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INVENTORY MANAGEMENT OF STEEL RETAILER

By
NUANTHIP PARAMANGKOON

A Final 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
Bangkok, Thailand

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Martin de Tours School of Management and Economics
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Declaration of Authorship Form

I, Nuanthip Paramangkoon ,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 Steel Retailer

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2. Where any part of this dissertation has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
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ADVISOR'S STATEMENT

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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(Assoc. Prof. Dr. Wuthichai Wongthatsanekorn)

Date ______________________________

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my advisor, Asst. Prof. Dr. Wuthichai Wongthatsanekorn, for the continuous support in this study, for his guidance and patience which helped me in all the time spent studying and writing this report.

Besides my advisor, I would like to thank to the members of the examination committee, Asst. Prof. Dr. Nucharee Supatn and Dr.Piyawan Puttibarncharoensri for their valuable guidance and suggestions which made me have a better understanding of the clear method to complete this graduate project.

Finally, I would like to thanks to my family for their support, understanding and love through the duration of my study.

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ABSTRACT

Nowadays, there is high competition in every business. As inventory is the important key for trading businesses, thus, managing the amount of inventory is important to find the suitable amount to reduce expenditures from storage costs and stock carrying costs. As a result, the profits of the company can be increased and, the competitive power of the business can also be increased. In this project, Economic order quantity (EOQ) was chosen for managing inventory in the ABC company. The scoped inventory for this project are fives products those generated first 80 percent of total revenue. Therefore, the research question of this project is "Can economic order quantity reduce total inventory costs and which numbers are optimal order quantities for ABC Company?" The total inventory cost in this project consists of total ordering cost and total carrying cost.

Before applying the EOQ model, it is needed to make sure whether demands of selected products are suitable for the model or not. The demand patterns are tested their consistent by using variability coefficient (VC). The VC of selected products was below 0.25, which means EOQ is suitable.

Next, the total inventory ordering cost, total carrying cost were calculated to determine EOQ, safety stock (SS), and reorder point (ROP). The EOQ ordering process was then simulated. Then the total inventory cost of the current ordering process was compared with the EOQ ordering process. The results indicated that EOQ is appropriate as it had a lower total inventory cost compared to the current ordering policy.

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and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

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CHAPTER I

GENERALITIES OF THE STUDY

Nowadays, there is high competitive atmosphere in every business, thus every company needs to apply new techniques or tactics to survive and grow. Consequently, we cannot deny that management has a crucial role as the tool to improve activities in order to reach the business goals. Inventories, which are counted as costs of company, influence a company's ability to generate profits and opportunity to generate additional income.

Inventory management is a very important key to make a company profitable. Thereby, efficiency in inventory management could balance out between carrying costs and ordering costs which need appropriate numbers of products in order to avoid unnecessary stock holding costs making the inventory will flow better.

1.1 Background of the Study

ABC Company is a steel retailing company. It runs its business as a retailer selling instant shaped steel since 1983. Located in the Rangsit area of Pathumthani province, the company's target customers are medium sized enterprises including machine shops and local constructing companies around the Pathumthani province, especially Rangsit area and, Navanakorn industrial zone and the provinces nearby. The company positioned itself as a middle-man between wholesalers and customers by purchasing from wholesalers then selling the products to retail customers. It earns from fast selling with a short-run stock holding policy.

ABC company purchases the products from the wholesale company in Thailand and stock the inventory in its wn warehouse located in same place as the office. The company has never applied historical sales data whenever it purchases the products.

In the sale department, the company strongly emphasizes the available stock on hand according to serving customer requirements. Due to a lack of effective inventory management, the company faces over-stock situations that make the company lose the opportunity to use money in another activities, likes expanding product lines or any other investments. Furthermore, the company has limited storing space so the inventory levels should be at the optimal numbers. However, to offer inventory management tools, the management must realize the services that customers get such as the product should available in stock and the customers do not have to wait for a long time etc. So the more the company can do to decrease inventory, the more it gets advantages while increases efficiency of its inventory management and gain more opportunities against the competition.

1.2 Statement of the Problem

Despite the company stressing on fast sales with a short-run stock holding policy, the problem from a high inventory level is found. The main problems are the lack of functional planning from concerned departments including sales and purchasing and effectiveness of inventory management. Consequently, inventories are accumulated until the warehouse has inadequate space. In addition, the capital is cumulatively tacked on to inventory. So, it is necessary to place an importance on fine-tuning the over-stock situations in order to increase efficiency, reduce costs and gain more capital for other activities.

In every business, availability of products is important for responding the customers' requirement, so the company needs to stock inventory in certain sizes and shapes for quickening its services.

As inventory is the stored products which have flow; incoming units from replenishment, stored unit waiting for the customers' demand, and outgoing units by sales transactions. Determining the company's trends to have much more inventory than it really needs or not, inventory turnover which is the ratio between total revenue and total inventory value may fluctuate.

Table 1.1: ABC Company's Inventory Turnover of 2010 to 2013

	2010	2011	2012	2013
Total Revenue (Baht)	39,257,524.74	32,354,132.56	40,048,135.78	36,423,145.63
Total Inventory Value (Baht)	6,414,628.22	6,684,738.13	10,043,600.54	10,852,345.59
Inventory Turnover	**6.12**	**4.84**	**3.99**	**3.36**
Changing Percentage	-	-21%	-18%	-16%

Source: ABC company data

Low inventory turnover indicates an over-stock of the company. This is ABC company's over-stock problem. Table 1.1 shows inventory turnover of 2011 decreasing about 21% from 2010, decreasing again about 18% from 2011 in 2012, then recently decreasing around 16% from 2012 to 2013. Inventory turnover is in a downturn because the proportion of inventory by total revenue increases continuously. It means that the ability of sold and replaced inventory for revenues is decreased. So, the products are stocked and not sold too often. This situation is costly for the company.

Table 1.2: ABC Company's Inventory Ratio of 2012

Product Code	Inventory Value (Baht)	Percentage of Inventory	Total Sale Revenue (Baht)	Percentage of Sale Revenue
P01	1,960,539.00	19.52%	9,221,392.69	23.03%
P02	580,182.63	5.78%	4,757,879.63	11.80%
P03	743,888.00	7.41%	5,466,601.59	13.65%
PO4	919,463.10	9.15%	8,129,758.36	20.30%
P05	744,577.84	7.41%	4,273,296.76	10.67%
P06	109,712.75	1.09%	24,457.15	0.06%
P07	72,111.33	0.72%	95,391.25	0.24%
P08	50,842.40	0.51%	4,128.06	0.01%
P09	134,192.82	1.34%	3,947.22	0.01%
P10	179,888.00	1.79%	84,597.78	0.21%
P11	77,860.35	0.78%	90,242.52	0.23%
P12	60,556.20	0.60%	172,014.58	0.43%
P13	238,436.00	2.37%	143,715.79	0.36%
P14	271,125.90	2.70%	253,837.77	0.63%
P15	256,436.16	2.55%	186,599.72	0.47%
P16	250,993.80	2.50%	188,088.02	0.47%
P17	269,575.56	2.68%	429,811.96	1.07%
P18	275,647.16	2.74%	204,015.63	0.51%
P19	232,460.28	2.31%	153,869.25	0.38%
P20	275,474.16	2.74%	797,046.90	1.99%
P21	409,132.85	4.07%	174,531.63	0.44%
P22	154,660.89	1.54%	259,843.34	0.65%
P23	206,762.66	2.06%	446,392.94	1.11%
P24	306,771.92	3.05%	239,654.10	0.60%
P25	236,956.64	2.36%	706,076.29	1.76%
P26	75,481.00	0.75%	455,656.53	1.14%
P27	276,530.49	2.75%	706,076.29	1.76%
P28	99,139.95	0.99%	560,693.42	1.40%
P29	338,380.50	3.37%	1,252,289.15	3.13%
P30	235,820.20	2.35%	566,229.46	1.41%
Total	10,043,600.54	100%	40,048,135.78	100%

Source: ABC company data

As shown in table 1.2, available inventory of each product is related directly to sales revenue. It means the more products generate revenue, the higher inventory found. For instance, product code P01 generates 23% of total revenue while its storage is 20% of total inventory. Conversely, product code P25 shares only 2% of total inventory and also generates 2% of total revenue.

Certain products like product code P06 to P13 are able to generate only a few percent of revenue whereas the inventory levels are higher. While product numbers P02 to P05 generate high revenue among all products but their inventories are less. Consequently, inventory management should be applied with the propose of allocating the stored value to match-up to the revenue.

However, the total sales annual revenue is 40,048,135.78 baht but total available inventory is 10,043,600.54 baht, which is around 25% of total sales revenue. It is quite high and leveraged against the company's financial condition.

As the company's supplier requires a minimum order quantity, so the company must purchase such a big amount per order which leads the company to face problems from batch sizes. Historical sales data and forecasting is essential for inventory replenishment whereas the company has never mentioned them. So, the mistakes from ordering numbers which do not match sales volume usually occur. This situation accentuates the company's over-stock situation again after the first time from ordering big batch sizes. Then, the company's main problem comes from overstock situations from this policy.

Overstock affects the company because ABC Company is a steel retailer business which has inventory value which relates directly to the inventory weight. That's why costs from holding inventory are important for the company to gain profits or losses. In a direct way, overstocks will gradually increase carrying costs from the stock value and probably add more costs to stored inventory like loan interest, land space or new warehouse rental fee.

With the adaptation of an inventory management policy as a tool, products availability is important to be concerned with. The products should be in stock in order to serve the customers promptly and not to make the customers wait. Optimization of inventory volume will make the company have more efficiency of its inventory management and a competitive advantage also. This study aims to answer the study question "Can economic order quantity reduce total inventory costs and which numbers are optimal order quantities for ABC Company?"

1.3 Research Objectives

The objective for this research is studying about inventory management and applies the tools to ABC Company as efficiently between costs of order and quantity of steel. The main objectives of the study are:

1.3.1 To classify the product category for arranging the priority of products for scoping inventory control.

1.3.2 To apply Economic Order Quantity (EOQ) in order to reduce inventory level and total inventory costs.

1.4 Scope of the Research

There are two shapes of steel which the company sells including instant shape steel and custom shape steel. Since ABC Company is a steel retailer the customers sometimes require steel in custom shape which needs cutting services. The selling of product will be separated into small pieces so it is impossible to check this product's inventory. Thus, this study will scope only instant shaped steel which provides high sales revenue based on ABC's inventory classification. The analysis uses historical data about purchasing orders and selling volume data of instant shaped steel for 2 year since the beginning of 2012 to the end of 2013.

Furthermore, the possibility of selecting the economic order quantity method will be checked by calculating variability coefficients.

1.5 Significance of the Research

This study focuses on applying Economic Order Quantity (EOQ) for ordering the selected products at an optimal quantity. The appropriate order quantities will affect the company's spending on inventory costs. There is useful information for trading companies to gain more of an understanding about the benefits from applying EOQ as an inventory management tool.

1.6 Limitations of the Research

The in-depth information concerning with the profits and losses such as holding assets information and total products claimed or refunded are confidential information, so they cannot be collected.

1.7 Definition of Terms

ABC Inventory Control	The technique to classify inventory into groups through product prices and sales volume in to optimized stock numbers with customers demand (Edward, 2009).
Economic Order Quantity (EOQ)	The inventory management tools for improvement in purchasing and procurement systems by balancing the costs of stocking inventory and costs of transactions in order method (Hariga, 1994).
Inventory	All kinds of products in the company which were stocked in the company's space to serve the market or customer requirements and include the risk of fluctuation from the market (Peterson & Silver, 1994).

Inventory Cost	The cost which comes from composition of ordering costs, carrying costs and shortage costs (Coyle, Bardi, & Langley, 2002).
Inventory Management	It is the management of the flow of inventory to balance inventory supply and demand (Coyle et al., 2002).
Safety Stock	The number of inventory which the company hold more than usual demand for assuring the products have enough to serve customers whenever supply or demand was changed (Render et al., 2006).
Variability Coefficient (VC)	The method used to identify which data is relatively stable or unstable (Peterson & Silver, 1994).

CHAPTER II

REVIEW OF RELATED LITERATURE

Inventory is one of the elements that is important to the company. It is a necessary for company to advert since it has the highest value among current assets of the company. To purchase products as inventory, the company should consider many factors. Inventory does not have an effect on a company's profits only, but it also impacts customer satisfaction about services and timing. Consequently, inventory management has a crucial role and needs good management for cost savings or minimum costs at optimal amounts (Chaicharn, 2003).

2.1 Objective of Inventory Management

Suharitdamrong (2003) stated that inventory management aims to serve the pleasant services to customers by spending optimal operation costs. That's why inventory management means ranking the sourced products in order to respond to demands of the products with optimal carrying costs.

However, Edward (2009) declared that rapidly changing the business and competitive atmosphere of the market, kept inventory has a large impact on business processes. Inventory controls relate many departments of the company from the shop floor workers to the top positions. There are three reasons for storing inventory which are as follows:

2.1.1 Time: Lead Time

2.1.2 Uncertainty situations: Fluctuations in demand and supply

2.1.3 Economies of scales: Price

2.2 Types of Inventory

There are two concepts which are used for separating inventory types. It depends on considered point as follows:

2.2.1 Types of Inventory Separated by Demand

Inventory types which are declared by Suharitdamrong (2003) focus on demand sources of the inventory. Types of inventory separated by demand classify into two kinds, which are as follows:

2.2.1.1 Independent Demand Inventory

This kind of inventory refers to the inventory which has demand independent from the business's operation or another product's demand. The products have demand from their market directly e.g. car electric appliances etc. Using EOQ (Economics Order Quantity) and ABC Inventory Controls are suitable for the management.

2.2.1.2 Dependent Demand Inventory

This kind of inventory means inventory which has demand depends on another product's demand or component, like demand of raw materials or particles which are used for producing finished products. MRP (Material Requirement Planning) are selected commonly to manage these kinds of products.

2.2.2 Types of Inventory Separated by Ability to Response to Customers' Need

Every inventory in the supply chain needs the decision on stored amounts, stated by Hugos (2005). Ability to respond to customers' needs and efficiency in storing are important factors to be considered. Keeping inventory in big volumes makes companie able to respond quickly against demand fluctuations. Moreover, inventory storage has an effect on the costs of the company. Therefore, costs from inventory storage should be minimized. Basic decisions for the storing depend on the inventory categories as follows

2.2.2.1 Cycle Inventory

Cycle Inventory means the inventory which was stored to meet the needs of customers in the time of purchase. Buying in big amounts, the company will get economie of scale from average costs. Conversely, storing the inventory brings high costs also. Thus, the company has to make the decision between reducing costs by ordering in larger quantities or increase the cost from storing the inventory.

2.2.2.2 Safety Inventory

This kind of inventory means the inventory which a company stores as a buffer for uncertain demand or supply. Furthermore, the forecasting maybe inaccurate so the company has to keep more inventory to make the product available whenever customers need it. Accordingly, the company has to make decision by weighing the benefits between increasing costs by storing the inventory and cost of lost sales while inventory is not available to serve.

2.2.2.3 Seasonal Inventory

This kind of inventory comes from increasing demand which can be forecasted at the exact time. The inventory will be stored more in low demand periods then wait to serve the customers seasonally when production rates are lower than market demand. Another alternative is to invest in facilities and production machines in order to make the company have more flexibility to adapt production rates according to customer needs at once.

2.3 **Role of Inventory**

Render et al. (2006) stated that inventory is associated with functions that enhance the flexibility of the company. The important roles are:

2.3.1 To make the parts of the production process independent

When the material receive rate is not certainty, it is important to prepare inventory in order to deal with the situation.

2.3.2 To protect from the effect of demand changing

2.3.3 To gain the advantage from purchase discounts.

Because of ordering in large quantities, the company will get lower prices of materials or lower delivery costs.

2.3.4 To protect the company from inflation or price changed situation.

2.3.5 To protect the product of stock by keeping safety stocks.

2.4 Inventory Management System

Suharitdamroeng (2003) said that inventory management in general means accounting for inventory and counting the number of inventory. Since each business has various products with different characteristics called SKU's (Stock Keeping Unit). Therefore, counting the exact number of inventory within limited time has to use many employees to identify the out of stock items or nearly out of stock items. To prepare the availability of products then order in optimal numbers, the company needs to use a system for managing the inventory. There are three systems including:

2.4.1 Continuous Inventory System

This system has an accounting report every time the company has incoming or outgoing stock. The account is able to show actual available stock in inventory. This system is necessary to control important stock which cannot be out of stock. Applying computer systems are commonly found. Bar code or UPC (Universal Product Code) are attached on the product. The employee will use a laser scan on it to record incoming or out-going items. The tools are not only accurate but the recorded data can be used in another inventory items also.

2.4.1.1 Advantages of Continuous Inventory System

2.4.1.1.1 To minimize safety stock. Safety stock is kept only waiting period. Each item should keep a safety stock while waiting for reorder periods and waiting for the stock to come.

2.4.1.1.2 To get the discounts from ordering in constant amounts.

2.4.1.1.3 To make the stock checking easier because the data is specific especially high priced items.

2.4.2 Periodic Inventory System

This inventory management system has accounting reports within specific times like end of the week or month. Whenever certain numbers of product are sold, purchasing for replenishment is placed also. This system is suited for static demand products such as the book selling rate of a university's book store which is nearly to the number of registered students. So the book store has to prepare the stock according to the number of students.

2.4.2.1 Advantages of Periodic Inventory System

2.4.2.1.1 Uses less time and less costs than Periodic Inventory Systems.

2.4.2.1.2 Works properly with purchasing products from one seller but many lists. Since it reduces the cost from documentation, operation in purchasing is more comfortable to check the number of stock.

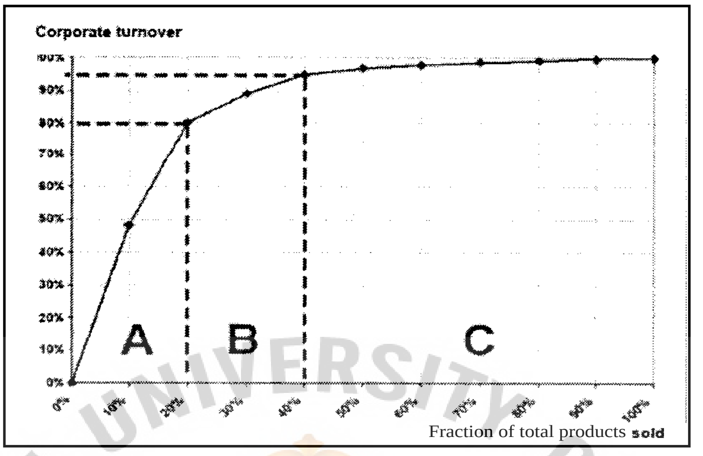
2.4.2.1.3 Lessen the costs from inventory data storing

2.5 Product Classification

Chase, Aquilana and Jacobs (2006) stated that ABC Classification is a tool which separates the different products from their contribution to the cooperate turnover. This tool is based on the 80/20 rule. The rule identify that about 20% of the effort is responsible about 80% of the product. Conversely, about 20% of the products provide turnover about of 80%.

Wannenwetsch (2006) informs of the difference between ABC Classification and Pareto Analysis by the number of separated groups. Since ABC Classification separates products in three groups as follows:

Figure 2.1: Diagram of ABC Classification



Source: Wannenwetsch (2006)

2.5.1 Differentiations of each group as follows:

2.5.1.1 Group A: Fraction of the total products about 15-25%. The products contribute to the corporate turnover at about 60-80%

2.5.1.2 Group B: Fraction of the total products about 30-40%. The products contribute to the corporate turnover at about 10-25%

2.5.1.3 Group C: Fraction of the total products about 40-70%. The products contribute to the corporate turnover at about 5-15%

Using ABC Classification to evaluate the most important inventory, items are found clearly resulting from the contribution of product group A generating the most corporate turnover. So, improving the inventory management of this group's items should be most considered because it will give the biggest effect to the company's performance.

2.6 Variability Coefficient (VC)

Peterson and Silver (1979) stated that variety of demand is caused by many factors. The Coefficient of Variation is required for demand pattern indicating. Then variability of coefficient can be calculated as the formulation follows:

$$d = \frac{1}{\,} \sum_{i=1} n$$

$$\text{Est. var D} = \frac{1}{n} \; {}_{i=1} \quad {}^{2} - d^{2}$$

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

Where;

= demand in period i

n = number of period

The value of the variability coefficient is able to indicate variability of demand patterns. A simple economics order quantity method can be applied when the value is lower than 0.25. On the other hand, if VC is higher than 0.25, the demand has too high of a variability to apply with the method.

2.7 Inventory Cost

According to Coyle, Bardi and Langley (2002), inventory cost can be separated into three main costs, which are:

Ordering Cost: Expenditure which the company should pay whenever the purchase order is placed. This cost does not relate to the number of inventory, instead it relates directly to the number of orders. Because the expense is still the same when the company orders in a large number. In contrast, the expense will be increased if the purchase orders are placed more frequently. For instance, expenses from documentation, employees' wages, telephone bill or shipping cost etc.

Carrying Cost: Expenditures which come from holding and storing inventories in the same condition. This cost relates directly to available inventory quantities and duration of storage e.g. interest from sunk cost etc.

Shortage Cost or Stock out Cost: The cost from having insufficient inventory to respond the production or customer needs. If the customers cancel orders, business will lose income that it should get. The company will lose credibility and the production parts will baulk. This cost relates inversely to the quality of holding inventory. The higher the quality of inventories, the less stock out situations will occur.

2.8 Economic Order Quantity (EOQ)

According to Mark et al. (2003), Economic Order Quantity or EOQ is the model that is applied for proper inventory items which do not need continual delivery or operation. Comparing holding costs to ordering costs will be considered.

Figure 2.2: Annual Product Costs Based On Size of Order

Source: Mark et al. (2003)

Economic Order Quantity is widely used. It proposes to manage independent demand inventory. Therefore, managed planning and demand forecasting should be considered individually.

The formula for Economic Order Quantity and Total Costs is shown below:

$$\mathrm{EOQ} = \sqrt{\frac{2CoD}{Cc}}$$

$$\mathrm{TC}_{\min} = \left|\frac{CoD}{Q}\right| + \left[\frac{QCc}{2}\right]$$

Where;

EOQ optimal number of units to order Q*

annual inventory demands (Units)

Co ordering cost of each order (Baht)

Cc = carrying cost per unit per year (Baht)

number of units to order

TC = total annual inventory costs (Baht)

Considering the formulation above, found that;

Ordering Cost per year = $\left[\quad\right]Co$

Carrying Cost per year $\left[\frac{O}{2}\right]Cc$

Ordering quantity $Q*$

Order Cycle = $\frac{Q*}{D}$

2.9 Re-order Point

Time has a crucial role for inventory purchasing also. The company should reorder in constant numbers (fixed order quantity) when the is inventory left in certain amounts. Thereby Anupindi et al. (2006) supported that the re-order point relates directly to two variables in the formulation below;

$$\mathbf{R} = (d \times L) + SS$$

Where;

R = Re-order Point

d = average demand per day (Units)

L = lead time

SS Safety Stock

Moreover, Ray and Millman (2007) supported that costs of stock out situations are difficult to estimate. Thus, service levels have been used for defining a service level.

2.10 Safety Stock and Service Level

Ray and Millman (2007) has explained them as follow;

Safety Stock

This kind of stock works as the buffer inventory when the inventory items are used and reduced to re-order points. Safety stock proposes to prevent shortages when demand for inventory items is higher than the availability. The company has to make a decision on re-order points then add the number of safety stock to re-order points. Safety Stock can be calculated by the formulation below;

$$\text{Safety Stock} = \sqrt{LT\sigma_d^2 + d^2\alpha_{LT}^2}$$

Where;

Z = Service level factor

LT = Average replenishment lead time

d = Average demand per unit of time

σ_d = Standard deviation of demand

σ_{LT} = Standard deviation of replenishment lead time

$$LT = LT \, I \, N$$

$$d = \sum_{i=1}^{n} d_i \, / \, N$$

$$\sigma_{LT}^2 = \sum_{=1} (LT_i - LT) \; / \, N$$

$$\sigma_d = \sum_{i=1}^{n} (d - d)^2 \, / \, N$$

Service Level

For safety and maintaining and conforming to quality requirements, the service level is method is applied in order to adjust the waiting time of replenishment. Whether a customer gets much satisfaction in serving products and services or not, it depends on how the company specifies the service level. This will cost the company inventory holding costs and a loss in opportunity to sell.

2.11 Approach to Determining the Safety Inventory

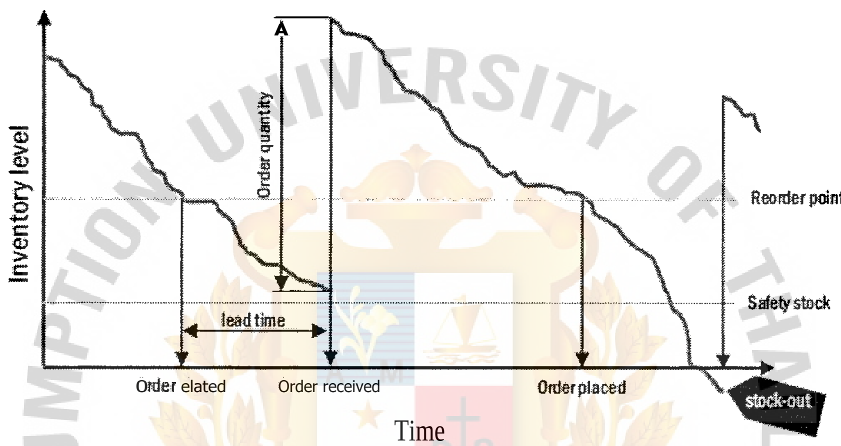
Laoprajong and Sritulchoti (1993) found four factors to specify the level of safety inventory or safety stock as follows:

1. The policy from managing departments. If the policy does not want to face out stock situation, it is necessary to determine the big numbers of inventory items. On the other hand, the company has to reduce inventory items if the policy aims to minimize costs.
2. The variation of demand for inventory items. Since demand is not constant, the requirement rate of inventory is an average demand.
3. Inventory management systems are used to determine purchase order quantities.
4. Lead time of replenishment.

Safety inventory or safety stock means a minimum inventory level which a business needs to keep in order to avoid out stock situations. Thus, adding safety stocks cause the formulation for re-order points below:

$$ROP = (L \times d) + \text{quantity of safety stock}$$

Figure 2.3: The Re-order Point



Source: Ravi (1999)

2.12 Related Research

In this section, the reviewed research for gaining more information and knowledge of Economics Order Quantity (EOQ) application in real case studies is reviewed. Certain studies propose the concepts as follow:

Tothanakom (1999) objected to find the inventory management method for finished goods which are made to stock in the mixed lubricating oil industry. ABC Classification was selected to find the most important items. Then the study proposed Economic Order Quantity (EOQ) to control the order system and order quantities by calculating safe inventory and order quantity in the meantime. The result was a decrease of out stocking by about 83% and stock turns was adjusted 31% approximately.

Beamon and Kotleba (2006) studied inventory management of the humanitarian relief operations to support emergency situations in south Sudan, South Africa. Normally, the company used inventory management to reduce stock or raise the profit but it is different in this situation. Cost is a point to mention but the emphasis is on product quantity needs to be at full stock all time because this research was also support for a Non-Governmental Organization (NGO). By the way, these two keys focused on involving order quantities (size) and re-ordering point (timing). In result, inventory management was quite effective and efficient in the experiment. Cost efficiency occurred and outstanding volume flexibility did also.

Sridathamn (2008) proposed an Economic Order Quantity (EOQ) to improve inventory management methods and increase inventory turnover. Then find the optimal reorder point and order quantities for studied items. Sampled items were the items which generated 80% of total revenue and were valued at more than 500,000 Baht. The study found that value of inventory is reduced by about 49% and inventory turnover increased by about 64%. So, reducing inventory costs and increasing inventory turnover gained more liquidity and profitability to the business.

Jose Gonzalez and Daniel Gonzalez (2010) studied the research about Economic Order Quantity (EOQ) and re-ordering point techniques for surviving XYZ Company in their competitive field. XYZ Company had problems in an ineffective forecasting process. There were frequently errors and mistakes from the Company's inventory forecast. A reason of ineffective forecast probably from existing forecasting methods, they were concerned with the rolling average method which used historical data for computing the new inventory order quantity. Disadvantages of this method are no mention in variability of the data. Then, the forecast is inaccurate. By the way, XYZ Company improves the EOQ and re-ordering point method instead of the old method. It makes total costs dramatically decrease from $13,654 to $5,366 which means almost $8,300 is saved. Moreover, another advantage is solving problems due to stock- outs and back-orders. Inventory quantity is increasing smoothly and accurately as well.

Sandhu, Helo and Kristiento (2013) reviewed the case study about steel supply chain management in a bullwhip effect situation. In this case the significant tool to avoid risk from the bullwhip effect is sharing information along the supply chain network between suppliers, manufacturers, retailers, and customers. However, the bullwhip effect is directly a problem of inventory quantity and the information sharing helps all inbound and outbound company operations to obtain the actual demand and data. The research shows results in quantity of stock, including ordering times are affected by the bullwhip effect in the supply chain. The Coefficient of Variation is an important tool for determining demand information from each state in the network, whether significant or not and these data and information are part of the source to forecast the product quantity and ordering time.

2.13 Summary

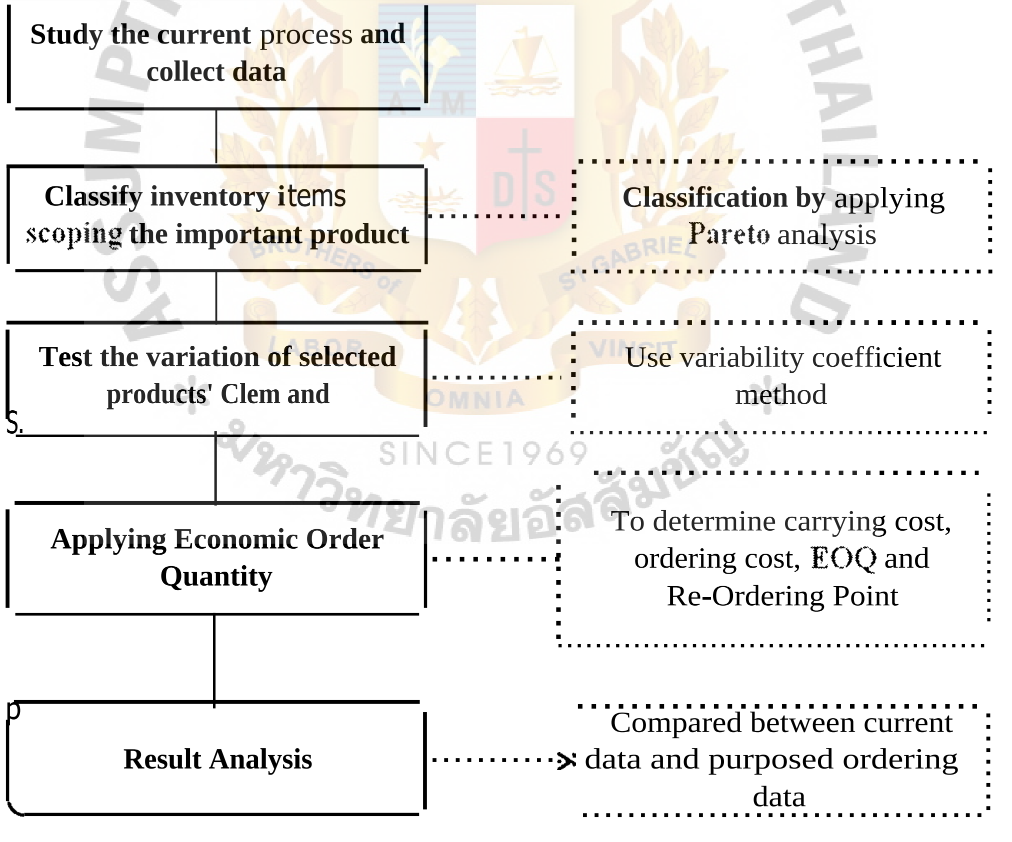
The literature reviews in this chapter are methodologies which are applied by the company to improve its inventory management. Pareto methodology is used to classify to the scope of inventory and even the inventory's significance. Testing variability of demand through VC to confirm whether data is stable enough to apply the EOQ model or not. Then, linking company data with the EOQ model in order to figure out the appropriate ordering quantity and reduce excess inventory including matching numbers of ordering, stock inventory, and sale quantities is performed.

CHAPTER III

RESEARCH METHODOLOGY

This study aims to minimize the company's cost from unnecessary inventory on hand by finding the most suitable order quantity and time for re-ordering. This section presents stages of the the research process and implementation. The research methodology is as shown in Figure 3.1

Figure 3.1: Flow Chart of the Research Methodology



Source: Author

3.1 Data Collection

In order to collect the data, the related documents including purchase orders, invoices, available inventory reports are collected in this part. Documents from two related departments including the sales department and the purchasing department are required as follows:

1. Secondary data from the sales department: Collect data of sales volume, sales price and total revenue from invoices.
2. Secondary data from the purchasing department: Collect data of purchased product quantities and purchase price from purchased orders. Then collect available inventory amounts from the merchandise inventory report.
3. Primary data from the director: The Company's expenditures such as employee salary, property tax, insurance fees, loan interest rates are collected from interviewing the director.

All are historical data which the concerning departments have collected month by month from the beginning of 2012 to the end of 2013, totaling 2 years.

3.2 Inventory Items Classification

From the collected data of the ABC Company, there are 30 products which the company sells. In order to find the items which provide high impact to the company accurately, Pareto analysis is applied. To select the items for scoping which generate around 80% of total sales revenue of 2012, sales revenues of each product are ranked from highest to lowest. Then, the selected products which generate accumulative sales of about 80% are selected for the study.

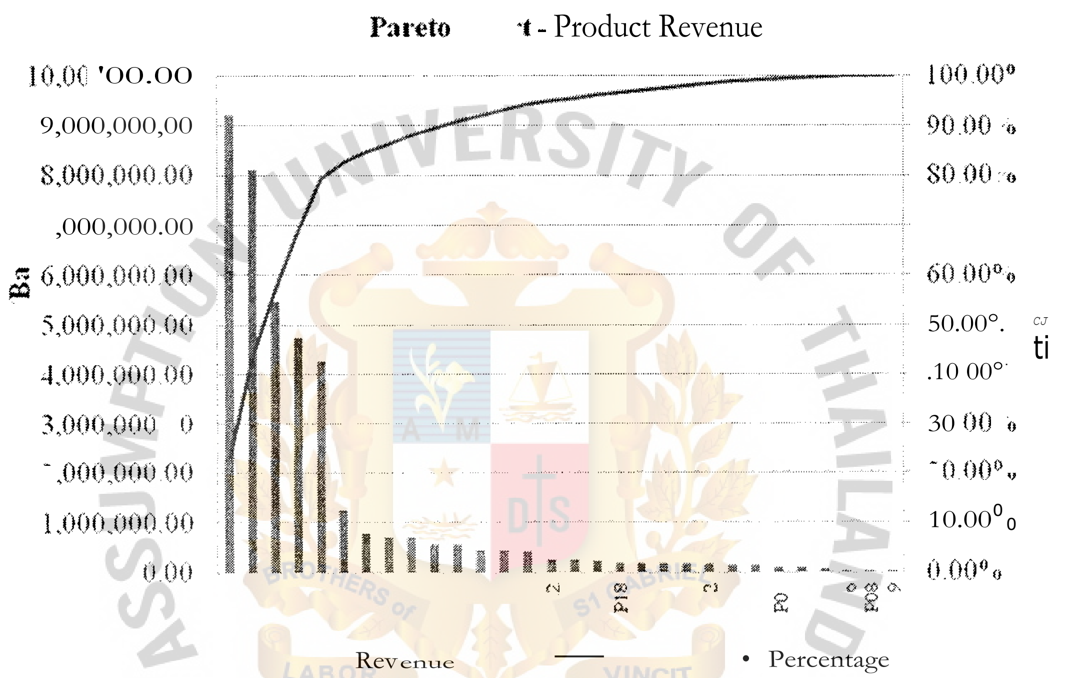
Table 3.1: Products Revenue Ranked High to Low

Rank / Code	Revenue (Baht)	Percentage of Revenue	Cumulative Percentage
P01	**9,221,392.69**	**23.03%**	**23.03%**
PO4	**8,129,758.36**	**20.30%**	**43.33%**
P03	**5,466,601.59**	**13.65%**	**56.98%**
P02	**4,757,879.63**	**11.88%**	**68.86%**
P05	**4,273,296.76**	**10.67%**	**79.53%**
P29	1,252,289.15	3.13%	82.65%
P20	797,046.90	1.99%	84.64%
P25	706,076.29	1.76%	86.41%
P27	706,076.29	1.76%	88.17%
P30	566,229.46	1.41%	89.58%
P28	560,693.42	1.40%	90.98%
P26	455,656.53	1.14%	92.12%
P23	446,392.94	1.11%	93.24%
P17	429,811.96	1.07%	94.31%
P22	259,843.34	0.65%	94.96%
P14	253,837.77	0.63%	95.59%
P24	239,654.10	0.60%	96.19%
P18	204,015.63	0.51%	96.70%
P16	188,088.02	0.47%	97.17%
P15	186,599.72	0.47%	97.64%
P21	174,531.63	0.44%	98.07%
P12	172,014.58	0.43%	98.50%
P19	153,869.25	0.38%	98.89%
P13	143,715.79	0.36%	99.24%
P07	95,391.25	0.24%	99.48%
P11	90,242.52	0.23%	99.71%
P10	84,597.78	0.21%	99.92%
P06	24,457.15	0.06%	99.98%
P08	4,128.06	0.01%	99.99%
P09	3,947.22	0.01%	100.00%
Total	**40,048,135.78**	100.00%	

Source: ABC Company Data

According to table 3.1, the table shows revenue from each product and their percentages of total revenue, and cumulative percentages. The products which provide the first 80% of total revenue are selected as the scope in this study.

Figure 3.2: Pareto Chart of Products Revenue



Source: ABC Company Data

Table 3.2: Products Classification

Rank / Product Code	Total Sale Revenue (Baht)	Percentage of Sale Revenue (%)	Available Inventory (Baht)	Percentage of Inventory Value (%)
P01	9,221,392.69	23.03%	1,960,539.00	19.52%
PO4	8,129,758.36	20.30%	919,463.10	9.15%
P03	5,466,601.59	13.65%	743,888.00	7.41%
P02	4,757,879.63	11.88%	580,182.63	5.78%
P05	4,271,996.76	10.67%	744,577.84	7.41%
Total	**31,848,929.03**	**79.53%**	**4,948,650.57**	**49.27%**
Others (25 products)	8,199,206.75	20.47%	5,094,949.97	50.73%
Grand Total	**40,048,135.78**	**100.00%**	**10,043,600.54**	**100.00%**

Source: Author

Table 3.2 shows five products which provide the first 80% of total revenue including product code P01, PO4, P03, P02 and P05 respectively. They are first five important products generating 31,848,929.03 baht, equal 79.53% or about 80% of sales revenue when the data were ranked. Therefore, the products code P01, PO4, P03, P02, and P05 are selected as the scope of this study. Their inventories share about 49% of total inventory or 4,948,650.57 baht. However, other inventories which were not selected in this study share only 20.47% of sales revenue while the total inventory value is 50.73%.

3.3 Testing the Variation of Selected Products' Demand

After selecting the products by using Pareto analysis for classification, the next step is to select the purchasing policy which depends on the demand of each product. As Peterson and Silver (1979) stated that demand variation counts on many factors, to test the consistency of demand patterns, testing variability coefficient (VC) is applied. The result's value defines demand patterns of historical sales data before applying economic order quantity.

For the results from using the variability coefficient, it determines whether the demand patterns haves high or low variability at 0.25. It means that demand patterns have a high variability if the VC is over 0.25. Conversely, the demand patterns have a low variability and are suitable for applying economic order quantity when VC is lower than the criterion.

Table 3.3: VC of Products Sold

Product Code	P01	P04	P03	P02	P05
Number of period	12 months				
Total Demand	242,668.23	90,330.65	49,696.38	105,730.66	35,610.81
Average Demand	20,222.35	7,527.55	4,141.37	8,810.89	2,967.57
(Total Demand)^2	5,617,902,783.82	744,172,982.65	227,890,852.58	1,023,993,877.71	121,994,085.69
(Average Demand)	408,943,540.63	56,664,071.73	17,150,904.06	77,631,753.22	8,806,456.87
1/12(Total Demand)	468,158,565.32	62,014,415.22	18,990,904.38	85,332,823.14	10,166,173.81
Est var D	59,215,024.68	5,350,343.49	1,840,000.32	7,701,069.92	1,359,716.94
VC	**0.14**	**0.09**	**0.11**	**0.10**	**0.15**

Sources: Author

Table 3.3 shows the calculation for testing demand variability by using the formulation from chapter 2. VC of the studied products codes includes P01, PO4, P03, P02 and P05 are lower than 0.25. It means monthly demands of the products are not much diverse from their average demand in 2012. Thereby, demand patterns are assumed to be constant and suitable to apply economic order quantity.

3.4 Applying Economic Order Quantity

After checking the variability coefficient of demands, the next step is to apply the economic order quantity technique which needs to be related data including carrying costs, ordering costs, re-order point and economic order quantity. The calculations are shown as follows:

3.4.1 Calculate Inventory Carrying Cost

ABC Company has only one warehouse. All inventories are stored together in the same place. Carrying costs consist of two main costs including physical carrying costs and opportunity costs. The former one is a fixed cost which comes from facility charges, employees' salaries, company's taxes etc. The latter one is a variable cost which can be calculated by using loan interest rates of 2012 that the company has to pay to financial institutes. Finally, to sum up the results of physical holding costs and opportunity costs together and divided the results by the total amount of all products stored in order to transform carrying costs to costs per unit. The calculation is summarized as follows:

Carrying Cost (Baht/Kg/Year) = Physical Carrying Cost + Opportunity Cost

Where;

$$\text{Physical Carrying Cost (Baht/Kg/Year)} = \frac{\text{Total Physical Carrying Cost (Baht/Year)}}{\text{Total inventory (Kg)}}$$

Opportunity Cost (Baht/Kg/Year) = Each Product Cost (Baht/Kg) * Interest Rate (%/Year)

Table 3.4: Physical Carrying Cost

Expense **(Baht/Year)**	Expense **(Baht/Year)**
Electricity Charge (a)	180,000.00
Warehouse Officer Salary (b)	264,000.00
Security Officer Salary (c)	180,000.00
Property Tax (d)	120,000.00
Insurance Fee (e)	50,000.00
Total Physical Carrying Cost (Baht/Year) (a+b+c+d+e)	794,000.00
Total Inventory (Kg) (0	138,912.23
Physical Carrying Cost **(Baht/Kg/Year)** **(a+b+c+d+e)** (0	5.72

Source: ABC Company Data

The first step to calculate the carrying cost is to calculate the physical carrying cost. The physical carrying costs of ABC Company have five sources of expense and the calculation details are shown as follows:

Electricity charge is 15,000 baht/month. So it is 180,000 baht/year (15,000 baht x 12 months).

Warehouse officer salaries are 11,000 baht/month/person. There are two people who take responsibilities in this position. Therefore, warehouse officer salaries are 264,000 baht/year (11,000 baht x 2 persons x 12 months).

Security officer salary, the company has to pay 15,000 baht/month for only one person in this position. So it is 180,000 baht/year (15,000 baht x 12 months)

Property tax expense 120,000 baht/year

Insurance fee expense 50,000 baht/year

The summation of the five expenses above is 794,000 baht/year called the total physical carrying cost of ABC Company. Then, divide that figure by the total available inventory units to get the physical carrying cost (794,000 baht / 138,912.23 kg) which is equal to 5.72 baht/kg/year

In this study, the physical carrying cost will not be considered to affect the company's cost after propose **EOQ,** because physical carrying costs come from fixed costs which the company has to pay yearly whether the level of inventory is high or not. Thus, physical carrying costs do not varying from changing levels of inventory.

The next step is to calculate the opportunity cost of each product. Loan interest rate that the company has to pay to financial institutes is applied (8% /year).

Table 3.5: Opportunity Cost

Opportunity Cost	Product Code				
	P01	PO4	P03	P02	P05
Cost (Baht/Kg) (a)	24.50	62.00	80.00	25.50	62.00
Interest Rate (Percent/Year) (b)	8%				
Opportunity Cost **(Baht/Kg/Year) (a*b)**	1.96	4.96	6.40	2.04	4.96

Source: Author

Due to the different costs, each product has different opportunity costs. The opportunity cost is a variable cost, thus it depends on costs and interest rates. From table 3.5, the loan interest rate is 8% per year. Consequently, total expenses for the loan interest rate can be calculated by using the total inventory value, which can be defined as a sunk cost, multiplied by the loan interest rate. So the total opportunity cost for the studied products' inventory is 395,892.46 baht/year (4,948,560.57 baht x 8%).

The opportunity cost of each product is shown in table 3.6, using price per kilograms multiplied by the interest rate. The opportunity of P01, PO4, P03, P02 and P05 are equal to 1.96, 4.96, 6.40, 2.04, and 4.96 baht/kg/year in order.

Table 3.6: Summary of Inventory Carrying Cost

Cost (Baht/Kg/Year)	Product Code				
	P01	**PO4**	**P03**	**P02**	**P05**
Physical Carrying Cost (a)	5.72	5.72	5.72	5.72	5.72
Opportunity Cost (b)	1.96	4.96	6.40	2.04	4.96
Inventory Carrying Cost (a+b)	**7.68**	**10.68**	**12.12**	**7.76**	**10.68**

Source: Author

Inventory carrying costs can be calculated by summing up the value of physical carrying costs and the opportunity costs together. Table 3.7 shows the value of inventory carrying costs of the studied products including the product codes P01, PO4, P03, P02 and P05 are 7.68, 10.68, 12.12, 7.76, 10.68 baht/kg/year in order.

3.4.2 Calculate Inventory Ordering Cost

The expenditure called ordering costs can be calculated by related staffs salaries, operational fixed costs and others variable costs likes telephone charges etc. The formulation is summarized as follow:

$$\text{Ordering Cost} = \frac{\text{Total purchasing department fixed cost} + \text{Total variable cost (Baht/Year)}}{\text{Number of purchase orders (Order)}}$$

Table 3.7: Ordering Cost Expenses

Ordering Cost	**Expense**	
Purchasing Department Officer salary	216,000.00 baht/year	
Clerk Salary	**180,000.00** baht/year	Fixed Cost
Computer Depreciation	10,000.00 baht/year	
Other Expense	10,000.00 baht/year	
Telephone/Fax	15.00 baht/order	Variable Cost
Purchasing Document	4.50 baht/form	

Source: ABC Company Data

From table 3.7, the ordering costs of ABC Company consist of purchasing department officer salaries, clerk salaries, computer depreciation, and other expenses as fixed costs and the variable cost are telephone charges, and purchasing documents. The calculation details are as follows:

1. Fixed Ordering Costs:

Purchasing department officer salary is 18,000 baht/month. The company hires one position. So it is 216,000 baht/year (18,000 baht x 12 months).

Clerk salary, one person is performed in this position. The company has to pay 15,000 baht/month. Thus, the expense for the clerk's salary is 180,000 baht/year for one person in this position (15,000 baht x 12 months)

Computer depreciation can be calculated by the computer price divided by usage time. Therefore, the depreciation is 10,000 baht/year (30,000 baht / 3 years).

Other expense is 10,000 baht/year. The transportation expense for receiving the **products** from the supplier's place, internet fee, computer maintenance etc. **are** all **counted** as other expenses.

2. Variable Ordering Costs:

The company orders the products on the 1St and 15th day every month. So the total purchase order number is 24 orders for each product (2 orders x 12 months) and 120 orders for 2012 (24 orders x 5 products).

Telephone and fax charge is 3 baht/time. Once the purchasing department places an order, telephone and fax are used about 5 times/order. So, the telephone and fax expense of each product is **15 baht/order** (3 baht x 5 times).

Purchasing document charges 4.50 baht/form

Table 3.8: Inventory Ordering Cost

Product	Fixed Ordering Cost (a)	Variable Ordering Cost (b)	Ordering Cost (a+b)
	Baht/Order/Year		
P01	3,466.67	19.5	**3,486.17**
PO4	3,466.67	19.5	**3,486.17**
P03	3,466.67	19.5	**3,486.17**
P02	3,466.67	19.5	**3,486.17**
P05	3,466.67	19.5	**3,486.17**

Source: Author

Total inventory ordering cost is 3,486.17 baht/order. The result comes from summation of fixed ordering costs and variable ordering costs per order. The fixed ordering cost is 3,466.67 baht/year (416,000 baht/year divided by 120 orders). The variable ordering cost is 19.5 baht/order (15 baht/order from telephone charge + 4.5 baht/order from purchasing document)

As summarized in the result from table 3.6, the inventory carrying costs of products P01, PO4, P03, P02 and P05 are equal to 7.68, 10.68, 12.12, 7.76, 10.68 baht/kg/year in order. And the inventory ordering costs of each product from table 3.8 are the same or equal to 3,486.17 baht/order/year.

Similar to the physical ordering costs, fixed and variable ordering costs will not be considered to effect when applying EOQ. Because fixed ordering costs come from fixed expenditures which the company has to pay yearly, as the changing of variable costs is too little to give an impact to the company. Consequently, it does not vary from a changing level of inventory.

3.4.3 Calculate Re-Order Point and Economic Order Quantity

When the data of the total annual volume, carrying costs and ordering costs are gathered completely, economic order quantity and re-order point can be calculated by using the reviewed formulations in chapter 2 (2.8 to 2.10). Getting economic order quantity, the purchasing department knows the optimal order amount of selected products. In addition, the re-order point and safety stock point can point out when it's time to order again.

3.5 Compare the Results of Calculation between Current and Proposed Inventory Management Tool

To compare the results of applying economic order quantity as an inventory management tool, this study will compare the current data and proposed results of studied products in 2012 as follows:

1. Total inventory amount and total inventory costs.
2. The changing of inventory carrying cost

After comparing, the policy which has lower inventory cost is selected.

3.6 Summary

Steps in this chapter are the preparation done before applying company data to find out appropriate ordering quantities and ordering times with the economic order quantity technique. Data preparation shows steps of the research, Pareto techniques to separate products which affect against company revenue, and use variability coefficients to test demand variation in classified groups. Furthermore, this chapter is definitely defining principle costs in terms of inventory management. Carrying and ordering costs are analyzed to be applied in the next chapter.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

From the data preparation from chapter 3, Pareto analysis has been applied with the company's products in order to scope the study. The selected products provide high impact to the company. Variability coefficients of the products is tested to check whether they are suitable for using economics order quantity (EOQ) or not. After determining a demand pattern, related inventory costs including inventory carrying costs and inventory ordering costs are calculated before applying the EOQ model.

In this chapter, the re-order point (ROP) and economic order quantity (EOQ) are calculated. Total inventory cost between current and proposed EOQ as inventory management policy are compared. Changing of inventory carrying cost and ordering cost are compared also. The implementation's results are investigated.

4.1 Calculate the Economic Order Quantity (EOQ) and Re-order Point (ROP)

As the EOQ and ROP formulas mentioned in chapter 2, the variables which need to be substituted in the formula are gathered. Then, the EOQ and ROP are calculated.

4.1.1 Calculate the Economic Order Quantity (EOQ)

The economic order quantity is calculated by using the formula below
(Details in chapter 2);

$$\text{EOQ} = \sqrt{\frac{2CoD}{Cc}}$$

Ordering cost (Co), annual demand (D) and carrying costs (Cc) are required variables for calculation. The results are in table 4.1;

Table 4.1: Economic Order Quantity (EOQ)

	Product Code				
	P01	**PO4**	**P03**	**P02**	**P05**
Ordering Cost (Co) (a)	3,486.17	3,486.17	3,486.17	3,486.17	3,486.17
Annual Demand (D) (b)	242,668.23	90,330.65	49,696.38	105,730.66	35,610.81
Carrying Cost (Cc) (c)	7.68	10.68	12.12	7.76	10.68
EOQ (kg) $\left(\frac{2(a)(b)}{(c)}\right)$	**14,842.78**	**7,679.29**	**5,346.88**	**9,746.73**	**4,821.64**

Source: Author

After substituting the variables into the formula to find the EOQ which is the optimal amount for ordering each product code P01, PO4, P03, P02 and P05 which are equal to 14,842.78 kg/order, 7,679.29 kg/order, 5,346.88 kg/order, 9,746.73 kg/order and 4,821.64 kg/order consequently.

4.1.2 Calculate Re-order Point (ROP)

The re-order point is calculated by using the formula below (detailed in chapter 2) ;

$$ROP = (d \times L) + SS$$

Where; Safety Stock = $\sqrt{\overline{LT}\sigma_a + d\ \sigma_{LT}}$

Average demand per year (d), lead time (L) and number of safety stock (SS) are required variables for the re-order point calculation. Average demand per year comes from annual demand divided by 365 days. Lead time comes from the company's data, and safety stock needs to calculate by using the formula detailed in chapter 2. The results of ROP are shown in table 4.2.

Table 4.2: Re-order Point (ROP)

	Product Code				
	P01	**PO4**	**P03**	**P02**	**P05**
Average Demand per Year (d) (a)	664.84	247.48	136.15	289.67	97.56
Lead Time (L) (b)	7	7	7	7	7
Safety Stock (SS) (c)	6,091.06	1,685.30	724.15	2,196.61	923.00
ROP (kg) (a*b)+c	**10,744.97**	**3,417.67**	**1,627.23**	**4,224.32**	**1,605.95**

Source: Author

From table 4.2, the results of ROP indicate the number of inventory left in the stock when the company should reorder. The ROP of products P01, PO4, P03, P02 and P05 are equal to 10,744.97 kg, 3,417.67 kg, 1,627.23 kg, 4,224.32 kg and 1,605.95 kg.

4.2 Simulation of Ordering Process by Applying Economic Order Quantity (EOQ), Re-order Point (ROP) and Safety Stock (SS)

After the required data including economic order quantity (EOQ), re-order point (ROP), and safety stock (SS) are calculated. The next step is to apply the results into the simulation of the ordering process which contains two parts as follow:

4.2.1 Insert the Basic Data

Basic data of studied products including Economic order quantity, re-order point, safety stock, lead time, daily sales recorded and number of available stock at the end of 2011

4.2.2 Processing Part

After finished filling in the basic data, the simulation of ordering process is completed. The available inventory each day, received orders and number of orders are calculated in this step.

4.3 Compare Inventory Data of Studied Products between Current and Proposed Economic Order Quantity (EOQ)

To compare the inventory data between the current and the proposed EOQ of the scoped products including product codes P01, PO4, P03, P02 and P05, the compared data includes inventory amount, inventory ordering cost, inventory carrying cost and total inventory cost. All are data of 2012.

4.3.1 Compare Inventory Amount between Current and Proposed Economic Order Quantity (EOQ) model

After simulating the ordering process which proposed an economic order quantity, the inventory amount of the studied products of each day are compared with the current ordering process and shown below:

Figure 4.1: Inventory Amount of Studied Product Code, P01

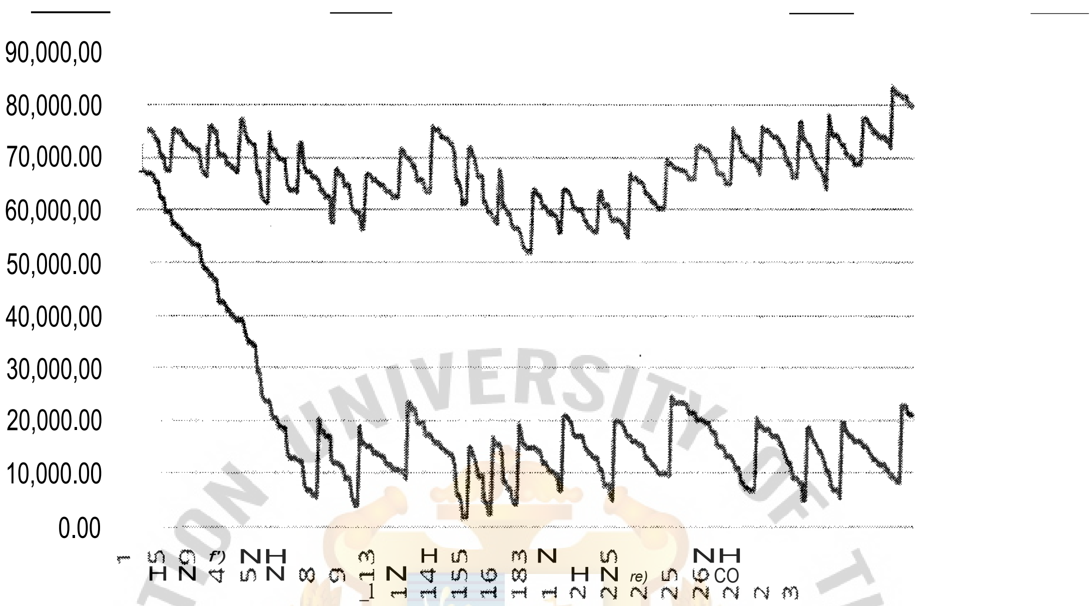


Figure 4.2: Inventory Amount of Studied Product Code, PO4

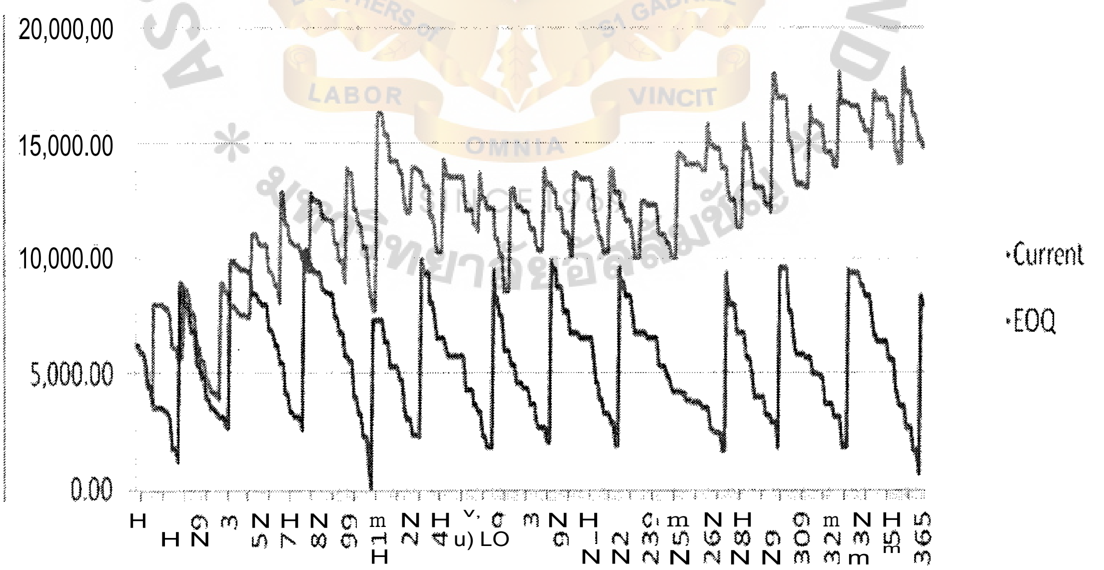


Figure 4.3: Inventory Amount of Studied Product Code, P03

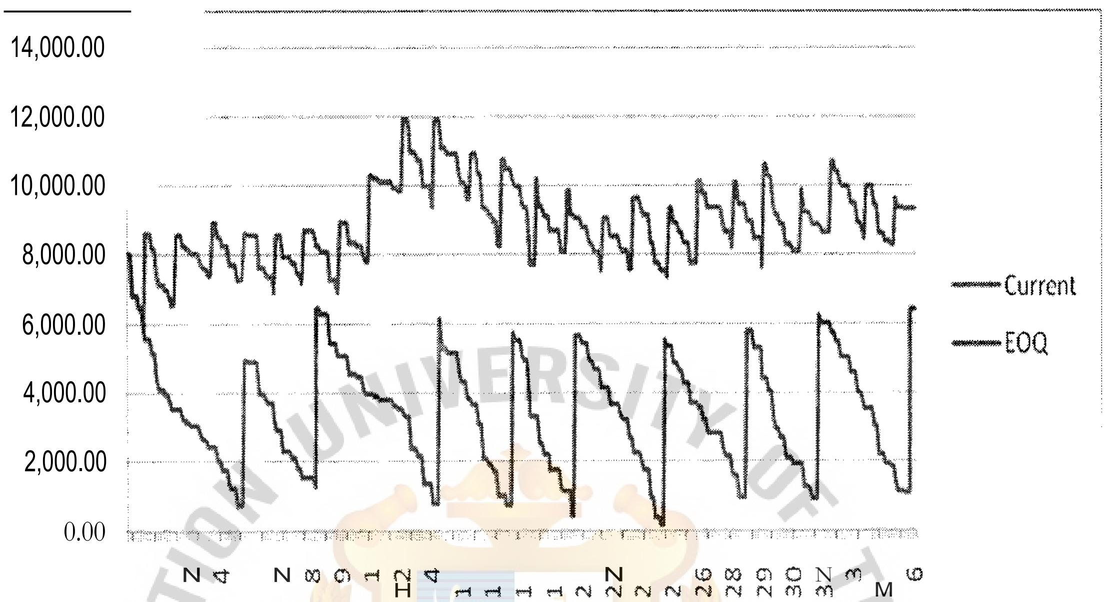


Figure 4.4: Inventory Amount of Studied Product Code, P02

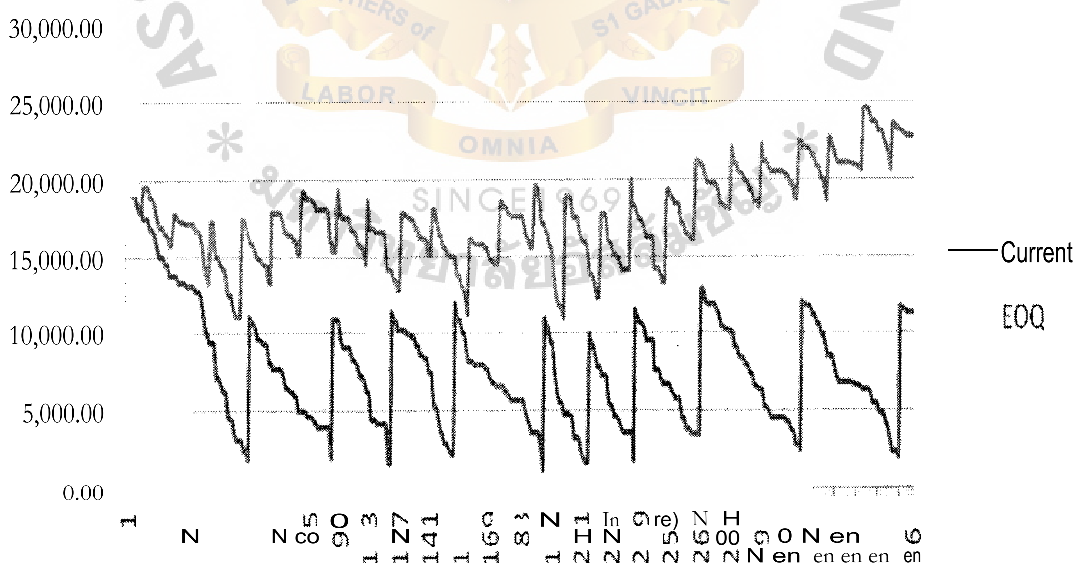
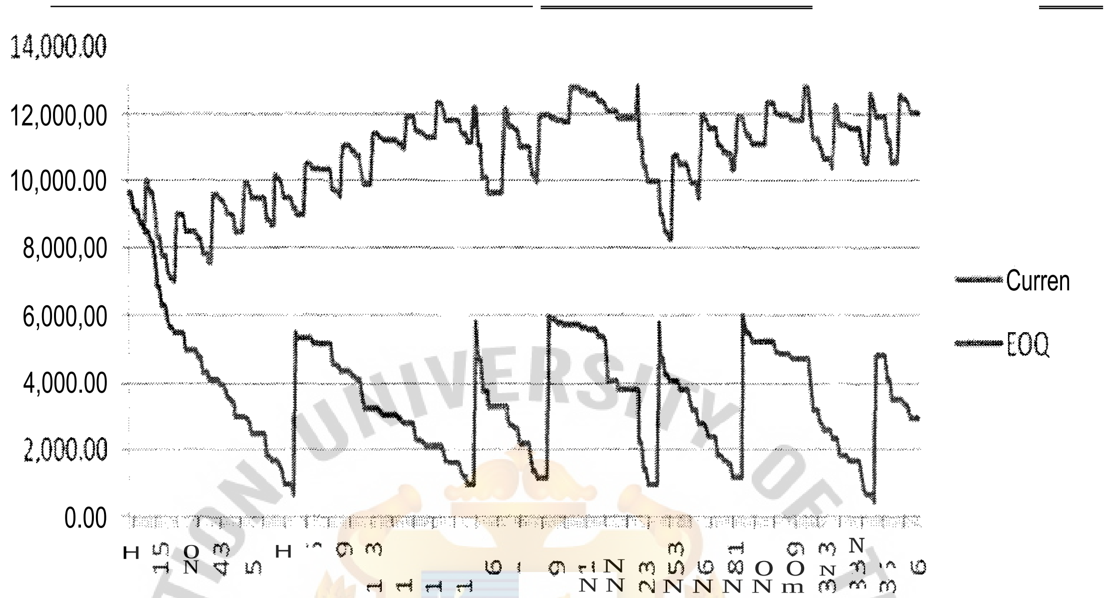


Figure 4.5: Inventory Amount of Studied Product Code, P05



From figure 4.1 to 4.5, the inventory amount of studied products on each day from using the current ordering policy and proposed economic order quantity (EOQ) model are shown. Every product has lower inventory at the end of the year when the company applies EOQ. The purchasing department places orders every 1 and 15th day of month. The lead time for incoming replenishment is 7 days. So, the inventory is filled every 8th and 22nd. Applying EOQ makes the company manage the inventory amount to conform to customers' demand. The figures show high inventory levels of the products in the beginning of the year. After applying EOQ, the company has to sell on hand inventory without any replenishment until the inventory amount reaches the re-ordering point. Then, the company is able to orders the products in appropriate quantities, waiting for the inventory to be refilled, selling the products until the inventory amount reach the re-ordering point then order again and so on.

4.3.2 Compare Inventory Ordering Cost between Current and Proposed Economic Order Quantity (EOQ) model

Ordering cost increased or decreased by the number of orders placed and it concerned directly with inventory costs. Applying economic order quantity (EOQ) makes the frequency of placing orders and the number of orders change. So, the ordering costs between current and proposed EOQ are not the same. This study shows the comparison of ordering costs between the current and the proposed model. Table 4.3 shows current ordering cost. Table 4.4 shows the ordering costs of proposed EOQ model. And table 4.5 shows the comparison between result from table 4.3 and 4.4.

Table 4.3: Current Ordering Cost

Product Code	Fixed Cost **(Baht)** (a)	Variable Cost **(Baht)** (b)	Number of Orders (c)	Total Ordering Cost **(Baht)** **(a+(b*c))**
P01	3,486.17	19.50	*24*	3,954.17
PO4	3,486.17	19.50	*24*	3,954.17
P03	3,486.17	19.50	*24*	3,954.17
P02	3,486.17	19.50	*24*	3,954.17
P05	3,486.17	19.50	*24*	3,954.17

Source: Author

Table 4.4: Proposed EOQ Ordering Cost

Product Code	Fixed Cost **(Baht)** (a)	Variable Cost **(Baht)** (b)	Number of Orders (c)	Total Ordering Cost **(Baht)** **(a+(b*c))**
P01	3,486.17	19.50	*13*	3,739.67
PO4	3,486.17	19.50	*12*	3,720.17
P03	3,486.17	19.50	*9*	3,661.67
P02	3,486.17	19.50	*10*	3,681.17
P05	3,486.17	19.50	*6*	3,603.17

Source: Author

Table 4.5: Comparisons of Ordering Cost between Current and Proposed EOQ

Product Code	Current Total Ordering Cost (Baht) (a)	EOQ Total Ordering Cost (Baht) (b)	Saved (Baht) (a-b)	Saved Percentage (%)
P01	3,954.17	3,739.67	**214.50**	**5.42%**
PO4	3,954.17	3,720.17	**234.00**	**5.92%**
P03	3,954.17	3,661.67	**292.50**	**7.40%**
P02	3,954.17	3,681.17	**273.00**	**6.90%**
P05	3,954.17	3,603.17	**351.00**	**8.88%**

Source: Author

According to table 4.4, applying economic order quantity (EOQ) makes the company's ordering costs lower than current ordering processes shown in table 4.3 via reducing the number of orders. However, the company usually pays for the fixed ordering costs such as purchasing officer salaries and computer depreciation. These costs are fixed and do not depend on the changing of order numbers. On the other hand, the variable costs which come from telephone and documentation charges are too little to provide an impact to the company. Consequently, changing ordering cost from applying EOQ shown and compared in table 4.5 of studied products around 5-9% are a very little effect to the company's inventory cost.

Applying economic order quantity to help make decisions about ordering processes, helps the company decides on the ordering quantity and timing. Therefore, numbers of orders are changed and are more appropriate with sales volume.

4.3.3 Compare Inventory Carrying Cost between Current and Proposed Economic Order Quantity (EOQ) model

For calculation of inventory carrying cost, first step is to calculate the average inventory level in order to figure out the inventory amount per day. Then multiply the average inventory level by the summation of physical carrying costs and the opportunity cost per kilogram. Current carrying costs are shown in table 4.6. Table 4.7 shows the proposed carrying cost as follows:

Table 4.6: Current Carrying Cost

Product Code	**Average Inventory (Kg) (a)**	**Physical Holding Cost (Baht/Kg) (b)**	**Opportunity Cost (Baht/Kg) (c)**	**Total Carrying Cost (Baht) (a*(b+c))**
P01	67,466.84	5.72	1.96	**518,145.33**
PO4	12,051.97	5.72	4.96	**128,715.04**
P03	8,858.67	5.72	6.40	**107,367.08**
P02	17,605.24	5.72	2.04	**136,616.66**
P05	10,753.45	5.72	4.96	**114,846.85**

Source: Author

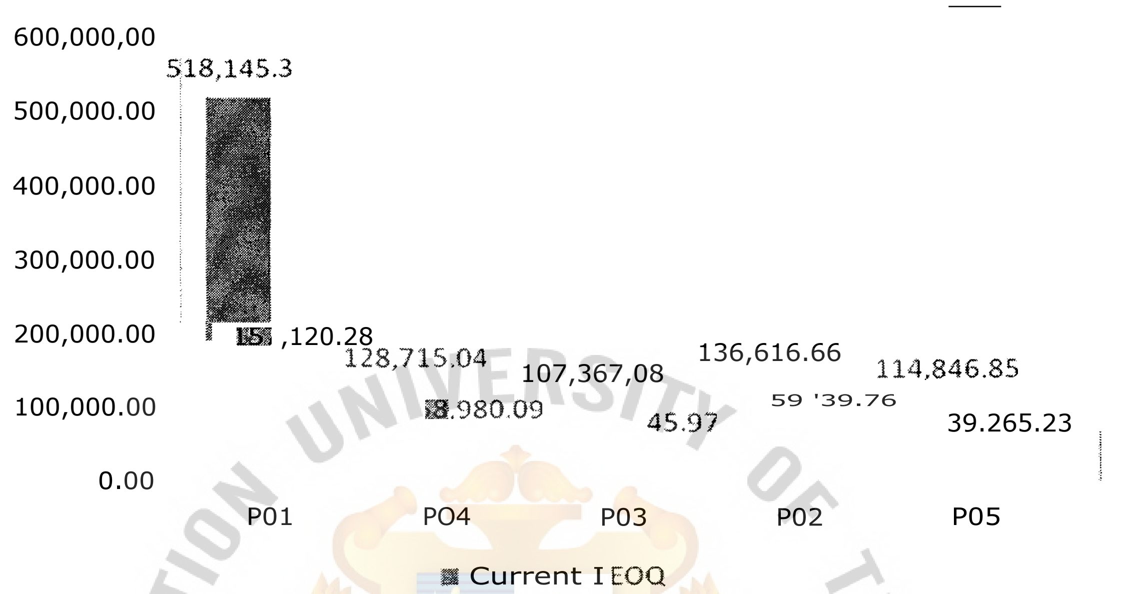
Table 4.7: Proposed EOQ Carrying Cost

Product Code	**Average Inventory (Kg) (a)**	**Physical Holding Cost (Baht/Kg) (b)**	**Opportunity Cost (Baht/Kg)** (c)	**Total Carrying Cost (Baht) (a*(b+c))**
P01	20,458.37	5.72	1.96	**157,120.28**
PO4	5,522.48	5.72	4.96	**58,980.09**
P03	3,378.38	5.72	6.40	**40,945.97**
P02	7,653.32	5.72	2.04	**59,389.76**
P05	3,676.52	5.72	4.96	**39,265.23**

Source: Author

Figure 4.2 and table 4.8 show the comparisons between current and proposed EOQ carrying costs of the studied products. It shows that the inventory carrying costs of proposed EOQ as ordering policy of all five products are less than the current ones.

Figure 4.6: Comparisons of Carrying Cost between Current and Proposed **EOQ**



Source: Author

Table 4.8: Comparisons of Carrying Cost between Current and Proposed **EOQ**

Product Code	Current Total Carrying Cost **(Baht)** (a)	**EOQ** Total Carrying Cost **(Baht)** (b)	Saved **(Baht)** (a-b)	Saved Percentage **(%)**
P01	518,145.33	157,120.28	361,025.05	69.68%
PO4	128,715.04	58,980.09	69,734.95	54.18%
P03	107,367.08	40,945.97	66,421.11	61.86%
P02	136,616.66	59,389.76	77,226.90	56.53%
P05	114,846.85	39,265.23	75,581.61	65.81%

Source: Author

By applying the economic order quantity (EOQ), the inventory level of studied products is decreased. The appropriate inventory level saves inventory carrying costs of the company. Total inventory carrying costs consists of physical carrying costs and opportunity costs. Physical carrying costs are fixed costs while opportunity costs are variable costs. So, high inventory costs from large amounts of inventory come from an increasing of the opportunity cost.

The calculations found that economic order quantity can reduce inventory levels which related directly to inventory carrying costs via opportunity costs. In this study, the ABC Company can reduce its carrying cost of product codes P01, PO4, P03, P02 and P05 by about 69.68%, 54.18%, 61.86%, 56.53% and 65.81% respectively.

4.3.4 Compare Total Inventory Cost between Current and Proposed Economic Order Quantity (EOQ) model

Total inventory cost of current ordering policies and the proposed economic order quantity (EOQ) model are compared in order to select the better one. Total inventory costs consist of carrying costs and ordering costs. Total inventory costs of current ordering policies and the proposed EOQ ordering policy are shown in table 4.9:

Table 4.9: Total Inventory Cost of Current and Proposed EOQ

Product Code	Current Ordering Policy			Proposed EOQ		
	Carrying Cost (a)	Ordering Cost (b)	Total Inventory Cost (a+b)	Carrying Cost (c)	Ordering Cost (d)	Total Inventory Cost (c+d)
	Unit: Baht					
P01	518,145.33	3,954.17	**522,099.50**	157,120.28	3,739.67	**160,859.95**
PO4	128,715.04	3,954.17	**132,669.21**	58,980.09	3,720.17	**62,700.26**
P03	107,367.08	3,954.17	**111,321.25**	40,945.97	3,661.67	**44,607.64**
P02	136,616.66	3,954.17	**140,570.83**	59,389.76	3,681.17	**63,070.93**
P05	114,846.85	3,954.17	**118,801.02**	39,265.23	3,603.17	**42,868.40**

Source: Author

From table 4.9, the calculations of the proposed EOQ model indicate that the total inventory costs of all products are lower than using current ordering policies. The total inventory costs of product codes P01, PO4, P03, P02 and I 05 are lessen at 160,859.95 baht, 62,700.26 baht, 44,607.64 baht, 63,070.93 baht and 42,868.40 baht respectively.

Table 4.10: Comparisons of Total Inventory Cost between Current and Proposed **EOQ**

Product Code	Total Inventory Cost **(Baht)**		Saved ((a -b))	Saved Percentage **(%)**
	Current (a)	Proposed **EOQ** (b)		
P01	522,099.50	160,859.95	361,239.55	69.19%
PO4	132,669.21	62,700.26	69,968.95	52.74%
P03	111,321.25	44,607.64	66,713.61	59.93%
P02	140,570.83	63,070.93	77,499.90	55.13%
P05	118,801.02	42,868.40	75,392.62	63.46%
Total	1,025,461.81	374,107.18	651,354.63	63.52%

Source: Author

The comparisons from table 4.10 show saved total inventory costs of the studied products. With the proposed EOQ ordering policy, total inventory cost of product codes P01, PO4, P03, P02 and P05 are decreased by 69.19%, 52.74%, 59.93%, 55.13%, and 63.46% respectively. In conclusion, ABC Company can save 63.52% of total inventory cost from applying the EOQ model to the studied products.

4.4 Results' Comparisons after Continues Applying Economic Order Quantity **(EOQ)** in 2013

After finished comparisons of the inventory data before and after the proposed applying of EOQ in 2012, inventory data of 2013 will be compared in this part in order to clearly illustrate the benefits from applying EOQ as an inventory management tool.

For the inventory level, figure 4.7 to 4.11 shows inventory levels when the company continues to apply the EOQ model from 2012 to 2013. The tendency of the inventory level is unvarying and the company has stock in appropriate amounts to sales volumes. Unnecessary stocks are decreased. The inventory amounts of each product are lower than the current ordering policy similar to 2012.

Figure 4.7: Inventory Amount of Product Code P01 from 2012 to 2013

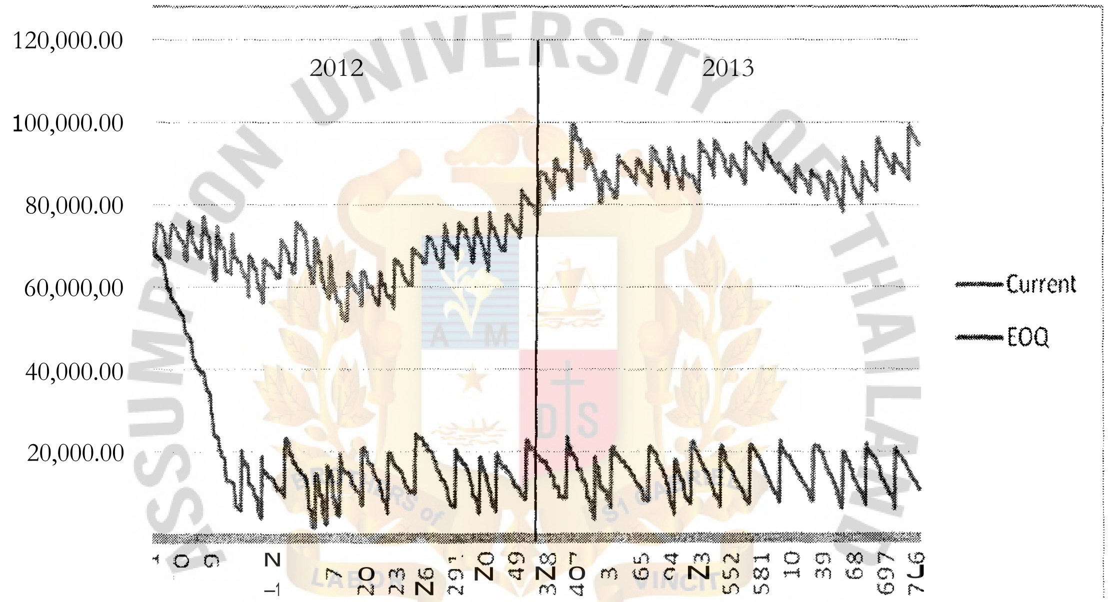


Figure 4.8: Inventory Amount of Product Code PO4 from 2012 to 2013

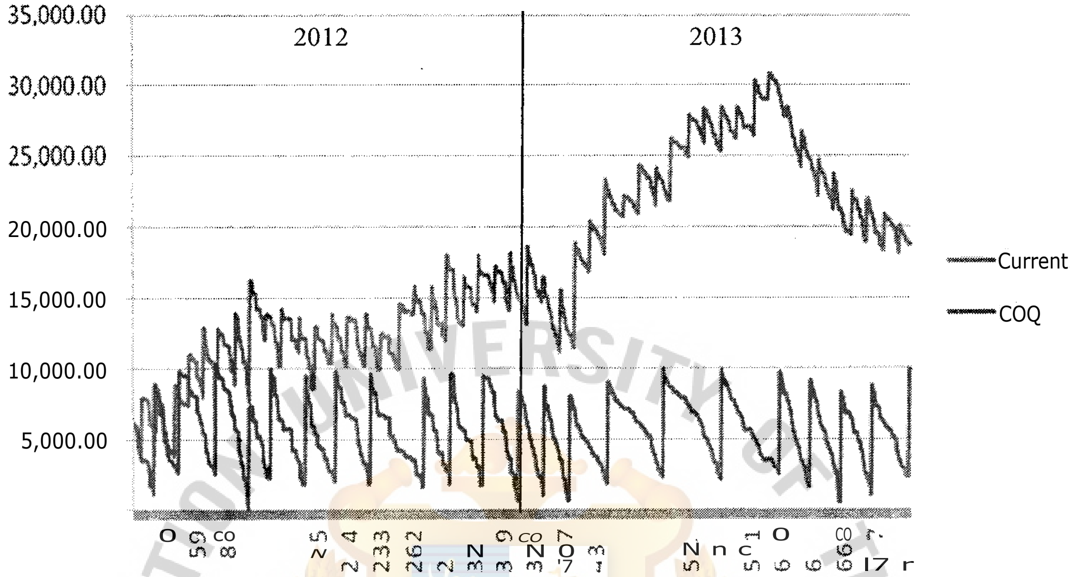


Figure 4.9: Inventory Amount of Product Code P03 from 2012 to 2013

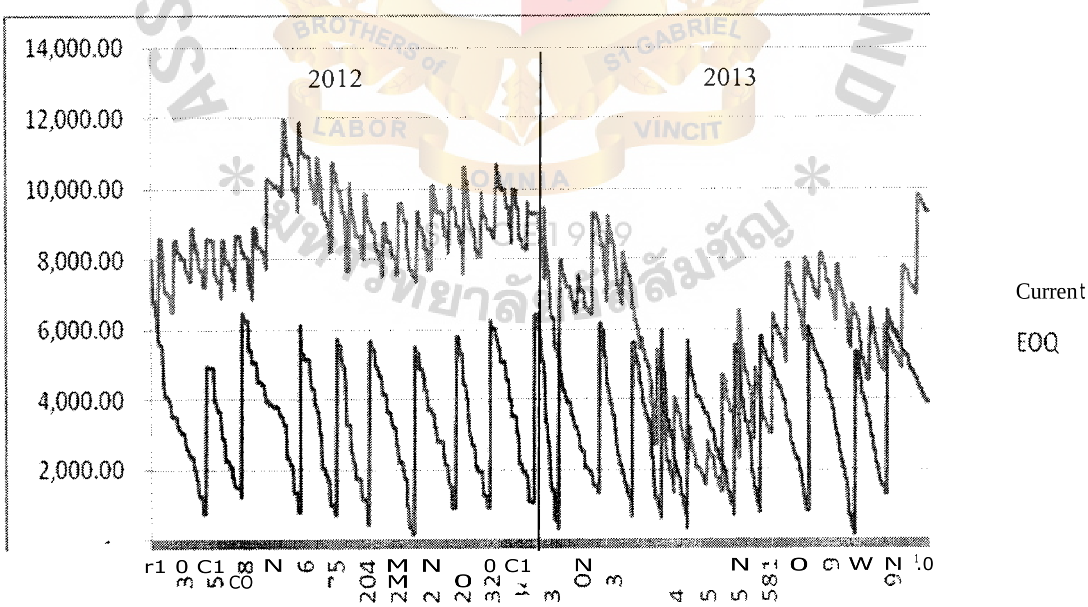


Figure 4.10: Inventory Amount of Product Code P02 from 2012 to 2013

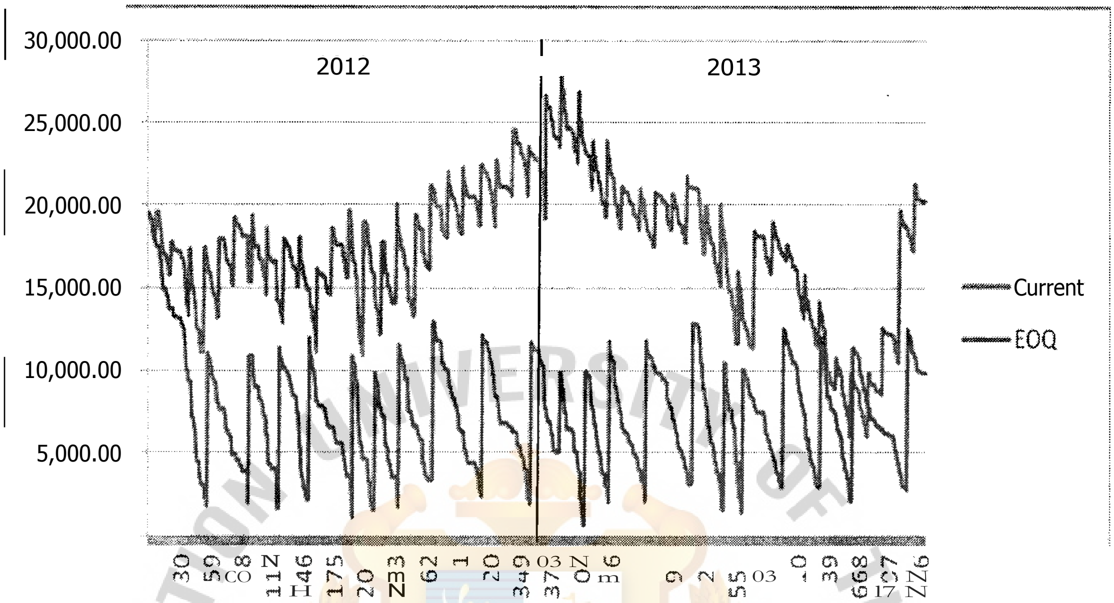
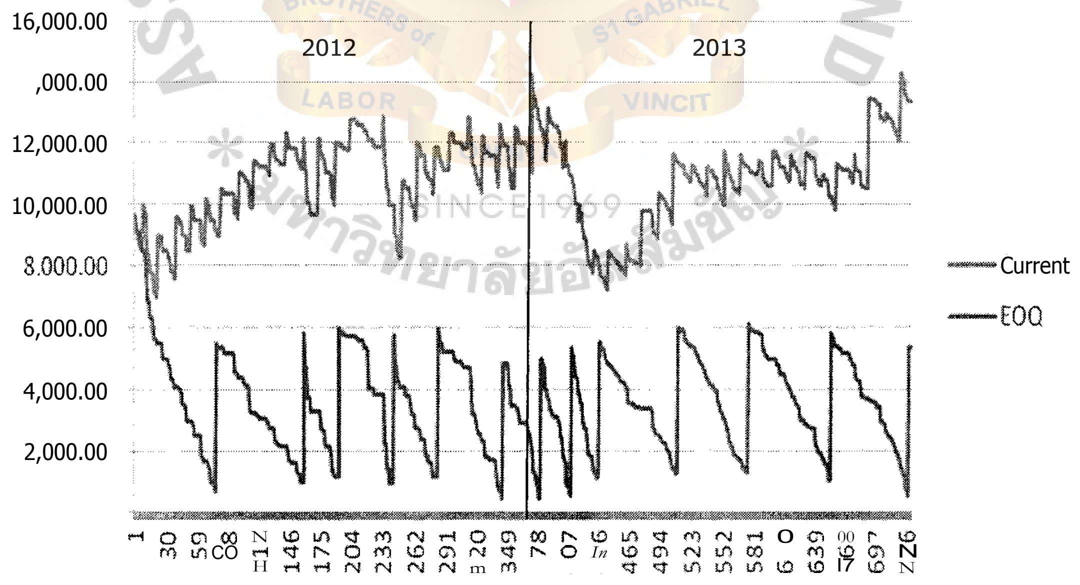


Figure 4.11: Inventory Amount of Product Code P05 from 2012 to 2013



Applying EOQ will lessen the variability of inventory levels. It will decrease average inventory amounts and the inventory amount at the end the of year. The company will save costs from lower stock levels since the available inventory amount is more consistent with sales volume than current ordering policies.

Declining inventory levels contribute to the company having lower expenses from reducing of inventory ordering costs while the majority of changes almost come from the cost of carrying inventory in big amounts. Table 4.11 shows ordering costs and carrying costs after continuing to use EOQ model.

Table 4.11: Ordering Cost and Carrying Cost of 2013

Product Code	Inventory Cost of Year 2013 (**Baht**)					
	Total Ordering Cost			Total Carrying Cost		
	Current (a)	**EOQ** (b)	Saved (a-b)	Current (c)	**EOQ** (d)	Saved (c-d)
P01	3,954.17	3,739.67	214.50 *(5.42%)*	678,680.06	111,262.69	567,417.37 *(83.60%)*
P04	3,954.17	3,681.17	273.00 *(6.90%)*	238,880.20	59,268.98	179,611.22 *(75.19%)*
P03	3,954.17	3,681.17	273.00 *(6.90%)*	69,955.55	41,183.76	28,771.79 *(41.13%)*
P02	3,954.17	3,700.67	253.50 *(6.41%)*	137,472.12	55,111.75	82,630.37 *(59.91%)*
P05	3,954.17	3,622.67	331.50 *(8.38%)*	115,489.89	37,220.12	78,269.77 *(67.77%)*
Total	19,770.85	18,425.35	1,345.50 *(6.81%)*	1,240,477.82	304,047.30	936,430.52 *(75.49%)*

Source: Author

According to table 4.11, the calculations show saved costs from continuing to apply the EOQ model in 2013. Total ordering costs of the studied products are lower than using current ordering policies by about 6.81%. Saved ordering cost of product codes P01, PO4, P03, P02 and P05 are equal to 5.42%, 6.90%, 6.90%, 6.41% and 8.38% respectively. In the same way as ordering cost, carrying costs are decreased by about

75.49% from their total. Saved carrying costs are 83.60%, 75.19%, 41.13%, 59.91% and 67.77% respectively.

After finishing the ordering costs and carrying costs calculations, total inventory costs are calculated next.

Table 4.12: Total Inventory Cost of Studied Products of 2013

Product Code	Inventory Cost of Year 2013 (Baht)		
	Current (a)	EOQ (b)	Saved (a-b)
P01	674,634.23	115,262.69	559,371.54 *(82.92%)*
P04	242,474.37	62,950.15	179,524.22 *(74.04%)*
P03	73,909.72	44,864.93	29,044.79 *(39.30%)*
P02	141,426.29	58,812.42	82,613.87 *(58.41%)*
P05	119,444.06	40,842.79	78,601.27 *(65.81%)*
Total	1,251,888.67	**322,732.98**	929,155.69 *(74.22%)*

Source: Author

As table 4.12 shows, continuing apply the EOQ model in 2013 makes the company able to reduce total inventory costs of product codes P01, PO4, P03, P02 and P05 about 82.92%, 74.04%, 39.30%, 58.41%, and 65.81% respectively. In conclusion, ABC Company can save 74.22% of total inventory costs in 2013 as a consequence of continuous application of the EOQ since 2012.

4.5 Summary

Table 4.13: Decrease of Average Inventory Level and Saved Total Inventory Cost of EOQ Proposed Model in 2012

Code	**Average Inventory Amount (kg)**		**Change**	**Total Inventory Cost (Baht)**		**Saved Total Inventory Cost**	**Change**	*Saved Carrying Cost*
	Current	**EOQ**	**(%)**	**Current**	**EOQ**	**(Baht)**	**(%)**	*(Baht)*
P01	67,466.84	20,485.37	**69.64%**	522,099.50	160,859.95	**361,239.55**	**69.19%**	*361,025.05*
PO4	12,051.97	5,522.48	**54.18%**	132,669.21	62,700.26	**69,968.95**	**52.74%**	*69,734.95*
P03	8,858.67	3,378.38	**61.86%**	111,321.25	44,607.64	**66,713.61**	**59.93%**	*66,421.11*
P02	17,605.24	7,653.32	**56.52%**	140,570.83	63,070.93	**77,499.90**	**55.13%**	*77,226.90*
P05	10,753.45	3,676.52	**65.81%**	118,801.02	42,868.40	**75,392.62**	**63.46%**	*75,581.61*
Total	116,736.17	40,716.07	**65.12%**	1,025,461.81	374,107.18	**651,354.63**	**63.52%**	*649,989.62*

Source: Author

According to the table above, the effect of applying economic order quantity (EOQ) as an inventory management tool benefits the company in terms of decreasing the average inventory amount by about 76,020.10 kg (116,736.17-40,716.07) or 65.12% from the current amount of studied products. The less inventory storage, the more the company saves on total inventory costs. In this study, ABC Company saves about 651,354.63 baht (1,025,461.81-374,107.18) or 63.52% of the current total inventory cost.

Table 4.14: Results from Continuous Applying EOQ in 2013

Code	Saved Average Inventory Amount	Saved Total Inventory Cost	Saved Carrying Cost
	(%)	**(%)**	**(%)**
P01	83.60%	82.92%	83.60%
PO4	75.19%	74.04%	75.19%
P03	41.13%	39.30%	41.13%
P02	59.91%	58.41%	59.91%
P05	67.77%	65.81%	67.77%
Total	65.52%	74.22%	75.49%

Source: Author

Similar to the results from table 4.13, the effects of the studied products' costs from applying the EOQ in 2013 are described in detail in table 4.14. Continuous application of EOQ from 2012 to 2013 can reduce inventory levels by about 65.52%. Total inventory levels are reduced 74.22% while total carrying costs reduced are 75.49%.

This study noticed that the saved costs of both 2012 and 2013 almost come from the saved carrying cost through reducing lose opportunity costs from holding high levels of inventory. Conversely, saved ordering costs comes from reducing order numbers. So it saves only a little expenditure from telephone, fax and documentation charges.

Therefore, this study can conclude that applying economic order quantity (EOQ) as an inventory management tool is better than using the current ordering policy. Since the company can calculate the appropriate time and amount of a products' order more related to sales volume. Furthermore, the proposed model not only can reduce the company's costs from overstocking, but it prevents the problem from inadequate warehouse space also.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the findings are summarized. The research's results conclude with recommendation.

5.1 Summary of the Findings

The discussion of findings of the results from chapter 4 shows the benefit by applying economic order quantity (EOQ) as an inventory management tool for the case study. The results of data analysis present the usefulness of EOQ as it is able to improve the purchasing performance with effective inventory cost savings and inventory level reduction.

As calculated in the results, inventory classification by ABC analysis then applying EOQ is a better policy for inventory management which archived the objective of the study. The important products are scoped and the inventory level and inventory costs are decreased.

5.2 Conclusions

According to the study, ABC Company found that it has never set the appropriate inventory management technique which was able to assist the purchasing department about making decision on reorder timing and proper quantity of product orderings. Therefore, the company has a high inventory level than its necessary. This causes the company to have high inventory costs also. Analyzing ABC Company, high inventory levels were found and tended to become higher. The inventory turnovers from 2010 to 2012 are in a downturn. The company assumes high expenses for inventory management, for instance, inventory ordering costs and carrying costs.

This study's main objective is to define the economic order quantity (EOQ) and reordering point (ROP) for important products which provide high revenue to the company with reference to inventory classification by ABC inventory classification theory.

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

1. Sales volume or demand patterns of studied products including product codes P01, PO4, P03, P02 and P05 have low variability enough to apply EOQ regarding to variability coefficient (VC) method. The demand of the products can be assumed as constant. Thereby, it is suitable to apply EOQ for inventory management.

2. After EOQ is applied to studied products, total inventory costs of these five products was reduced by about 63.52% while inventory amount was decreased by 65.12% as summarized in the data from table 4.10 in chapter 4.

3. Applying EOQ helps the company lessen total inventory costs from 1,025,461.81 baht to 374,107.18 baht or equal to 651,354.63 baht, but it significantly reduces inventory carrying costs by about 649,989.62 baht as summarized in the data from table 4.10 in chapter 4.

5.3 Theoretical Implications

This study proposes two main objectives. The former is applying economic order quantity (EOQ) to minimize total inventory cost and inventory level. The latter is to determine the re-order point (ROP) of each product.

To implement the economic order quantity (EOQ) as an inventory management technique, the company needs to gather another related data such as market price and economic trends in order to support the ordering determination and improve competitiveness. Sales volume of objective products should be tested for stability before applying. Aspects need to be studied and read up on for suitability and restrictions of application to avoid wrong selected policies which are useless for implementation.

5.4 Managerial Implications

This study proposes to redesign the new ordering policy based on applying economic order quantity (EOQ) model to minimize total inventory costs and inventory levels by providing exact figures to the company to reference the amount of inventory they are carrying, time to order and order quantity.

As managerial implementations, the purchasing department may not able to follow the ordering's pattern as applying EOQ determine at all. In order to keep the good relationship with suppliers, the company has to re-order every month. Continuous ordering makes the company get more benefits from good relation such as cash discount or extension of credit period in the future. However, application of EOQ is the solution for reduce inventory level and save the inventory cost from giving precedence to order amount and order timing.

5.5 Limitations and Recommendations for Future Research

In accordance with the focus of this study, it is on minimizing inventory cost under EOQ application for the scoped products. It is also recommended to extend the implementation to the other products of company too.

A key to access minimizing inventory cost by EOQ model is continuously reviewing the sales volume or demand e.g. every month or quarter before re-calculating figures concerning the EOQ numbers.

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APPENDICES

APPENDIX A

APPENDIX A

Sales Report of 2012

Code	Total Revenue of Year 2012		Cost/Kg	Sale Price/Kg
	(Kg)	(Baht)	(Baht)	(Baht)
P01	242,668.23	9,221,392.69	24.50	38.00
P02	105,730.66	4,757,879.63	25.50	45.00
P03	49,696.38	5,466,601.59	80.00	110.00
PO4	90,330.65	8,129,758.36	62.00	90.00
P05	35,610.81	4,273,296.76	62.00	120.00
P06	244.57	24,457.15	35.00	100.00
P07	1,467.56	95,391.25	27.00	65.00
P08	58.97	4,128.06	35.00	70.00
P09	32.89	3,947.22	53.00	120.00
P10	1,127.97	84,597.78	40.00	75.00
P1 1	1,128.03	90,242.52	45.00	80.00
P12	2,023.70	172,014.58	30.00	85.00
P13	2,874.32	143,715.79	22.00	50.00
P14	4,615.23	253,837.77	30.00	55.00
P15	1,866.00	186,599.72	38.00	100.00
P16	2,212.80	188,088.02	45.00	85.00
P17	12,280.34	429,811.96	27.00	35.00
P18	5,513.94	204,015.63	28.50	37.00
P19	4,396.26	153,869.25	27.00	35.00
P20	21,541.81	797,046.90	28.50	37.00
P21	2,493.31	174,531.63	49.00	70.00
P22	3,464.58	259,843.34	53.00	75.00
P23	13,129.20	446,392.94	26.00	34.00
P24	6,477.14	239,654.10	28.00	37.00
P25	22,064.88	706,076.29	26.50	32.00
P26	12,657.13	455,656.53	28.00	36.00
P27	19,083.14	706,076.29	28.25	37.00
P28	13,349.84	560,693.42	32.50	42.00
P29	31,307.23	1,252,289.15	31.00	40.00
P30	11,796.45	566,229.46	35.00	48.00
		40,048,135.78		

Inventory Reports of 2012

Code	Inventory at the end of year 2012 (Kg)	Inventory at the end of year 2012 (Baht)	Cost/Kg (Baht)	Sale Price/Kg (Baht)
P01	80,022.00	1,960,539.00	24.50	38.00
P02	22,752.26	580,182.63	25.50	45.00
P03	9,298.60	743,888.00	80.00	110.00
PO4	14,830.05	919,463.10	62.00	90.00
P05	12,009.32	744,577.84	62.00	120.00
P06	3,134.65	109,712.75	35.00	100.00
P07	2,670.79	72,111.33	27.00	65.00
P08	1,452.64	50,842.40	35.00	70.00
P09	2,531.94	134,192.82	53.00	120.00
P10	4,497.20	179,888.00	40.00	75.00
P11	1,730.23	77,860.35	45.00	80.00
P12	2,018.54	60,556.20	30.00	85.00
P13	10,838.00	238,436.00	22.00	50.00
P14	9,037.53	271,125.90	30.00	55.00
P15	6,748.32	256,436.16	38.00	100.00
P16	5,577.64	250,993.80	45.00	85.00
P17	9,984.28	269,575.56	27.00	35.00
P18	9,671.83	275,647.16	28.50	37.00
P19	8,609.64	232,460.28	27.00	35.00
P20	9,665.76	275,474.16	28.50	37.00
P21	8,349.65	409,132.85	49.00	70.00
P22	2,918.13	154,660.89	53.00	75.00
P23	7,952.41	206,762.66	26.00	34.00
P24	10,956.14	306,771.92	28.00	37.00
P25	8,941.76	236,956.64	26.50	32.00
P26	2,695.75	75,481.00	28.00	36.00
P27	9,788.69	276,530.49	28.25	37.00
P28	3,050.46	99,139.95	32.50	42.00
P29	10,915.50	338,380.50	31.00	40.00
P30	6,737.72	235,820.20	35.00	48.00
		10,043,600.54		

APPENDIX B

APPENDIX B

Monthly Demand of 2012

Month	Products Demand (Kg)				
	P01	PO4	P03	P02	P05
Jan	16,986.78	9,033.07	4,969.64	6,343.84	4,629.41
Feb	19,413.46	4,516.53	3,478.75	12,687.68	2,492.76
Mar	29,120.19	7,226.45	3,975.71	6,343.84	2,136.65
Apr	21,840.14	10,839.68	2,484.82	9,515.76	2,136.65
May	14,560.09	7,226.45	3,975.71	11,630.37	1,424.43
Jun	38,826.92	9,033.07	4,969.64	6,343.84	4,273.30
Jul	16,986.78	6,323.15	5,466.60	13,744.99	1,424.43
Aug	19,413.46	8,129.76	4,472.67	11,630.37	4,629.41
Sep	9,706.73	3,613.23	3,478.75	7,401.15	3,917.19
Oct	16,986.78	9,936.37	5,466.60	7,401.15	1,780.54
Nov	26,693.51	5,419.84	2,981.78	7,401.15	3,204.97
Dec	12,133.41	9,033.07	3,975.71	5,286.53	3,561.08
Total Demand	242,668.23	90,330.65	49,696.38	105,730.66	35,610.81

Variability Coefficient Calculation (1)

Month	Products Demand (Kg)				
	P01	PO4	P03	P02	P05
Jan	16,986.78	9,033.07	4,969.64	6,343.84	4,629.41
Feb	19,413.46	4,516.53	3,478.75	12,687.68	2,492.76
Mar	29,120.19	9,226.45	6,975.71	6,343.84	2,136.65
Apr	21,840.14	10,839.68	2,484.82	9,515.76	2,136.65
May	14,560.09	6,226.45	3,975.71	11,630.37	1,424.43
Jun	38,826.92	9,033.07	1,969.64	6,343.84	4,273.30
Jul	16,986.78	7,323.15	5,466.60	13,744.99	1,424.43
Aug	19,413.46	8,129.76	4,472.67	11,630.37	4,629.41
Sep	9,706.73	2,613.23	3,478.75	7,401.15	3,917.19
Oct	16,986.78	9,936.37	5,466.60	7,401.15	1,780.54
Nov	26,693.51	5,419.84	2,981.78	7,401.15	3,204.97
Dec	12,133.41	8,033.07	3,975.71	5,286.53	3,561.08
E d	242,668.23	90,330.65	49,696.38	105,730.66	35,610.81
d	20,222.35	7,527.55	4,141.37	8,810.89	2,967.57
d^2	408,943,540.63	56,664,071.73	17,150,904.06	77,631,753.22	8,806,456.87

Variability Coefficient Calculation (Continue)

Month	$\bar{d}^2_{P01}$	$\bar{d}^2_{P04}$	$\bar{d}^2_{P03}$	$\bar{d}^2_{P02}$	$\bar{d}^2_{P05}$
Jan	288,550,562.27	81,596,263.29	24,697,301.85	40,244,300.87	21,431,393.43
Feb	376,882,367.05	20,399,065.82	12,101,677.91	160,977,203.48	6,213,835.97
Mar	847,985,325.86	85,127,416,51	48,660,535.58	40,244,300.87	4,565,267.24
Apr	476,991,745.80	117,498,619.14	6,174,325.46	90,549,676.96	4,565,267.24
May	211,996,331.46	38,768,704.51	15,806,273.18	135,265,566.81	2,029,007.66
Jun	1,507,529,468.19	81,596,263.29	3,879,473.85	40,244,300.87	18,261,068.96
Jul	288,550,562.27	53,628,460.01	29,883,735.24	188,924,634.64	2,029,007.66
Aug	376,882,367.05	66,092,973.27	20,004,814.50	135,265,566.81	21,431,393.43
Sep	94,220,591.76	6,828,950.13	12,101,677.91	54,776,965.07	15,344,370.45
Oct	288,550,562.27	98,731,478.59	29,883,735.24	54,776,965.07	3,170,324.47
Nov	712,543,225.20	29,374,654,79	8,891,028.67	54,776,965.07	10,271,851.29
Dec	147,219,674.63	64,530,133.29	15,806,273.18	27,947,431.16	12,681,297.89
$\sum(d\ )$	5,617,902,783.82	744,172,982.65	227,890,852.58	1,023,993,877.71	121,994,085.69

Monthly Demand of 2013

Month	Products Demand (Kg)				
	P01	PO4	P03	P02	P05
Jan	12,423.96	9,936.37	7,853.35	10,109.31	4,665.86
Feb	19,653.14	8,129.76	2,556.20	11,117.92	5,172.38
Mar	17,349.71	5,286.45	6,436.00	9,309.31	3,130.61
Apr	14,252.17	2,456.53	7,575.56	5,817.51	1,039.30
May	25,299.55	5,034.11	4,660.49	6,400.67	2,344.47
Jun	17,518.42	4,516.53	2,995.94	14,889.75	1,893.28
Jul	14,000.00	5,419.84	6,407.01	9,942.50	2,782.56
Aug	16,331.48	3,041.97	3,083.62	6,961.85	1,532.00
Sep	13,609.67	8,839.68	3,387.43	11,640.00	1,759.43
Oct	21,770.84	9,385.55	5,437.72	7,895.39	2,378.30
Nov	16,937.83	7,723.15	3,618.13	4,226.34	1,734.95
Dec	15,139.04	5,123.37	1,978.87	5,911.86	2,919.48
Total Demand	204,285.81	74,893.31	55,990.32	104,222.41	31,352.62