by using variability coefficient (VC). So it would be advantageous to consider the VC value for determining the demand pattern before applying economic order quantity. If VC is less than 0.25(<0.25), it means that the demand pattern has low variability, and it would be convenient to apply economic order quantity.

On the other hand, if VC is greater than 0.25(>0.25), it means that the demand has high variability, and it would mean that economic order quantity's cannot be applied. The calculation of variability coefficient needs consumption data for one year in order to calculate the average consumption for one year and the variability coefficient value in order to determine the possibility of applying the economic order quantity model.

3.3.1 Verify the Demand Pattern of Product AA, and if Possible to Apply the Economic Order Quantity

The variability coefficient calculation of product AA is summarized in Table 3.3.

Table 3.3: The Variability Coefficient of Product AA Consumption in 2010

PRODUCT AA		
on	onsumption o	
Jan-10	950	0.90
Feb-10	1,250	1.56
Mar-10	1,200	1.44
Apr-10	1,250	1.56
May-10	1,400	1.96
Jun-10	1,250	1.56
Jul-10	1,150	1.32
Aug-10	1,500	2.25
Sep-10	1,550	2.40
Oct-10	600	0.36
Nov-10	1,100	1.21
Dec-10	1,050	1.10
Average Demand		1.19
Average,		1.47
verage eman		1.4102
Est Var D		0.0596
		0.0423

Source: Computed by Using Company Data

According to Table 3.3, the variability coefficient of product AA is less than 0.25. It indicates that consumption in each month does not much deviate from the average consumption of the whole of year 2010. It means that the consumption pattern has low variability. Therefore, the study can assume that consumption pattern is constant, and that economic order quantity can be applied in this study.

3.4 Determine the Appropriate Quantity and Timing for Order by Economic Order Quantity and Reorder Point

After investigating the variability of consumption, the step for applying the economic order quantity model will be discussed. Before determining whether to apply economic order quantity, three following related data should be collected:

1. Calculate the inventory ordering cost of product AA.
2. Calculate the inventory carrying cost of product AA.
3. Calculate the economic order quantity and reorder point for product AA.

3.4.1 Calculate the Inventory Ordering Cost of Product AA.

The ordering cost can be calculated from the following data:

1. Total salary expense of all purchasing department's staffs in year 2010
2. Total of fixed Cost for all products issued by ABC in year 2010.
3. Total of variable cost per order.
4. Calculation of total ordering cost per order (summarized in the equation below).

Fixed Cost per Order in 2010

$$= \frac{\text{Total Purchasing Department Fixed Cost in Year 2010}}{\text{Number of Orders for All Products in Year 2010}} \quad (3.1)$$

Total Ordering Cost per Order in 2010

$$= \text{Fixed Cost per Order in Year 2010} + \text{Variable Cost per Order in Year 2010} \quad (3.2)$$

3.3.2 Calculate the Inventory Carrying Cost of Product AA.

ABC has three warehouses for separately keeping product AA. Warehouses no. 1, 2, and 3 have expenses such as operational storing costs, consisting of the physical holding cost and opportunity cost.

3.3.2.1 Calculate the Physical Holding Cost of Product AA per Ton in Year 2010 of Warehouses no. 1, 2, and 3

All warehouses' physical holding costs can be calculated by adding all fixed costs and variable costs which incurred by each warehouse. Then, total warehouses fixed expenses are divided by the total amount of all products stored at each warehouse in order to define the physical holding cost per ton and per year for product AA in each warehouse. The calculation is summarized in the equation below:

Warehouses no. 1, 2, and 3's Physical Holding Cost per Ton in 2010

$$= \frac{\text{Total Warehouse No. 1, 2, and 3's Product Warehouse Expense in Year 2010}}{\text{Total Amount of All Products Stored at Warehouse No. 1, 2, and 3 in Year 2010}} \quad (3.3)$$

3.3.2.2 Calculate the Opportunity Cost of Product AA per Ton in Year 2010 of Warehouse no. 1, 2, and 3

We can determine the opportunity cost per ton and per year by using the minimum loan rate (MLR) of the average of Bangkok Bank's MLR in 2010. The opportunity cost per ton and per year is not same for all warehouses because there is not the same purchase cost for each warehouse. The opportunity cost per ton of product AA is calculated below:

Opportunity Cost per Ton of Product AA in 2010

= Average Bangkok Bank's MLR X Purchased Cost per Ton in Year 2010 (3.4)

In conclusion, the total carrying cost per ton and per year is calculated for product AA of each warehouse by determining the physical holding cost per ton in year 2010 and the opportunity cost per ton in year 2010 together, as below:

Each Warehouse's Carrying Cost per Ton in 2010 of Product AA

= Opportunity Cost per Ton in Year 2010 + Each warehouse's Physical Holding Cost per Ton in Year 2010 (3.5)

3.4.3. Calculate the Economic Order Quantity and Reorder Point

After gathering the above data, the economic quantity and reorder point will be calculated in order to find the appropriate quantity and time for reducing the total inventory cost in ABC. In addition, product AA is kept in the all warehouses, so the calculation will be for each warehouse.

3.5 Simulation of ordering Process by Applying Economic Order Quantity and Reorder Point

After gather all the related data, the economic order quantity and reorder point of product AA will be calculated. The economic order quantity and reorder point have to be simulated in the following model

3.5.1 Arrange the Simulation Model by using Microsoft Excel 2010

Table 3.4: Simulation Ordering Process Model in the Calculation Part

Date	I s the New	Stock on Hand	Dispatch	ccumulate Stock on Hand
1-Jan				2,000.00
2-Jan				2,000.00
3-Jan				2,000.00
4-Jan				2,000.00
5-Jan				2,000.00
6-Jan	500.00			2,000.00
.				2,000.00
6-Feb		500.00		2,500.00
7-Feb			500.00	2,000.00

The Calculation Part consists of the following information:

- Issue the new order when accumulated stock on hand in less than the reorder point.
- Stock on Hand is the quantity of product AA which ABC receives after an order is issued under the specified lead time.
- Dispatch is the actual quantity of product AA shipped out from a warehouse.
- Accumulated Stock on Hand is the actual quantity of product AA which accumulates each day.

The above data is calculated in the equations below:

- Issue the new order = The economic order quantity will be exposed when the accumulated stock on hand is less than the reorder point.
- Stock on Hand = The inventory which is in stock in each day
- Accumulated Stock on Hand = Today's schedule received + Stock on hand from previous day – Dispatch

Table 3.5: Simulation the Ordering Process Model in the Conclusion Part

Lead Time	30	**Days**
Reorder Point (ROP)	[redacted]	**Tons**
Optimal Order Quantity (EOQ)	?	**Tons**
Average Accumulated Stock on Hand		**Tons**

The Conclusion Part consists of the following information:

- Lead time is the period from issuing an order until product receiving, as 30 days.
- Reorder Point is the appropriate point to issue a new order.
- Optimal Order Quantity is the economic order quantity.
- Average Accumulated Stock on Hand is the actual quantity of product AA which accumulates each day.

3.6 Summary by Comparison of the Total Inventory Cost between the Current and Proposed Economic Order Quantity

This research compares the total inventory cost in 2010 of the current ordering process with the proposed of economic order quantity model by simulating the ordering process using Microsoft Excel 2010. Moreover, the research will decide to provide inventory management which has the lower total inventory cost. It will be compared with the three related costs, as follows:

- Ordering cost in Year 2010
- Carrying cost in Year 2010
- Total inventory cost in Year 2010

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter will show the step of determining the appropriate quantity and timing for order by calculating the economic order quantity (EOQ) and reorder point (ROP). Then, a simulation of the ordering process is presented, for the current ordering process and the proposed EOQ model. Finally, a comparison of the total inventory cost from Microsoft Excel 2010 is explained.

4.1 Determine the Appropriate Quantity and Timing for Order

According to this theory, there are three main costs that are necessary to determine before applying EOQ:

1. Calculate the inventory ordering cost of product AA in year 2010
2. Calculate the inventory carrying cost of product AA in year 2010
3. Calculate the economic order quantity (EOQ) and reorder point (ROP) for product AA in year 2010

4.1.1 Calculate the Inventory Ordering Cost of Product AA in Year 2010

Actually, the inventory ordering cost is calculated from the related expenses of the purchasing department, divided into two costs, as illustrated in Table 4.1.

Table 4.1: Purchasing Department Expenses in 2010

	etail		uantity	Cost ear)
Fix Cost				
1	Salary Expense	Purchasing Department Manager	1 person	600,000.00
		Purchasing Group Manager	2 persons	840,000.00
		Officer	3 persons	720,000.00
2	Depreciation Expense	Computer	6 Machines	54,000.00
3	Other Expenses			40,000.00
Total Fix ost		4		**2,254,000.0k**
Variable Cost				
1	Purchase Order Form			5.00
2	Telephone Expense			3.00
3	Facsimile Expense			10.00
Total Variable Cost				18.00

Source: Computed by Using Company Data

Therefore, the total inventory ordering cost is calculated in this equation:

1. Fixed Cost — Fixed Cost in year 2010 / No. of Orders
   2,254,000.00 baht / 63 orders baht 35,777.78
2. Variable Cost — 18 baht per order
3. The total inventory ordering cost = Fix Cost + Variable Cost (35,777.78+18)

Therefore, the total inventory cost is 35,795.78 baht per order.

4.1.2 Calculate the Inventory Carrying Cost of Product AA

4.1.2.1 Calculate the Physical Holding Cost of Product AA in All Warehouses

Product AA is contained in all three warehouse, for supporting customers on time. Thus, calculation of the related expense e.g. operational cost of storing, must be estimated for all warehouses.

4.1.2.1.1 Calculate the Physical Holding Cost of Product AA in Warehouse No. 1

Calculating the physical holding cost related with the expense of the warehouse, is illustrate in Table 4.2, Table 4.3, and Table 4.4.

Table 4.2: Expense of Warehouse No. 1 in 2010

No.			uantity	Fix Cost Bala / Year
1	Salary Expense	Warehouse Manager	1 person	240,000.00
		Officer	2 persons	240,000.00
		Worker	2 persons	156,000.00
2	Depreciation Expense	Computer	2 machines	18,000.00
		Warehouse		25,000.00
		Forklift	2 machines	70,000.00
3	Other Expenses			35,000.00
	ota	r.		4;006*

Source: Computed by Using Company Data

As illustrated in Table 4.2, after the annual expenses of Warehouse No. 1 is estimated, we can calculate the physical holding cost per ton, as below:

1. Annual expenses of warehouse no. 1 = baht 784,000.
2. Total amount of all products stored = 750 tons.
3. Physical holding cost = 784,000 / 750 = 1,045.33 baht / ton in year 2010.

4.1.2.1.2 Calculate the Physical Holding Cost of Product AA in Warehouse No. 2

Table 4.3: Expense of Warehouse No. 2 in 2010

		[illegible]	a [illegible]	IX Cost [illegible] Year
1	Salary Expense	Warehouse Manager	1 person	240,000.00
		Officer	2 persons	600,000.00
		Worker	2 persons	936,000.00
2	Depreciation Expense	Computer	5 machines	45,000.00
		Warehouse		100,000.00
		Forklift	10 machines	420,000.00
3	Other Expenses			50,000.00
	Total			2,391,000.00

Source: Computed by Using Company Data

As illustrated in Table 4.3, after the annual expenses of Warehouse No. 2 are estimated, we can calculate the physical holding cost per ton as below:

1. Annual expenses of Warehouse No. 2 = baht 2,391,000.
2. Total amount of all products stored = 3,000 tons.
3. Physical holding cost = 2,391,000 / 3,000 = 797 baht / ton in year 2010

4.1.2.1.3 Calculate the Physical Holding Cost of Product AA in Warehouse No. 3

Table 4.4: Expense of Warehouse No. 3 in 2010

No.		etai	11antity	Baht / Year
1	Salary Expense	Warehouse Manager	1 person	240,000.00
		Officer	2 persons	1,200,000.00
		Worker	2 persons	1,560,000.00
2	Depreciation Expense	Computer	5 machines	45,000.00
		Warehouse		200,000.00
		Forklift	20 machines	700,000.00
3	Other Expenses			100,000.00
otal				4.045.000.00

Source: Computed by Using Company Data

As illustrated in Table 4.4, after the annual expenses of Warehouse No. 3 are estimated, we can calculate the physical holding cost per ton as below:

1. Annual expenses of Warehouse No. 3 = baht 4,045,000.
2. Total amount of all products stored = 5,250 tons.
3. Physical holding cost = 4,045,000 / 5,250 = 770.48 baht / ton in year 2010.

4.1.2.2 Calculate the Opportunity Cost

Opportunity cost can be determined by using the minimum loan rate (MLR) as a reference. In this study, the average of Bangkok Bank's MLR in 2010 is used, as in Table 4.5

Table 4.5: Bangkok Bank's Minimum Loan Rate in 2010

Month	Minimum Loin Rate (MLR)
January	5.88%
February	5.88%
March	5.88%
April	5.88%
May	5.88%
Jun	5.88%
July	6.00%
August	6.00%
September	6.00%
October	6.00%
November	6.00%
December	6.13%
Average Minimum oan Rate	55%

Source: Bangkok Bank (Retrieval Date Sep 25, 2011)

The opportunity cost of holding is calculated by multiplying the average minimum loan rate by the average purchased cost per ton of product AA, as illustrate in Table 4.6.

Table 4.6: Opportunity Cost per Ton of Product AA in Year 2010

Average Price (Baht)	Average MLR	Opportunity Cost (Baht/Ton/Year)
23,000	5.95%	1,368.50

Source: Computed by Using Company Data

The total carrying cost per ton in year 2010 of product AA in all warehouses can be specified by calculation of the physical holding cost and opportunity cost per ton in year 2010, as in Table 4.7

Table 4.7: Carrying Cost per Ton of Product AA for All Warehouses in 2010

Warehouse	Physical Holding Cost	Opportunity Cost	Carrying Cost
	Baht/ Ton / Year	Baht / Ton / Year	Baht/ Year
No. 1	1,045.33	1,368.50	2,413.83
No. 2	797.00	1,368.50	2,165.50
No. 3	770.48	1,368.50	2,138.98

Source: Computed by Using Company Data

4.1.3 Calculate the Economic Order Quantity (EOQ) and Reorder Point (ROP) of Product AA.

4.1.3.1 The EOQ is calculated by the formula below (as explained in chapter 2).
When all variables are substituted in the above formula, the EOQ is determined as illustrated in Table 4.8

Table 4.8: Economic Order Quantity (EOQ) of Product AA for All Warehouses

Annual Consumption **(D)**	3,850.00	4,500.00	5,900.00	Tons
Ordering Cost (S)	35,795.78	35,795.78	35,795.78	Baht / Order / Year
Carrying Cost (r+h)C	2,413.83	2,165.50	2,138.98	Baht / Ton / Year
EOQ	338	386	**444**	**Ton / Order**

Source: Computed by Using Company Data

Example 4.1: According to Table 4.8, EOQ of Product AA for Warehouse No. 1 can be calculated as below:

EOQ = 338 tons

Example 4.2: According to Table 4.8, EOQ of Product AA for Warehouse No. 2 can be calculated as below:

EOQ = 386 tons

Example 4.3: According to Table 4.8, EOQ of Product AA for Warehouse No. 3 can be calculated as below:

EOQ = 444 tons

4.1.3.1 Calculate the Safety Stock (SS)

In this study, the value of $Q^2 LT$ is equal to zero. It means that there is no variability in replenishment lead time because product AA is delivered to the company from the supplier within 30 days every time after issue of an order. Therefore, the safety stock can be determined as:

$$SS \quad z\sqrt{VLT\sigma_d^2}$$

The safety stock (SS) of all warehouses can be calculated as the Table 4.9

Table 4.9: Safety Stock (SS) of Product AA for All Warehouses

Warehouse	Total Demand (Tons)	Average Demand (Tons)	Variance of Demand per Day (Tons)	Safety Stock (Tons)
No. 1	3,850.00	320.83	0.41	$1.65 \times \sqrt{0 \times 0.41} = 6$
No. 2	4,500.00	375.00	0.32	$1.65 \times \sqrt{30 \times 0.32} = 5$
No. 3	5,900.00	491.67	0.49	$1.65 \times \sqrt{30 \times 0.49} = 6$

Source: Computed by Using Company Data

4.1.3.2 Calculate the Reorder Point (ROP) of Product AA

The ROP calculation will be related to the safety stock (SS) to prevent any stock-out in the business. So it will be calculated as follows:

$$ROP = d \times LT + SS$$

Table 4.10: Reorder Point (ROP) Product AA for All Warehouses

Variable	Warehouse No	Warehouse o	Warehouse No. 3	Unit
Consumption per Year	3,850.00	4,500.00	5,900.00	Tons / Year
Consumption per Day	10.55	12.33	16.16	Tons / Day
Replenishment Lead Time	30	30	30	Days
Demand during Replenishment Lead Time *(LTD)*	316.50	369.90	484.80	Tons
Safety Stock (SS)	6	5	6	Tons
Reorder Point (ROP)	322 5	374	490.80	Tons

Source: Computed by Using Company Data

Example 4.4: According to Table 4.10, ROP of Product AA in Warehouse No. 1 can be calculated as below:

ROP = (10.55 x 30) + 6

ROP = 322.50 tons

Example 4.5: According to Table 4.10, ROP of Product AA in Warehouse No. 2 can be calculated as below:

ROP = (12.33 x 30) + 5

ROP = 374.90 tons

Example 4.6: According to Table 4.10, ROP of Product AA in Warehouse No. 3 can be calculated as below:

ROP = (16.16 x 30) + 6

ROP = 490.80 tons

4.2 Simulation of the Ordering Process

After all associated data is calculated, it is used in the simulation model. There are two parts in the ordering process simulation:

4.2.1 Fill in the Calculation Part

The calculation part has been corrected the historical data by including the following quantities.

- New order
- Stock on hand
- Dispatch from warehouse to customers.
- Accumulated stock on hand

All the data above has been collected for each day.

4.2.2 Fill in the Conclusion Part

The conclusion part has conclude the main data by including the following quantities.

- Lead time
- Reorder Point
- Optimal order quantity
- Average accumulated stock on hand

The all data above has been collected for each day.

4.3 Comparison of the Total Inventory Cost between the Current and Proposed Economic Order Quantity (EOQ)

After simulating the ordering process, this study compares the total inventory cost in 2010 between the current ordering and the proposed economic order quantity (EOQ) model. Then, this study selects the ordering policy that has the lower total inventory cost. The costs to be compared are:

- Ordering cost in Year 2010
- Carrying cost in Year 2010
- Total inventory cost in Year 2010

4.3.1 Compare Ordering Cost between Current and Proposed Economic Order Quantity (EOQ) Model.

In general, the number of orders directly affects the inventory cost because if the company places more orders for the product, the ordering cost increases. On the other hand, if the company places fewer orders, the ordering cost is lower. Therefore, this study must compare the number of orders and annual ordering cost between the current ordering and the proposed economic order quantity (EOQ) model.

The number of orders can be calculated by counting the number of planned orders after simulating the ordering process. The total ordering cost calculation is explained in examples 4.7, 4.8, and 4.9

Example 4.7: Ordering Cost of Product AA for Warehouse No. 1 can be calculated as below:

Current Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 22)

= Baht 36,191.78

Proposed Economic Order Quantity Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 10)

= Baht 35,975.78

Example 4.8: Ordering Cost of Product AA for Warehouse No. 2 can be calculated as below:

Current Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 20)

= Baht 36,155.78

Propose Economic Order Quantity Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 9)

= Baht 35,957.78

Example 4.9: Ordering Cost of Product AA for Warehouse No. 3 can be calculated as below:

Current Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 21)

= Baht 36,173.78

Propose Economic Order Quantity Ordering Cost

Fix Cost + (Variable Cost x Number of Orders) = 35,795.78 + (18 x 11)

= Baht 35,993.78

The total ordering cost can be determined by multiplying the number of orders with the ordering cost per order, using the two components of fixed cost and variable cost.

This study can conclude that the total ordering cost of economic order quantity is lower than the total ordering cost of current ordering for all warehouses.
According to Table 4.11, there is a different value when only variable cost is applied the economic order quantity ordering.

Table 4.11 Comparisons of the Cost between Current Ordering and Proposed Economic Order Quantity Ordering for All Warehouses

Warehouse	Current Ordering Process			Proposed Economic Order Quantity Ordering Process		
	Fix Cost (Baht)	Variable Cost (Baht)	Total Ordering Cost (Baht)	Fix Cost (Baht)	Variable Cost (Baht)	Total Ordering Cost (Baht)
No. 1	35,777.78	396.00	**36,173.78**	35,777.78	180.00	**35,957.78**
No. 2	35,777.78	360.00	**36,137.78**	35,777.78	162.00	35,939.78
No. 3	35,777.78	378.00	**36,155.78**	35,777.78	198.00	35,975.78

Source: Computed by Using Company Data

It can be concluded that the total ordering cost of product AA is baht 36,173.78 when warehouse no. 1 applied the current ordering. However, if warehouse no. 1 applies the economic order quantity the total inventory cost is baht 35,975.78. Therefore, total inventory cost is reduced by baht 198 or 0.55 percent. However, in term of the variable cost, it would be reduced from baht 396 to baht 180, or 54.55 percent.

Moreover, in warehouse no. 2 the total inventory ordering of product AA is baht 36,173.78 when the current ordering was applied. However, if we apply the economic order quantity the total inventory cost is baht 35,939.78. Therefore, the total inventory cost is reduced by baht 234, or 1.00 percent. However, in terms of the variable cost, it would reduce from baht 360 to baht 162, or 55.00 percent.

And also, in warehouse no. 3 the total ordering cost of product AA is baht 36,155.78 when the current ordering was applied. However, if we apply the economic order quantity the total inventory cost is baht 35,975.78.
Therefore, the total inventory cost is reduced by baht 180, or 0.50 percent. However, in terms of the variable cost, it would reduce from baht 378 to baht 198, or 47.62 percent.
Therefore, this study must compare the inventory carrying cost between the current ordering and the proposed one. It will be compared as explained in Table 4.12

Table 4.12: Comparisons of Total Inventory Carrying Cost of Product AA between Current Ordering Process and Propose Economic Order Quantity Ordering Process for All Warehouses

	Current Ordering Process			Proposed Economic Order Quantity Ordering Process		
Warehouse	Average Inventory (Tons)	Carrying Cost (Baht)	Total Inventory Carrying Cost (Baht)	Average Inventory Tons)	Carrying Cost (Baht)	Total Inventory Carrying Cost (Baht)
No. 1	266.49	2,413.83	**643,262.45**	230.11	2,413.83	555,446.20
No. 2	950.55	2,165.50	**2,058,411.58**	280.10	2,165.50	**606,553.58**
No. 3	829.59	2,138.98	**1,774,471.21**	264.88	2,138.98	**566,576.70**

Source: Computed by Using Company Data

Actually, the total inventory cost should consist of three components, the total ordering cost, total inventory carrying cost and stock out cost. But in ABC, they never have a stock out problem, since 2006. So the stock out cost is zero.

4.3.2 Compare Total Inventory Cost between Current and Proposed Economic Order Quantity Ordering.

Tables 4.13 and 4.14 explain differences between the current ordering and economic order quantity ordering for total ordering cost, total inventory carrying cost and total inventory cost of all warehouses.

Table 4.13: Total Inventory Cost of Current Ordering Process in 2010

	Current Ordering Process		
Warehouse	**Total Ordering Cost (Baht)**	**Total Inventory Carrying Cost (Baht)**	**Total Inventory Cost (Baht)**
No.1	36,173.78	643,262.45	**679,436.23**
No.2	36,137.78	2,058,411.58	**2,094,549.36**
No.3	36,155.78	1,774,471.21	**1,810,626.99**

Source: Computed by Using Company Data

Table 4.14: Total Inventory Cost of Economic Order Quantity Ordering Process in 2010

	Economic Order Quantity Ordering Process		
Warehouse	**Total Ordering Cost (Baht)**	**Total Inventory Carrying Cost (Baht)**	**Total Inventory Cost (Baht)**
No.1	35,957.78	555,446.20	**591,403.98**
No.2	35,939.78	606,553.58	642,493.36
No.3	35,975.78	566,576.70	602,552.48

Source: Computed by Using Company Data

Tables 4.13 and 4.14 can compare costs in Warehouse no. 1. In the current ordering process the total inventory cost of product AA is baht 679,436.23. On the other hand, with the economic order quantity process, the total inventory cost of product AA is only baht 591,403.98.

Furthermore, for Warehouse no. 2, in the current ordering process the total inventory cost of product AA is baht 2,094,549.36. On the other hand, in the economic order quantity process the total inventory cost of product AA is only baht 642,493.36.
And also in Warehouse no. 3, in the current ordering process the total inventory cost of product AA is baht 1,810,626.99. On the other hand, in the economic order quantity process the total inventory cost of product AA is only baht 602,552.48.

4.4 Summary

According to Table 4.15, after applying economic order quantity (EOQ), the ABC company can reduce its total inventory cost of product AA. It can be concluded that Warehouse no. 1 can obtain an annual cost saving of baht 88,032.25, or 12.96 percent. Warehouse no. 2 can obtain savings of baht 1,452,056.00, or 69.33 percent. Warehouse no. 3 can obtain annual cost saving of baht 1,208,074.51, or 66.72 percent.

Table 4.15: Conclusion: the Total Inventory Cost in 2010

Warehouse	Current Ordering Process	Proposed Economic Order Quantity Ordering Process	Annual Saving Cost	
	Total Inventory Cost (Baht)		Value (Baht)	Percentage (%)
No. 1	679,436.23	591,403.98	**88,032.25**	**12.96**
No. 2	2,094,549.36	642,493.36	**1,452,056.00**	**69.33**
No. 3	1,810,626.99	602,552.48	**1,208,074.51**	**66.72**

Source: Computed by Using Company Data

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The research question that "What are the appropriate quantity and time to reduce the total inventory cost of ABC Company?" incorporates the main objective of this study. Clarification that can answer this research question will be presented in this chapter.

5.1 Summary of the Findings

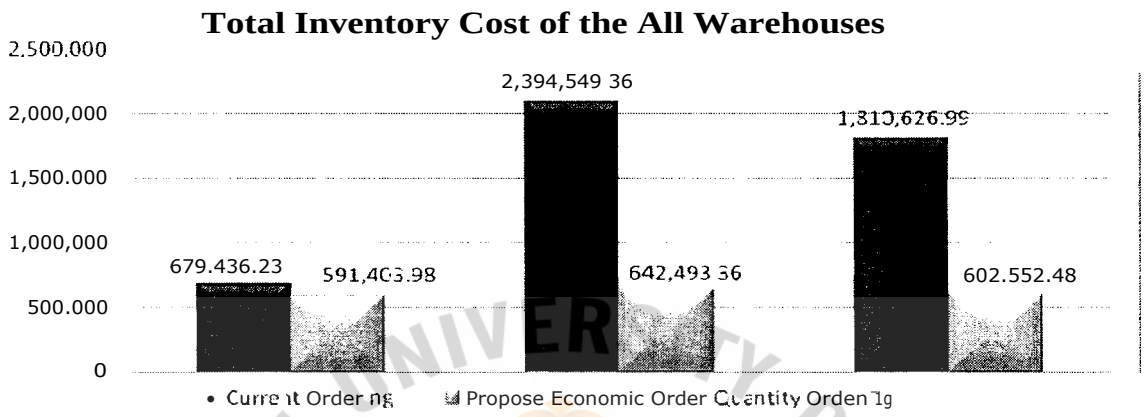
In conclusion, the major findings obtained from this study are as follows:

1. There are five products in ABC, so they were categorized in degrees of importance in ABC by ABC inventory control. The highest cost volume usage product, product AA, was selected because according to Figure 3.2, product AA has the highest cost volume usage product with annual cost volume usage baht 22,666,500.00 which accounts for 51.82 percent of total annual cost volume usage. Therefore, this study selected product AA as the pilot project to develop an inventory management system for the ABC company.

2. According to the variability coefficient (VC) concept, if the consumption pattern is constant, it is possible to apply the economic order quantity model. After investigating the demand pattern, product AA's VC value was less than 0.25, which meant that the consumption pattern of Product AA in all three warehouses made it appropriate to apply the economic order quantity model.

3. According to Figure 5.1, it is possible to apply economic order quantity to reduce the total inventory cost in ABC. Simulation was necessary to compare and collect the necessary data about the total inventory cost. Comparison was made between the current ordering and proposed economic order quantity ordering in each warehouse.

Figure 5.1: Comparisons of Total Inventory Cost of Product AA between Current Ordering Process and Economic Order Quantity Ordering Process for All Warehouses

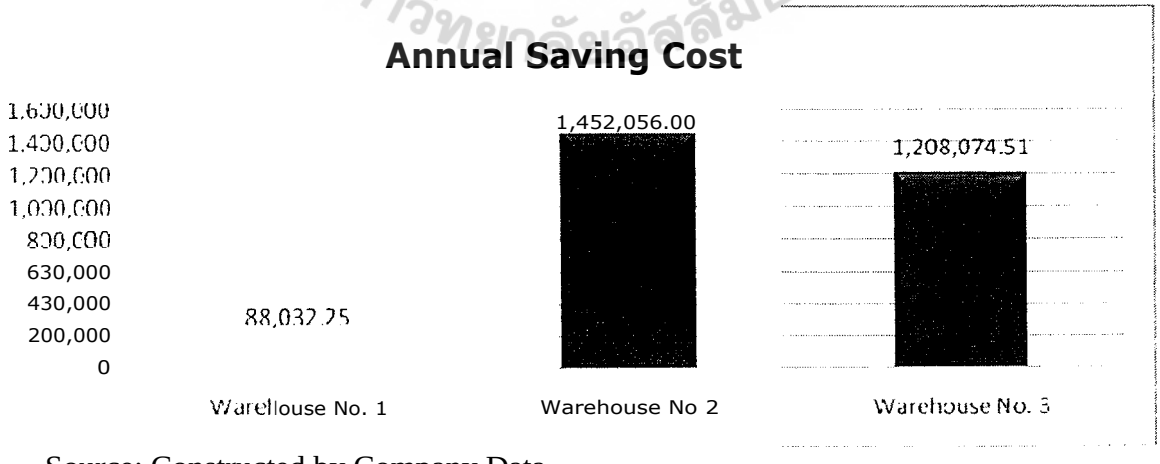


Source: Constructed by Company Data

5.2 Conclusions

According to Figure 5.2, ABC company can minimize the total inventory cost of product AA in all warehouses after applying the economic order quantity ordering process, saving baht 2,748,162.76, or 59.94 percent.

Figure 5.2: Totally Annual Cost Saving in the All Warehouses after Applying Economic Order Quantity (EOQ)



Source: Constructed by Company Data

Moreover, it would increase the efficiency of manpower when operating with the right quantity and timing for orders.

5.3 Theoretical Implications

There are only two main theories in this research

- Economic order quantity
- Reorder point

It would be very beneficial for the ABC company to control and manage the inventory because it can verify and clarify the research question as to what are the appropriate quantity and time for order. Other researchers could study these theories and concepts in order to adjust or improve the inventory management in other businesses. It would be advantageous to minimize the total inventory cost as the main problem in many businesses.

5.4 Managerial Implications

From theoretical implications, it would be advantageous for management to make the following improvements.

- **Cost Management**

It would benefit the ABC company to reduce the total inventory cost of the selected product because it can identify the appropriate quantity and time for ordering, based on the total inventory cost of the selected product. After applying economic order quantity, ABC can decrease the total inventory cost by 59.94 percent.

- **Financial Management**

EOQ increases the inventory turnover of the selected product because the relevant theory is available to operate stock control. So it would be possible for ABC to increase the efficiency of financial management by decreasing the average inventory of the three warehouses by 62.13 percent.

Moreover, it would be convenient for ABC to apply this technique to another product which could increase the financial flexibility also.

5.5 Limitations and Recommendations for Future Research

5.5.1 Limitations of this Research

In reality, the consumption might change from the usual customer demand, so the ABC company should concentrate on analyzing the consumption pattern. It would be convenient and prevent any mistakes in the economic order quantity and reorder point calculations.

5.5.2 Recommendations for Future Research

This research focused only on the quantitative factors. However, it is necessary to consider the qualitative factors about ordering in the purchasing department because the current ordering situation in ABC is separate for each warehouse. The weak point of current ordering in the purchasing department is lack of centralizing the management and control of the operation of purchasing tasks. Moreover, it causes decreased power in negotiations with the supplier.

Thus, it would benefit ABC to focus on the centralization of purchasing in order to get more advantage for the company. Reading the case study of Procter & Gamble (P&G, NYSE: PG) might help. Its purchase division worked in union with GBS and made R&D the backbone of supply chain management. It linked the gap between suppliers and the R&D team by developing a new product formula and new packaging for the products. These were packed in half the size of the original ones, but with enough detergent to do the same load while saving on fuel consumption, warehouse space, and quantity packed and packaging material.

It an advantage for P&G purchasers to be much more than a cost-management leader. The organization is a strategic business partner that drives innovation, creates key alliances, and enables business agility and financial flexibility.

Thus, ABC company should focus on the qualitative factors about consolidating the purchasing department as in the case of P&G, in order to improve the ordering process of each warehouse. It will be vital for ABC to get more efficiency of management in their business in the future.

BIBLIOGRAPHY

Ballard, R. (1996). *The Managing of business process flows, principles of operation management.* New Jersey: Pearson Prentice Hall. 7th edition.

Bangkok Bank (n.d.). *Loan Rates.* Retrieved on September 25, 2011, from http://www.bangkokbank.com/Bangkok%20Bank%20Thai/Web%20Services/Rates/Pages/Laon%20Interest%20Rates.aspx

Chun, C., & Huang, K. (2002). Optimal replenishment policies for EOQ inventory model with limited storage capacity under permissible delay in payment. *Journal of Operational Research,* 41(1), 55-59.

Edward, A. (2009). *The Management of Business Logistics and Supply Chain Perspective.* Canada: South-Western. 5th edition.

Evan, L. (1985). Investing in Reduce Setups in the EOQ Model. *International Journal of Logistics Management,* 29(1), 998-1010.

Hariga, K. (1994). Optimal EOQ models for deteriorating items with time-varing demand, *Journal of the Operational Research Society,* 63(1), 1009-1200.

Jon, J. (2001). Managing inventories: What is the appropriate order quantity? *Supply Chain Management: An International Journal,* 25(1), 120-125.

Krishna, K. (2007). Optimal retailer's ordering policies in EOQ model under trade credit financing, *Journal of the Operational Research Society,* 48(3), 850-1008.

Krupp, Y., & James, A. (1994). *The Measuring Inventory Management Performance. Production and Inventory Management.* Ohio: South-Western. 2nd edition.

Peterson, R., & Silver, A. (1979). *Decision System for Inventory Management and Production Planning.* New York: John Wiley & Sons. 2"d edition.

Piasecki, 0. (2009). *Principle of inventory and materials management.* New York: McGraw-Hill. 9th edition.

Procter & Gamble (n.d.). *Logistics Revolution Co-creating Value Free Case.* Retrieved on October 10, 2011, from http://www.P&G.com/P&G Considers Consolidating Purchasing Efforts Management Consulting Case Interviews.mht

Render, B., & Hanna, M. (2008). *Quantitative Analysis for Management.* New Jersey: Pearson Prentice Hall. 10th edition.

Simchi, L., & Kaminsky, P. (2008). *Designing and managing the supply chain: Concepts, Strategies, and Case Studies.* New York: McGraw-Hill. 3rd edition.

Vollman, T., Berry, W., Whybark, D., & Jacobs, F. (2005). *Manufacturing planning and control for supply chain management.* New York: McGraw-Hill. 8th edition.

Weiss, H., & Mark, E. (1989). *Production and Operations Management.* Boston: Allyn and Bacon. 4th edition.

Wisner, J., Keong, G., & Tan, C. (2008). *Principles of supply chain management – A Balanced Approach.* Ohio: South-Western. 2nd edition.