# APPLYING AN EOQ MODEL TO REDUCE AN INVENTORY COST

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## ABSTRACT

*This research study applies an EOQ model (Economic Order Quantity) to reduce an inventory cost. The focus ABC Company is a Beer Importer in Thailand. It faced the problem of high inventory cost and lackluster inventory management. The root cause was that the Company had no standardized ordering process, which meant a high cost of carrying excess inventory, or having too little to meet demand. It also meant paying a high storage charge.*

*The EOQ Model was proposed, to make substantial improvements. Historical inventory stock data for years 2014 and 2015 shows that the ABC Company had low stock at the end of 2014, which meant the company was not able to fulfill customer demand. Conversely, it had excess stock at the end of 2015 which increased the carrying cost until the product moved from the warehouse (the internal supply chain) on to customers in the external supply chain.*

*The researchers collected historical data from June 2015 to May 2016 (twelve months) to compute and simulate in the EOQ model, thus identifying the re-order point and safety stock, in order to find the optimal order quantity for inventory. This enabled the identification of appropriate inventory levels and buffer stock until arrival of the next shipment. The driving objective of this research was to gain cost savings through an efficient and effective inventory management system.*

*After simulation with the EOQ model, the result indicates that the ABC Company can accomplish cost savings amounting to 50% of the old annual inventory cost. Therefore, the ABC Company should implement the tested EOQ model and its re-order points, to achieve the ultimate aim of improving customer satisfaction, through buying the optimal order quantity, achieving appropriate inventory levels, and minimizing inventory cost.*

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*This is a much condensed version of Ms. Russarin's MSc research report in part fulfillment of the requirements for the MSc degree in Supply Chain Management at Assumption University. Her email is: pprussarinj@gmail.com

**บทคัดย่อ**

งานวิจัยนี้เพื่อศึกษาบริษัทนำเข้าเครื่องดื่มแอลกอฮอล์ที่กำลังประสบปัญหาต้นทุนในการจัดเก็บรักษาสินค้าที่สูงและการจัดการบริหารสินค้าคงคลังที่ไม่มีประสิทธิภาพ ปัญหาเกิดขึ้นจากบริษัทไม่มีหลักการและเครื่องมือที่เป็นมาตรฐานในการกำหนดและตัดสินใจก่อนสั่งซื้อสินค้า ด้วยเหตุนี้จึงทำให้บริษัทประสบปัญหาต้นทุนการเก็บรักษาสินค้าต่อปีค่อนข้างสูงเนื่องจากมีสินค้าคงคลังคงเหลือเป็นจำนวนมากและบางปีประสบปัญหาสินค้าไม่เพียงพอต่อความต้องการของลูกค้า ซึ่งข้อมูลที่ได้มาจากประวัติข้อมูลย้อนหลังสินค้าคงเหลือปี พ.ศ. 2557 และ 2558 ตามลำดับ ดังนั้นจึงเป็นกรณีศึกษาตัวอย่างในการหาวิธีที่จะแก้ไขปัญหาดังกล่าว โดยศึกษาจากทฤษฎีการตัดสินใจสั่งซื้อสินค้าที่จุดปริมาณคุ้มทุนเพื่อไม่ให้สินค้าคงคลังคงเหลือหรือขาดมากเกินไป สูตรการคำนวณ EOQ หรือที่เรียกว่า Economic Order Quantity ซึ่งเป็นสูตรการคำนวณหาจุดสั่งซื้อที่ประหยัด ได้ถูกนำเสนอในการวิจัยครั้งนี้เพื่อพัฒนาและแก้ไขปัญหาในเรื่องของต้นทุนการเก็บรักษาสินค้าคงคลังต่อปีที่สูง อีกทั้งยังเป็นการลดค่าใช้จ่ายของต้นทุนการสั่งซื้อสินค้าต่อครั้งและต้นทุนการจัดเก็บสินค้าคงคลังต่อปีอีกด้วย ในการแก้ไขปัญหาดังกล่าว มีการนำข้อมูลย้อนหลังมาจำลองการคำนวณจริงเพื่อหาจุดสั่งซื้อที่ประหยัดที่สุด จุดสั่งซื้อซ้ำและจำนวนสินค้าคงคลังสำรองจนกว่าสินค้าที่สั่งซื้อรอบถัดไปจะมาถึงคลังสินค้า วัตถุประสงค์ของงานวิจัยครั้งนี้ เพื่อกำหนดสินค้าคงคลังคงเหลือที่เหมาะสม ไม่สั่งซื้อสินค้าในปริมาณที่มากหรือน้อยเกินไป ภายหลังการทดลองคำนวณ EOQ ผลชี้วัดว่า บริษัทสามารถลดต้นทุนการเก็บสินค้าต่อปีได้ถึง 50% จึงสรุปได้ว่า EOQ model คือเครื่องมือที่สามารถช่วยให้บริษัทลดต้นทุนการจัดเก็บสินค้า ต้นทุนการสั่งซื้อ พร้อมทั้งยังช่วยบริหารสินค้าคงคลังได้อย่างมีประสิทธิภาพมากขึ้น

# INTRODUCTION

The EOQ model is basically used before planning or making decisions to purchase a product from a supplier. The main objective is to identify an optimum order level, when to restock, and thus minimize the carrying cost. Overall, the EOQ model would help to improve inventory management through an efficient inventory approach. The EOQ model is an appropriate method which can help to minimize the annual inventory cost of imported products. The carrying cost is reflected in the inventory level. A high carrying cost means that the company is holding excess inventory. In a well-managed and efficient inventory system, demand and supply should be in balance.

## Statement of the Problem

The ABC Company has been an official Beer Importer in Thailand since 2011. The company sells two SKUs, which consist of Lager and Dark, in small 330ml bottles. Due to the company's lack of experience, stock ordering decisions were basic, and the staff had no standardized ordering method.

Hence, this research is focused on applying the EOQ formula to the making of supply purchase decisions. The company faced a high carrying cost after 2014. Based on historical data for the end of 2014, there was low stock, which caused problems of customer satisfaction as the company was not able to fulfill customer demand. However, the end-of-year stock for 2015 was excessive, causing the company extra carrying cost until the product finally moved out from the warehouse. This problem, with its high inventory carrying cost, is a major cost. Faced with an inappropriate inefficient ordering method, this research aim was to investigate the ordering process. The annual inventory cost can be reduced if there is an optimal order quantity and known dates when to replenish orders. Therefore, this research sought to identify an appropriate inventory level and minimize the inventory cost.

## LITERATURE REVIEW

### Inventory Management

Reid and Sanders (2007) explained that the standard of inventory management is concerned with two objectives. First, it is very important to provide the product at the right time and right place because that is a measure of good inventory management. Second, good management of inventory needs to consider lead time as well as related factors. Stevenson and Chuong (2014) stated that the primary objectives of inventory management are determining and controlling the stock level. This involves dealing with market demand, product availability, and handling cost. Therefore, inventory management is the set of policies and controls which determine what level should be maintained and when that stock should be replenished and how large the order should be (Ho, 1989).

### Inventory Cost

There are three types of inventory related cost, as follows

1. Ordering Cost. This is the cost of expenses incurred when the company places an order. This cost includes administrative cost, progress chasing and inspection cost (Piasecki, 2001).
2. Carrying Cost. This is the cost of holding or carrying a product for a period of time. This cost is computed based on finished goods per unit, with four subcategories, which consist of capital cost, storage cost, service cost, and risk cost (Piasecki, 2001).
3. Shortage Cost or Stock-out Cost. This is the cost of not having sufficient stock to serve the customer needs. This cost contributes to lost margin on sales, and affects customer goodwill (Piasecki, 2001).

**The Economic Order Quantity Model**

Piasecki (2001) defined the EOQ formula as a combination of ordering cost and carrying cost. A good inventory management system incorporates the factors which have an impact on EOQ in the purchasing period. Therefore, the company needs to have a good measurement process in order to achieve accuracy and up-to-date results. Lucey (1992) explained that the researched manufacturing company valued the EOQ model because it can maintain an optimal inventory level in its stores and can minimize the total cost of investment in inventory. Moreover, it was found to be good as a sales forecasting technique and to reduce the cost of production. Roach (2005) stated that the EOQ formula is used in various industrial engineering businesses but also can be found in both operational and financial companies. The EOQ formula has a practical concern for cost tradeoffs as well as specific applications in inventory. Another research team, Adeyemi and Salami (2010) studied efficient inventories which avoid the cost of changeable product rates. After analysis, the focus company applied the EOQ model to determine the optimum inventory level per year. Even though the EOQ formula provided the near-optimal order quantities regardless of whether the item's demand rate is either constant or not, it is associated with ordering and inventory-holding costs.

**EOQ Assumptions**

Gonzalez and González (2010) implemented the EOQ model to minimize the inventory problems such as ineffective forecasting, product stock-out and loss of sales. After they applied the model to the XYZ Company they found results which can help the company to determine the appropriate level of inventory on hand. Moreover, the EOQ and Re-Order Point could help the company to reduce its overall cost and reduce stock-out. In addition, Lucey (1992) stated that the basic assumptions of the EOQ model are that it is necessary to know the constant cost of holding stock, the constant cost of ordering, the demand rate, and the cost price per unit.

**Reorder Point (ROP)**

Chen (1998) explained that one more important method that is used along with the EOQ is the Reorder Point. The re-order point relates directly to two variables: demand and lead time. The ROP quantity can reflects the level of inventory, whereas the quantity associated with safety stock protects the company from stock-outs or backorders.

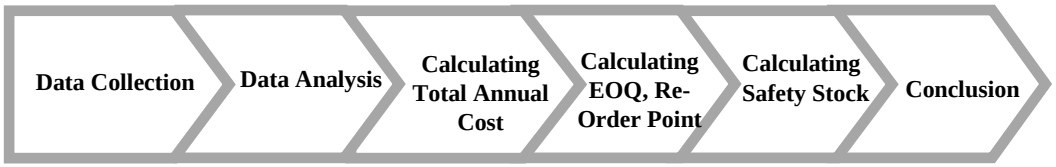
**Safety Stock**

Ray and Millman (2007) mentioned that safety stock is the buffer inventory necessary to prevent product shortages when the demand is higher than the stock availability. A level of extra stock can help maintain and mitigate the risk of stock-outs due to uncertainties in demand and supply. Moreover, Render et al.

(2008) stated that the significance of the EOQ is to achieve a balance between demand and the products available during the period, to avoid stock-out in the market. Even though the EOQ is useful for optimal stock level, fluctuations in demand and lead time have a critical impact on inventory and therefore must be taken into consideration. As the uncertainty in demand usually leads to an opportunity loss in sales, customer demand cannot always be fulfilled. Therefore, to prevent stock-out, it is necessary to consider having extra inventory called safety stock.

# RESEARCH METHODOLOGY

There are six procedures to explain the methodology. First is data collection, with information about the data gathering techniques. Second is to compute data for the total annual cost to show how much the company has spent in annual inventory cost. Third is to compute EOQ in order to find the appropriate order quantity. Fourth, is to compute ROP which can determine when to place a new order. Fifth is to compute safety stock which is already included in ROP. The last procedure is the conclusion, a comparison of results before and after applying the EOQ model.




**Data Collection**

The method of data collection consists of historical data of inventory reports, and actual ordering costs and actual carrying costs, from June 2015 to May 2016. The data includes product quantity received, stock in, stock out, actual demand, back order, and the beginning and ending stock. The purpose for collecting this data is to compare the result after simulating EOQ, ROP and safety stock.

**Data Compute**

**Calculation of Total Cost**

The researcher computed the total cost from June 2015 to May 2016 by summarizing the ordering and carrying cost of each month. The ordering cost is a fixed cost which is involved with the order process; for example the cost of preparing a purchase order including any cost of placing a purchase order, paper, and phone bill etc. This cost would not vary with demand and order quantity. The carrying cost is the cost which varies according to order quantity, and consists of the handling charge, warehouse management, and handling fees etc. As a result, the carrying cost is counted based on actual quantity received each month.

**Calculation of Economic Order Quantity (EOQ) and ROP**

The next step is to calculate the EOQ of each SKU by simulation of the historical data. The ordering cost and carrying cost need to be known before computing the EOQ and ROP, and include annual inventory demand in units. In this study the consumption demand of Beer Lager is higher than Beer Dark, therefore the result for the carrying cost per unit would be different and the number of units to order as well. After computing the EOQ, the next step is to calculate ROP, which due to the actual quantity received each month is variable Hence, the researchers' purpose is to calculate ROP with variable demand but with constant lead time. To calculate ROP with uncertainty of demand it is necessary to know the average annual demand during the production period which includes the amount of safety stock.

**Evaluate, and Expected Results**

The pilot study was conducted in August 2016 using data to simulate from June 2015 to May 2016. The data was exported from Navision software, using only internal ABC company data, to Excel spreadsheet. In order to evaluate the result, after simulating and computing data, the researcher compared two points. First is the amount of actual order quantity for each SKU; for example, how many order quantities were different before and after applying the EOQ and ROP with variable demand and constant lead time. Second is a comparison of the carrying cost of each SKU, without using EOQ and with EOQ. After all these calculations, the researcher anticipated that the result of the annual carrying cost should be reduced from what was actually spent, including the annual ordering cost. Furthermore, an appropriate inventory level and holding of sufficient stock is needed in order to serve and fulfill customer demand and prevent product shortage. The EOQ model should help the company to identify optimal quantity which would minimize the end stock of Beer Lager.

# PRESENTATION & CRITICAL DISCUSSION OF RESULTS

This chapter focuses on the data comparison after simulating the EOQ model. The aim of this research is to find the optimal order quantity, when to reorder, and how many items should be kept as a buffer until the next shipment arrives. The results from simulation are described below.

**Actual Total Cost Computing**

According to the data collected from the Navision software and transferred to Excel spreadsheet, the actual total cost was calculated based on actual quantity received per month; total annual demand for Beer Lager was 43,065 cartons and for Beer Dark 39,470 cartons. The details are as follows.

**Table 1: Total Cost of Beer Lager and Dark**

| Qty. Received | | Ordering Cost | Carrying cost | Total Cost |
|---|---|---|---|---|
| Beer Lager | 43,065.00 | 2,727.24 | 278,508.15 | 281,235.39 |
| Beer Dark | 39,470.00 | 2,727.24 | 191,219.47 | 193,946.71 |

Source: Company data

This indicates that the annual carrying cost of Beer Lager is higher than Beer Dark due to greater consumption demand for Beer Lager. The total cost of Beer Lager was 281,235.39 THB (Thai Baht), while the total cost of Beer Dark was 193,946 THB.

**Economic Order Quantity Computing (EOQ)**

After calculating the total annual cost, the next step is to calculate the EOQ, the carrying cost per unit variable to annual demand. To achieve the most accurate optimal order quantity the carrying cost per unit, we need to calculate it based on the number of storage days in the warehouse until the product is moved out.

**Table 2: EOQ Beer Lager and Dark**

| SKU | Annual demand D | Ordering cost Co | Carrying Cost Cc | Q |
|---|---|---|---|---|
| Beer Lager | 43,065 | 227.27 | 6.47 | 1,739 |
| Beer Dark | 39,470 | 227.27 | 4.84 | 1,925 |

Source: Company data

After simulating the EOQ, the results show that if the annual demand is 43,065 cartons, the company should order Beer Lager x 1,739 cartons per batch order, and Beer Dark x 1,925 cartons per batch order if the annual demand is 39,470 cartons.

**Compare Annual Carrying Cost**

When the researcher simulated historical data before applying the EOQ method, the annual carrying cost of Beer Lager was 278,508.15 THB, and for Beer Dark was 191,219.47 THB. The company spending on total annual carrying costs for both SKUs is almost 470,000 THB. per year. The results after applying the EOQ model are shown below.

**Table 3: Comparison of Annual Carrying Cost Using EOQ Model**

| Product SKU | EOQ | Carry Cost per carton (THB) | Actual Annual Carrying Cost | Annual Carrying Cost Using EOQ | Saving % |
|---|---|---|---|---|---|
| Beer Lager | 1,739 | 6.47 | 278,508.15 | 135,015.96 | 52% |
| Beer Dark | 1,925 | 4.84 | 191,219.47 | 111,804.00 | 42% |

Source: Company data

Table 3 indicates that the company would enjoy cost savings in the carrying cost, of about 52% for Beer Lager and 42% for Beer Dark. The annual carrying cost would reduce from the actual spending if the company implements the EOQ model to manage inventory.

**Compare Annual Inventory Cost**

The EOQ model has been proposed for minimizing the annual inventory cost. The comparison between the current cost and after applying the EOQ model is indicated in Table 4 as follow.

**Table 4: Comparing Annual Inventory Cost Using EOQ model**

| Product SKU | Actual Annual Inventory Cost (THB) | Annual Inventory Cost Using EOQ (THB) | Different of Inventory Cost (THB) | Different (%) |
|---|---|---|---|---|
| Beer Lager | 281,235.39 | 140,644.13 | 140,591.26 | 50% |
| Beer Dark | 193,946.71 | 116,463.92 | 77,482.79 | 40% |

Source: Company data

The result for the total annual inventory cost for Beer Lager, using EOQ, is 140,591.26 THB, and 77,482.79 THB for Beer Dark. This means that after applying the EOQ model, the annual inventory cost reduced by 50% for Beer Lager and by 40% for Beer Dark. Therefore, the EOQ model is an appropriate method to manage and minimize the cost of inventory.

# CONCLUSION

**Research Objectives**

The main purpose of the study was to test the EOQ model in order to minimize the carrying cost for imported products. The research purpose was to find the optimal order quantity and provide an improvement in inventory management. The problem, focused on the ordering process and high carrying cost. Because the company has no standardized ordering process, this problem directly impacts on the annual inventory cost. However, the EOQ model can help to minimize cost and provide appropriate inventory levels. The finding shows that the EOQ method was able to identify an optimal order quantity, including reorder point

and buffer stock until the next shipment arrives. The EOQ model can help the company to reduce the carrying cost average by 50% for Beer Lager and 40% for Dark; meanwhile the ROP gives advice as to the point when the company should refill its stock. After identifying these improvements, the researcher searched for an appropriate methodology for a solution. The methodology found is based on simulating the EOQ formula, ROP, and safety stock by using actual historical data. After implementation the company could see savings on annual carrying cost averaging 47% in a year, and the solution also provided that the company should re-order when stock falls down to 3,634 cartons for Beer Lager and should re-order Beer Dark when its stock falls down to 3,334 cartons.

**Limitations & Recommendations for Future Research**

There are some limitations found in this study. First, the early data of ABC Company was not available from the system. So, the researcher used historical data from June 2015 to May 2016 to simulate. Second, the data did not include seasonal demand. Third, due to the time limitation, the result from the calculations was not available to implement for a current period. Last, there are limitation of the EOQ model which is not suitable for seasonal production as it is quite difficult to manage inventory for that.

This research focus was to improve by minimizing the annual carrying cost, and that would decrease the total inventory cost The researcher considered the EOQ method after reviewing relevant published academic literature. The EOQ methodology is commonly applied in all industries, especially in the planning process. However, there are some areas which the researcher suggests could be studied in future research, especially about the forecasting time series method model and the seasonal dummy variable model. These models could help to improve the prediction of seasonal demand either in high or low seasons.

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