# ANALYSIS OF INVENTORY IN A FOOD REPACKAGING COMPANY

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering in Industrial Engineering
Department of Industrial Engineering
FACULTY OF ENGINEERING
Chulalongkorn University
Academic Year 2021

# การวิเคราะห์สินค้าคงคลังในบริษัทบรรจุอาหาร

น.ส.ชุติปภา เธียรตระวัน



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาวิศวกรรมอุตสาหการ ภาควิชาวิศวกรรมอุตสาหการ
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2564

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|---|---|
| Thesis Title | ANALYSIS OF INVENTORY IN A FOOD REPACKAGING COMPANY |
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| Field of Study | Industrial Engineering |
| Thesis Advisor | Associate Professor ORAN KITTITHREERAPRONCHAI, Ph.D. |

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อ.ที่ปรึกษาหลัก : รศ. ดร.โอฬาร กิตติธีรพรชัย

งานวิจัยฉบับนี้มีวัตถุประสงค์เพื่อประเมินลักษณะของธุรกิจและประยุกต์นโยบายสินค้าคงคลังที่เหมาะสมกับบริษัทกรณีศึกษาห่อบรรจุผลิตภัณฑ์อาหาร บริษัทกรณีศึกษาได้นำการจัดซื้อวัตถุดิบแบบกอง (Bulk-Purchasing) เพื่อการประหยัดโดยขนาด (Economy of Scale) แต่เนื่องจากขาดมาตรฐานการจัดซื้อและขาดการตรวจสอบอย่างต่อเนื่อง นโยบายการซื้อสินค้าดังกล่าวของบริษัทก่อให้เกิดสินค้าคงคลังที่มากเกินไป ไม่เคลื่อนไหว และ เสื่อมสภาพ นอกจากนี้ยังเป็นผลให้เกิดความแปรปรวนของอัตรารอบสินค้าคงคลัง (Inventory Turnover Rate) การวิเคราะห์ผลกระทบและการจัดกลุ่มด้วยการวิเคราะห์ ABC ของบริษัทแสดงให้เห็นว่าสินค้าคงคลังทั้งที่เป็นประเภทถุงและบรรจุภัณฑ์มีระยะเวลาการรอสินค้าที่ยาวนานและมีปริมาณการสั่งซื้อขั้นต่ำ (Minimum Order Quantity: MOQ) สูง เนื่องจากสินค้าเหล่านี้มีการจัดซื้อจากต่างประเทศ ดังนั้นงานวิจัยฉบับนี้จึงเสนอให้ทางบริษัททำการสั่งซื้อถุงและบรรจุภัณฑ์จากภายในประเทศแทนรวมกับเจรจาต่อรองกับผู้ขายเพื่อลดระยะเวลาและปริมาณการสั่งซื้อ ดังนั้น งานวิจัยนี้ได้นำเสนอการประยุกต์ ปริมาณการสั่งซื้อประหยัด (Economic Order Quantity: EOQ) การกำหนดจุดสั่งซื้อ (Reorder Point: ROP) และ การทบทวนสินค้าคงคลังแบบต่อเนื่อง ความเหมาะสมและผลกระทบของนโยบายได้ทดสอบและเปรียบเทียบด้วยการจำลองสถานการณ์แบบมอนติ-คาร์โล (Monte Carlo Simulation) ผลการจากแบบจำลองพบว่านโยบายดังกล่าวนำไปสู่การลดต้นทุน 23.46% จากการป้องกันสินค้าขาดจากส่ง และ การลดสินค้าคงคลังส่วนเกิน นอกเหนือจากสินค้าคงคลังแล้วงานวิจัยนี้ยังนำเสนอการนับสินค้า ของสินค้าแต่ละกลุ่ม



สาขาวิชา วิศวกรรมอุตสาหการ ลายมือชื่อนิสิต .....

ปีการศึกษา 2564 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

## 6170200421 : MAJOR INDUSTRIAL ENGINEERING
KEYWO RD: Inventory Management, Food Repackaging, Reorder point

Chutipapha Thiantravan : ANALYSIS OF INVENTORY IN A FOOD REPACKAGING COMPANY. Advisor: Assoc. Prof. ORAN KITTITHREERAPRONCHAI, Ph.D.

This research aims to evaluate the nature of business and apply a suitable inventory policy to a case study food-repackaging company. The company adopted bulk-purchasing to packaging inventory to realize the economy of scales. Because of the lacks of purchasing standard and monitoring, this inventory policy led to the overstock, deadstock, and obsolete packaging inventories as well as the fluctuation of inventory turnover rate. The further category analysis of the packaging inventories using ABC analysis reveals that special customized bags and packaging items have a long lead time due to international sourcing and high minimum order quantity (MOQ). As a result, this research proposed local sourcing and negotiation of purchasing volume as means to reduce ordering lead time for high-impact and active packaging items. Hence, the application of Economic Order Quantity (EOQ), reorder point (ROP), and continuous inventory review were suggested as inventory policy. The compatibility of the policy and its impacts was validated and compared using a Monte Carlo Simulation. The results suggested that the proposed policy could reduce inventory cost by 28.36% by preventing stock-out and reducing excess inventory. In addition to the inventory, the research also highlighted inventory cycle count of each group.



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| Field of Study: | Industrial Engineering | Student's Signature ..... |
| Academic Year: | 2021 | Advisor's Signature ..... |

# ACKNOWLEDGEMENTS

First of all, I would like to express the deepest gratitude to Assoc. Prof. Oran Kittithreerapronchai, for his expertly guidance, valuable comments, and suggestions on my thesis.

Besides my thesis advisor, I would also like to extend my appreciation and sincerely thank to the thesis examination committee, Assoc. Prof. Wipawee Tharmmaphornphilas and Assoc. Prof. Naragain Phumchusri for the useful suggestion and information.

Finally, my deeply gratitude also extends to my family and my friends, for their worthy support and encouraged me in this effort. This accomplishment would not have been possible without them.

Chutipapha Thiantravan

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# CHAPTER 1:
# INTRODUCTION

Demand fulfillment has been one of the most challenging topics for many companies. In upstream logistics, the challenges range from process management, availability of inventory, and market channel (Rego, 2015). The study by Zavanella (Zavanella, 2006) has further incorporated downstream challenging elements, including purchasing process, and inventory management and recommended that several companies should improve the purchasing and production processes, such as reducing production cycle time and delivery lead time.

In a production environment, a reliable and continuous flow of raw materials is essential for the effective production and suitable level of inventory. Nevertheless, small factories often suffered from large quantities and discrete purchasing of raw materials because of long lead time and economy of scale. Coupled with the lack of inventory visibility and necessary information, many factories have experienced either production disruption caused by insufficient inventory or insufficient storage location resulting from excessive purchasing, similar to a case study company with its packaging raw materials. This chapter will guide through the inventory problems and objectives of this research paper.



## 1.1 CASE STUDY COMPANY

Established in 1989, the case study company is an integrated agency and wholesaler who provides one stop services for foods and beverages products that are manufactured in Thailand. Positioned itself as business-to-business, the company wholesales its products to the international food importer as well as domestic retailers. The portions of sales in the international market and domestic market are shown in Figure 1-1.

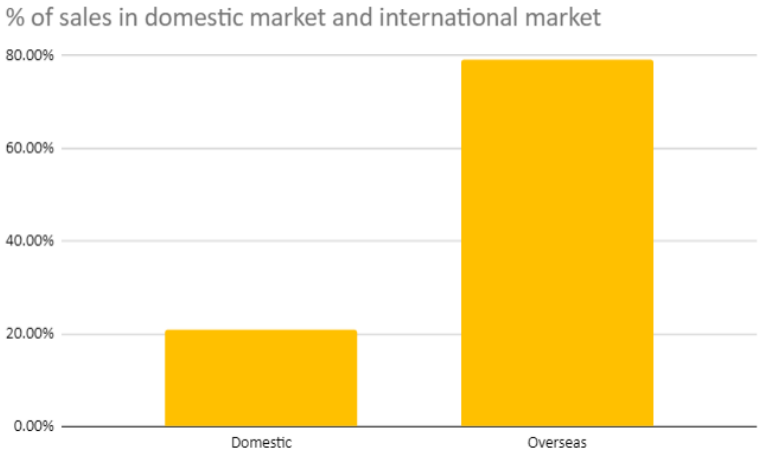


*Figure 1- 1: Percentage of Sales Distribution by Market*

The figure suggests that the majority of revenues comes from the international market as it accounts for approximately 80% of the total sales.

### 1.1.1 Products

Despite a few hundred products, the case study company stores and distributes more than 1,000 stock keeping units (SKU) as different customers may request different flavors and pack sizes. Furthermore, a proper sticker labeling may need to follow individual regulations by each country, as shown in Figure 1-2.



*Figure 1- 2: Different sticker labelling on product*

Figure 1-2 shows the identical product with different labels and packaging requested by different customers. The left side shows an English sticker label for the Mauritius market, while the product on the right-hand side is stickered with a Chinese label for the Hong Kong market. Despite of many SKUS, the case study company, in general, groups products into two categories as followed:

- **Trading product category:** This category is referred to a fast moving consumer goods (FMCG), as shown in Figure 1-3. The company purchases, places appropriate labels, and deliveries to overseas customers. Most of the orders for this category are from international customers following the operation process, as shown in Figure 1-4. After orders are received, a purchaser issues a PO for the exact quantity to respective suppliers. The trading product is then shipped to a warehouse for placing labels before loading into export containers. As a result, there is no inventory of such categories left once the products are shipped.


*Figure 1- 3: Examples of trading products (FMCG)*

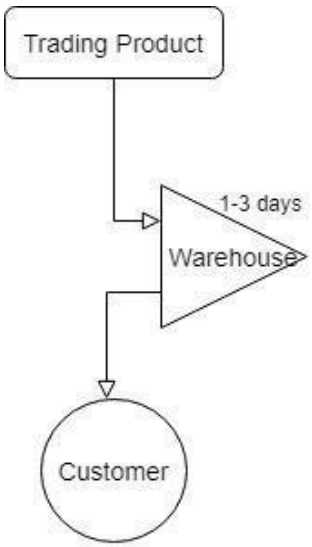


*Figure 1- 4: Trading product flow*

- **Repackaged product category**: This category refers to products that the company purchases in large bulk quantities and repackages them into specific and custom packaging requested by customers. In some sense, the company serves as an original equipment manufacturer (OEM) of products. The example of repackaged products is depicted in Figure 1-5. The repackaged products can be sold domestically and internationally with a different operation flow, as shown in Figure 1-6. After a customer's orders are received, a purchaser must convert the customer's order quantities into quantities required from different components based on Bill of Materials (BOM) and compare available inventories. The BOM of a repackaged product typically includes raw materials, product related packaging, and carton. When all its components are available in the warehouse, workers weigh and repackage components inside a production room following appropriate food standards. The repackaged products are then shipped to customers.


*Figure 1- 5: Examples of repackage products*

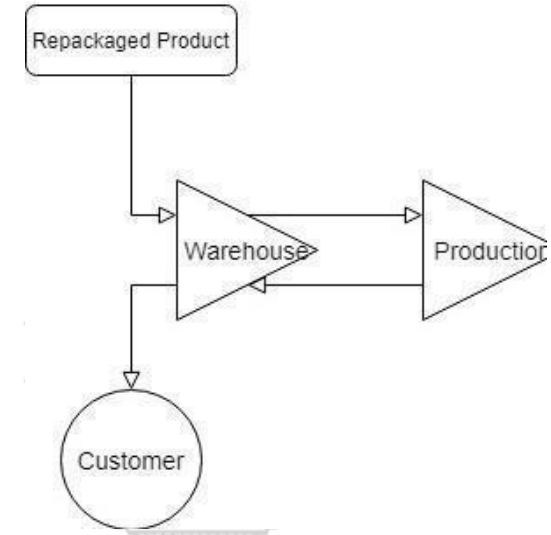


*Figure 1- 6: Repackage product flow*

The sales portion and sales value of these two categories depends on seasonality, as shown in Figure 1-7 and 1-8.

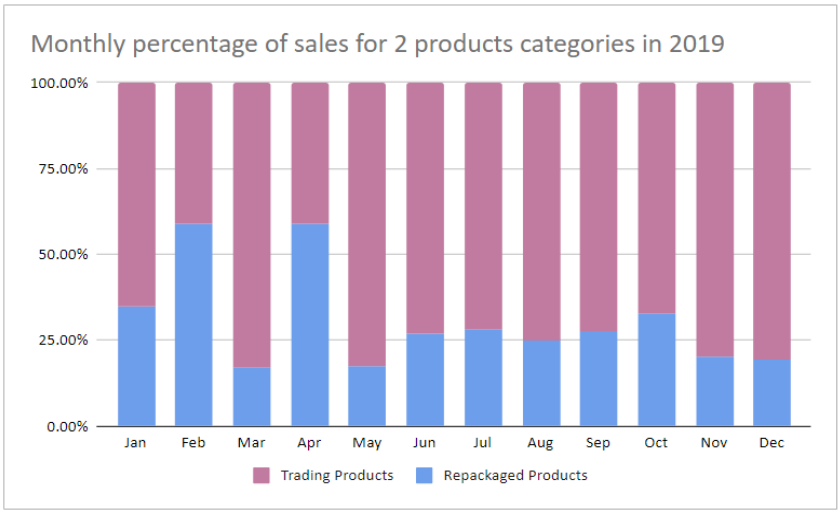


*Figure 1- 7: Monthly percentage of sales for two product categories*

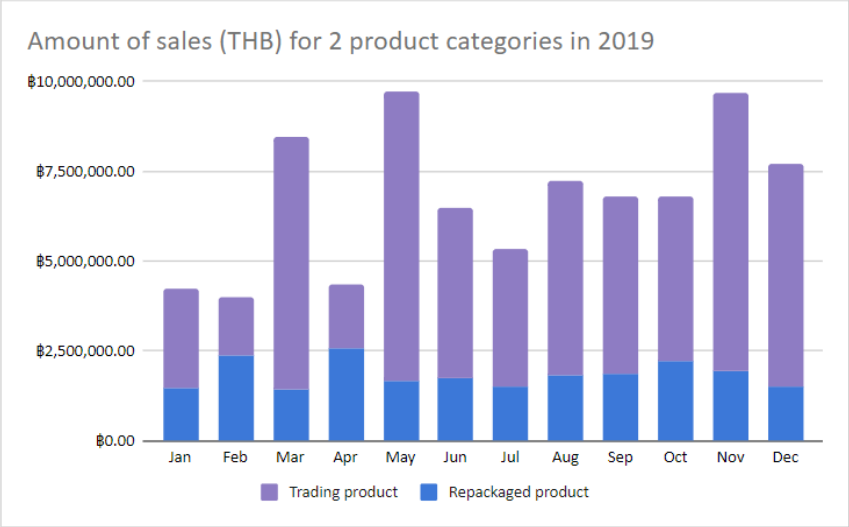


*Figure 1- 8: Number of sales (THB) for two product categories*

Figure 1-7 refers to the monthly percentages of sales in 2019 for Trading product (pink) and repackaged product (blue), while Figure 1-8 refers to the sales value in Thai Baht. Even though the trading product category contributes to a higher sales ratio, its nature yields little inventory in the warehouse after shipments. As a result, the remainder of this chapter will focus on the repackage product category as its purchasing practice and lack of visibility lead to inventory issues.

### 1.1.2 Office and Warehouse Layout



All activity occurs in the same building that consists of two zones, as shown in Figure 1-9. The front zone is a 225.0 square meters office building with three floors, occupying 12-15 office employees. Whereas the back zone is the company's 1,000 square meters warehouse in which it stores inventory and repack products. At the time of writing, approximately 20 workers operate in this area.

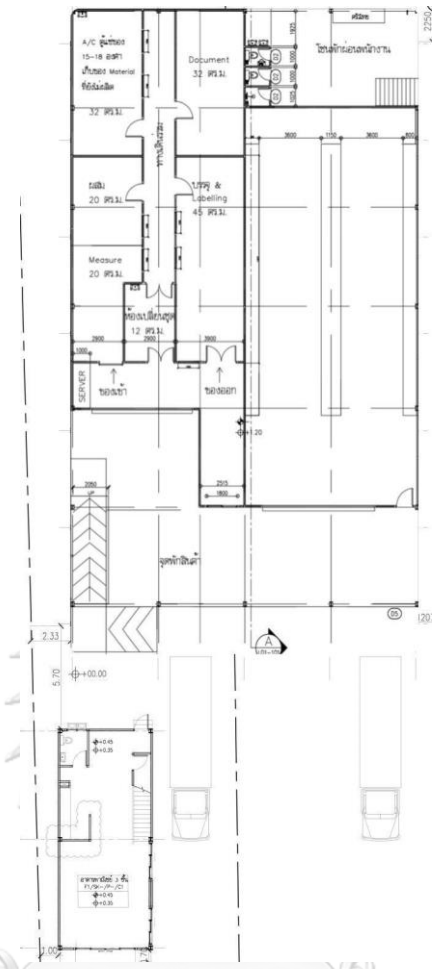


*Figure 1- 9: Company and warehouse layout*

The back zone is configured as an ‘u-shape’ layout as it shares loading and unloading docks. The production line (left area) is also divided into different rooms to comply with GMP standards. While all stock inventory is kept in the warehouse zone (right area) with three levels of selective rack at six meters height. Export products are also docked and loaded at the warehouse area.

### 1.1.3 Purchasing and Operation Processes

Despite the distinct purchasing and operating processes, both product categories share the same personal and storage location. Therefore, the processes of trading product and repackage product categories should be explained together, as shown in Figures 1-10 and 1-11, respectively.

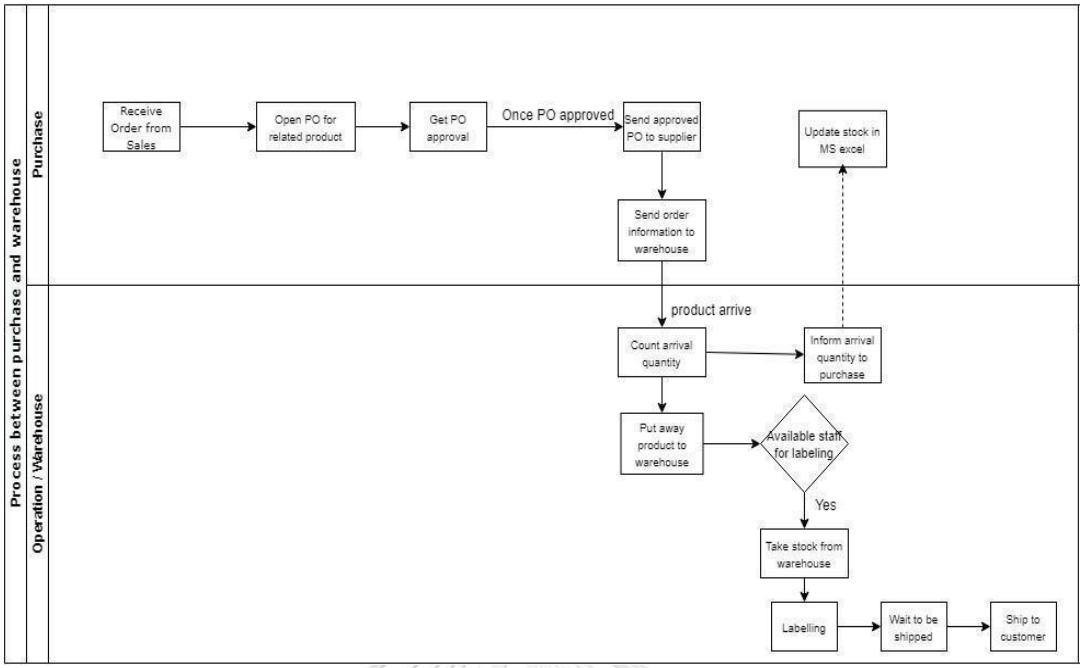


*Figure 1- 10: Work flowchart of Trading products*

Due to the limited shelf life of food products, the purchaser orders the exact purchasing quantities as the sales quantity. Once the purchase order (PO) is approved by the manager, it is transferred to the respective supplier. Then, the purchaser informs the operation, including the warehouse team, to inform about arriving goods. Warehouse workers count the arrival quantity and inform the purchaser to update the inventory level in the system.

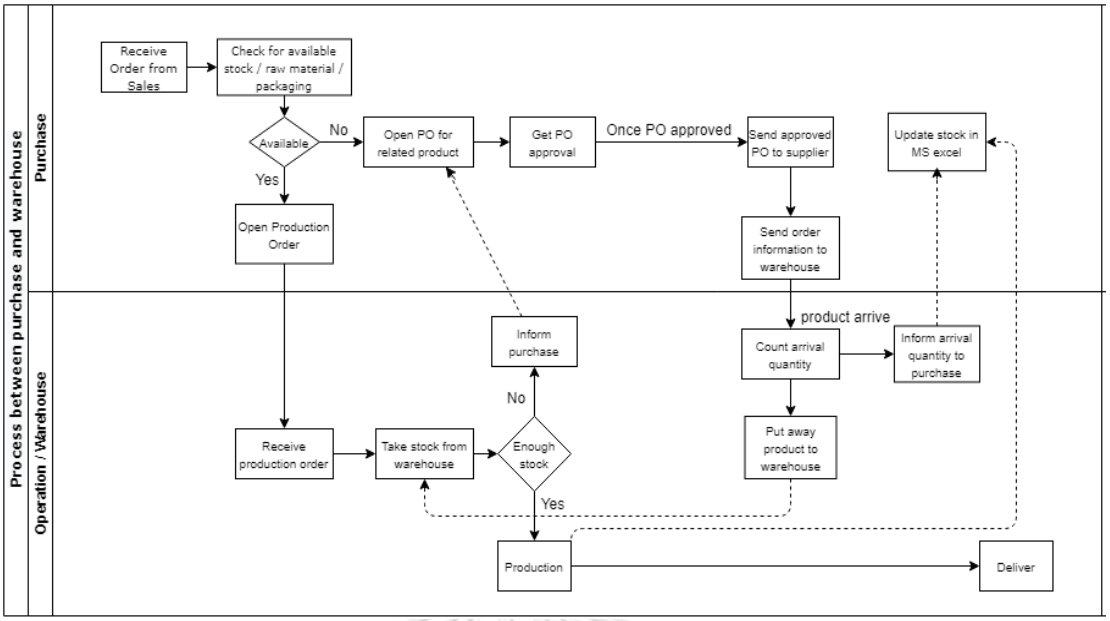


*Figure 1- 11: Work flowchart of repackaged products*

Figure 1-11 illustrates the work flow chart of repackaged products of the researched company. Once the purchaser receives the order from sale, she checks for the availability of related components, such as raw material and packaging, that are associated with the product. In the case that there is a shortage of any of the components, the approved purchase order needs to be issued to the respective supplier. This circumstance may cause shipment delays due to the following reasons:

- Generally, packaging products have minimum order quantity - the higher the quantity, the lower its cost. Occasionally, management will ask for an inventory usage report before making a decision on the order quantity in order to optimize cost.
- Printed packaging may require up to 60 days lead time before product delivery.

Once the order arrives at the warehouse, the workers count the arrival quantity and inform purchase to update in the inventory file in Microsoft Excel. The purchase issues a production order whenever *all* product components in the inventory file are ready.

Having received a production order from the purchase, the operation team retrieves all relevant components from the warehouse. In some cases, the available quantity in the warehouse is inadequate for the retrieval due to inaccurate information. When this happens, the operation team will notify the purchaser. The purchaser will issue PO, wait for manager approval, send approved PO to the respective supplier, and then wait for product arrival. Production cannot proceed unless all components are adequate for production.

## 1.2 PROBLEM ANALYSIS

The preliminary study of the case study company reveals a lack of purchasing standard as it operates without reorder point and without product forecasting. This leads to three interconnected inventory problems.

### 1.2.1 High inventory turnover

Inventory analysis of the packaging in the case study company found that some of the packaging in the company have too high inventory turnover rates. A high inventory turnover ratio indicates either strong sales or insufficient inventory (Hargrave, 2020). Figure 1-12 and Figure 1-13 refer to the inventory analysis of two types of packaging, Plastic bag (code B-002) and Tray (code P-015), that indicates insufficient inventory.

Packaging: B-002 Plastic Bag size 8” x 12”

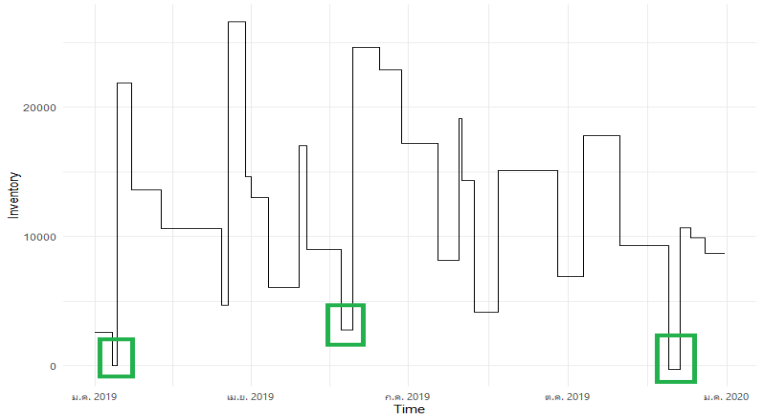


*Figure 1- 12: Inventory analysis of B-002*

Packaging: P-015 Tray 8x10

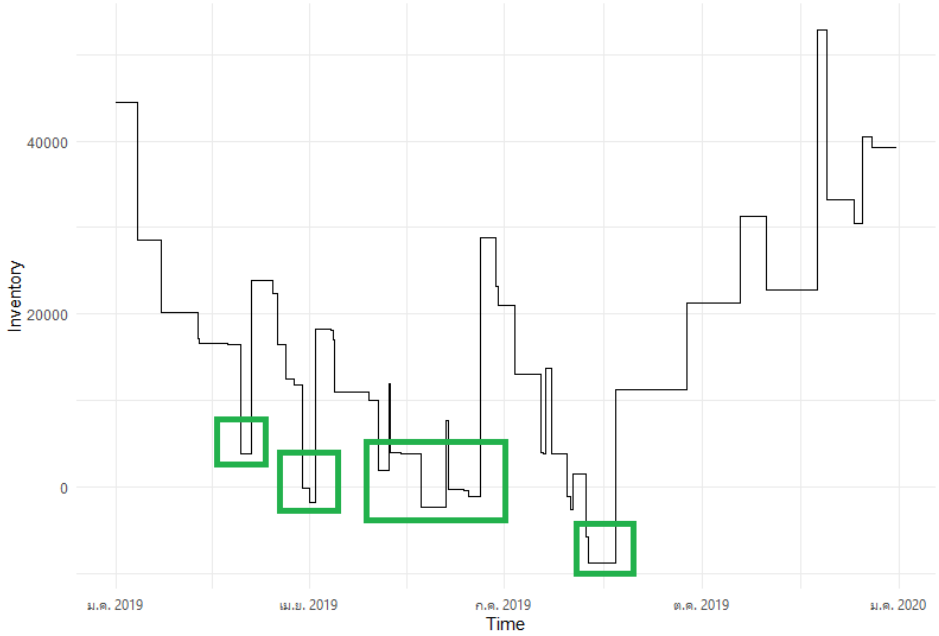


*Figure 1- 13: Inventory analysis of P-015*

The green square area in both Figure 1-12 and Figure 1-13 is an example of insufficient inventory in the warehouse. Lack of any kind of packaging may lead to production delay, and thus, inevitably shipment delay to the customers. This delay can be prevented with proper reorder point and order quantity.

### 1.2.2 High inventory but few transaction

Printed packaging has a high minimum order quantity with a long production lead time of approximately 45-60 days. Figure 1-14 and Figure 1-15 refer to two inventory analyses of printed packaging from the case study company that have high quantities with only few transactions annually.

Packaging: B-013 Dehydrate Mango Bag

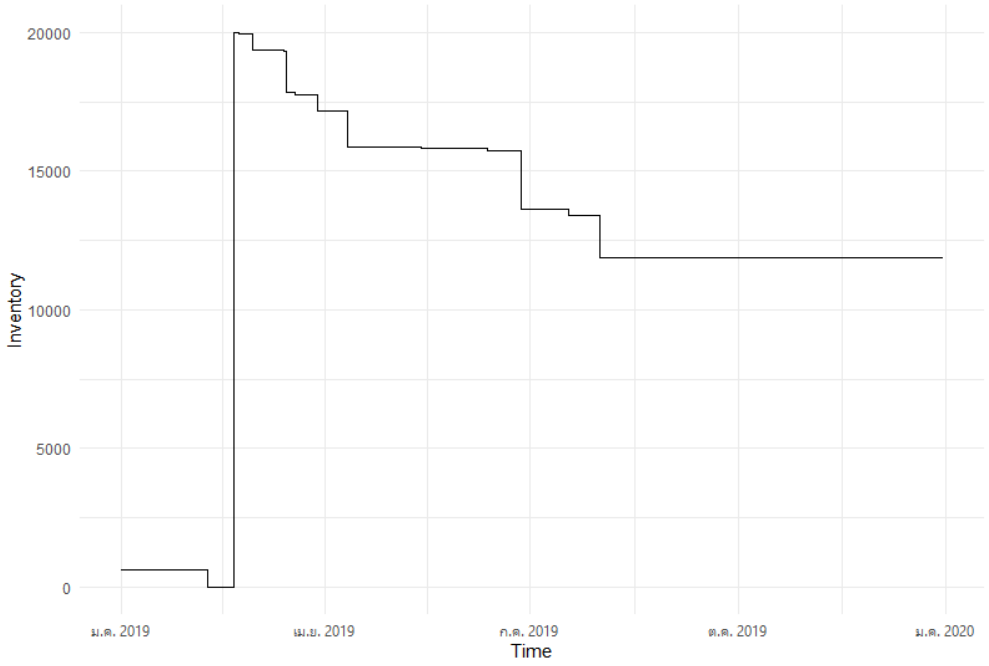


*Figure 1- 14: Inventory analysis of B-013*



Packaging B-015: CIP Banana salted egg outer bag

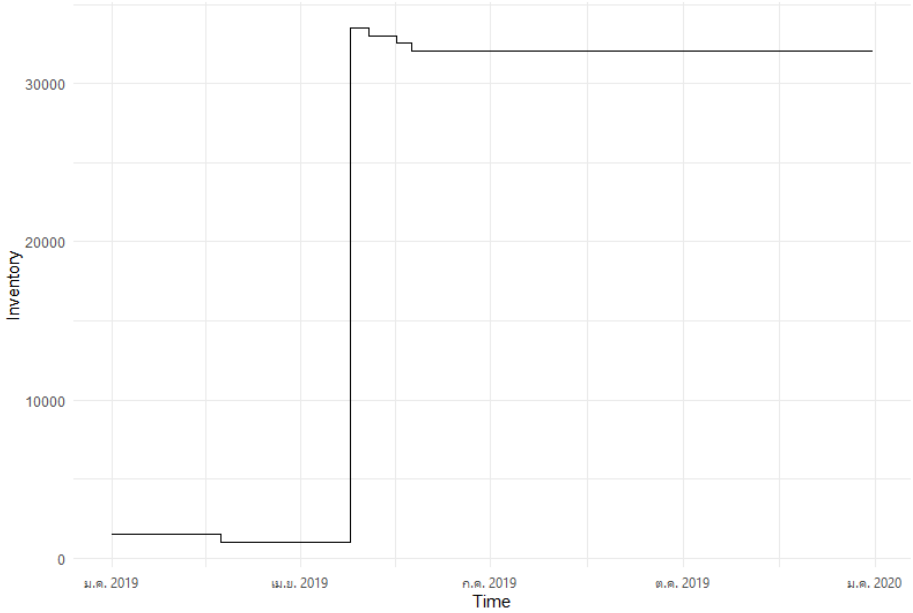


*Figure 1- 15: Inventory analysis of B-015*

The underlying reason is that these two SKUs are made to order (customized) bags and are also imported from overseas. If this continues without a product sales forecast, these printed packaging will be overstock and thus take up a lot of the company warehouse space, as well as causing high holding cost.

### 1.2.3 Inventory Discrepancy

The case study company also exhibits another classical inventory issue: a high stock discrepancy in the company inventory, as shown in Table 1-1.

*Table 1-1: Percent difference between stock quantity and annual count quantity*

| raw mat code | packaging name | stock qty | annual count | % difference | Cost |
|---|---|---|---|---|---|
| B-002 | Plastic bag size 8" x 12" | 2,555 | 3,685 | 44.23% | THB 1,299.50 |
| C-026 | CIP Crepe roll box | 100 | 653 | 553.00% | THB 5,530.00 |
| B-009 | Bag ChipMe Banana | 5,787 | 20,400 | 252.51% | THB 42,377.70 |
| B-013 | Dehydrated Mango | 11,890 | 11,449 | 3.71% | THB 661.50 |
| A-003 | Silica Gel (1cartonx6,000) Oxygen Abs | 13,307 | 10,500 | 21.09% | THB 140.35 |
| B-012 | CIP Pork floss salted egg outer bag | 13,007 | 10,250 | 21.20% | THB 7,995.30 |
| B-007 | Golden Bag Ziplock size L (Pack 100 g. | 5,871 | 5,000 | 14.84% | THB 1,654.90 |
| B-006 | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 26,087 | 24,521 | 6.00% | THB 2,192.40 |
| B-010 | (Small bag) ChipMe Eggs Crepe Roll | 38,690 | 40,440 | 4.52% | THB 5,075.00 |
| B-001 | Red Bag Durian Freeze Dried | 30,177 | 24,521 | 18.74% | THB 16,402.40 |
| B-006 | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 26,087 | 24,521 | 6.00% | THB 2,192.40 |
| P-024 | Crepe roll 2 side tray | 50,730 | 39,100 | 22.93% | THB 6,978.00 |
| B-006 | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 26,087 | 24,521 | 6.00% | THB 2,192.40 |
| B-019 | Hot Food Bag (size L) | 12,900 | 11,449 | 11.25% | THB 1,015.70 |
| B-006 | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 26,087 | 24,521 | 6.00% | THB 2,192.40 |
| B-015 | CIP banana salted egg outer bag | 32,080 | 26,451 | 17.55% | THB 16,324.10 |
| B-003 | (Plastic bag) Pack Durian (1 carton x 10 | 47,152 | 52,478 | 11.30% | THB 2,396.70 |
| B-006 | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 26,087 | 24,521 | 6.00% | THB 2,192.40 |
| P-024 | Crepe roll 2 side tray | 50,730 | 39,100 | 22.93% | THB 6,978.00 |
| B-008C | Bag Ziplock ChipMe Durian | 5,680 | 13,470 | 137.15% | THB 22,591.00 |
| | | | | | **THB 148,382.15** |

For example, CIP Crepe Roll box (C-026) should have an inventory of 100 pieces at the end of Year 2019; however, its actual quantity was 653 pieces. The example of this inventory implies a lack of trust in the recording system and operation as the stock count is performed annually, without any other periodic cycle count.

Furthermore, the purchaser is the only person who is aware of the current inventory level. The operation team in the warehouse who picks up and puts away products has a limited knowledge of quantities and batch status. Frequently, there is a gap between actual and recorded quantities as the inventory is counted annually. As a result, the inventory policy should be developed using a general understanding of purchasing and cycle counting to bridge the gaps and to provide the real time information for decision making.

## 1.3 PROBLEM STATEMENT

Because the purchaser and operation team work independently, the purchaser is the only person who is aware of the inventory and ordering status. The company has no inventory policy as it operates without reorder points and without accounting for forecasting and productivity yield. Lack of such policy could lead to fluctuation of inventory and inventory turnover rate.

## 1.4 OBJECTIVE

The objective of this study is to propose suitable inventory policy for each group of repackaging products so that inventory cost can be reduced and service level can be satisfied.

## 1.5 RESEARCH SCOPE

In addition to the specific case study company, the scopes of this research include:

- The raw material (perishable item) in repackaged products must be purchased with a lot-for-lot policy in order to maintain longest shelf life to customers. This study will omit the perishable raw material and will focuses only on the packaging items of the repackaged products, such as packaging, bag, carton, sticker / label and related packaging.
- The manufacturing aspects and operation of repackaged products are excluded.
- Microsoft Excel is used as a primary analytic tool.
- The company's 2019 production, purchasing, and shipping data are used as the main analytic data.
- The demand (shipping data) will be analyzed on a 52 weeks-based basis.
- Establishment of company ordering policies, including but not limit to, reorder point (ROP), safety stock, and economic order quantity (EOQ).
- Establishment of company inventory management policies, including but not limited to, vendor selection and cycle count.
- Monte Carlo simulation is developed and performed to validate the current situation and compare the proposed policy
- Inventory cost comprises ordering cost, holding cost and stockout cost.
    - Holding cost is proportional to the value of each inventory value.
    - Ordering cost is the expense incurred to purchase and receive products.
    - Stockout cost is an opportunity cost due to the shortage of inventory.



## 1.6 EXPECTED OUTPUT/OUTCOME

The expected outcomes of this study are:

- To improve overstock, stock shortage, and shipment delays.
- To reduce inventory cost

# CHAPTER 2:
# LITERATURE REVIEW

This chapter addresses major factors that have led to the amount of importance put on inventory review policy, and cover some of the inventory analysis as well as simulation that are currently in widespread use to facilitate better inventory management.

The theoretical overview follows the inventory review policy, particularly, both periodic and continuous review policy was assessed to understand the underlying gaps in the overall inventory management system to improve and implement policy on the purchasing department.

## 2.1 OVERVIEW OF INVENTORY CONCEPT

Inventory management is a very important aspect of every retail business. Although good inventory management does not guarantee profit, a company with good inventory management has a very little chance of losing its capital. An inventory management system is a combination of technology to perform procedures which monitors and maintains stocked products (Porras, 2008). The system can be implemented with many policies and methods. Managers are the one who decide on the best ones that will fit the business characteristics of that company.

### 2.1.1 Just in Time Manufacturing

The concept of Just-in-Time (JIT) first originated in Japan, which was also first implemented in Toyota Motor Corporation (Singh, 2012). One of the key roles of the Just-in-Time (JIT) method was to allow companies to invest in manufacturing or controlling the total time required to convert raw materials to finished products. This approach of JIT, which as the name suggests, discards any excessive inventory, insurance, and storage costs – also allowing to reduce the total waste that can be incurred due to the long-term storage of a product or excessive inventory (Phogat,

2017). However, as reported by Hayes (Hayes, 2019) – this method can have unexpected spikes in demand leading to a risky and faulty process management. This develops to ensure an appropriate development of the system that keeps all respective departments informed on the decision of purchasing and processing, as well as, providing detailed information on the key inputs and outputs processed within the processing of the organization.

### 2.1.2 Min-Max Strategy

A min-max strategy refers to a decision rule that is used to minimize the worst-case potential loss. In other words, the min-max strategy was utilized to consider all potential opponent responses and to have the strategies outlaid, paying off the best possible result (Hasibuan, 2018).

### 2.1.3 Cycle Count

Cycle count refers to a counting solution that would allow businesses to have a count in the total number of items that are available within an organization, without having the need to review, monitor and count the whole warehouse (Wijffels, 2016). Inventory counts are physically counting and comparing items on hand with the number of items in the inventory system or spreadsheet. However, performing inventory count is time consuming. Therefore, rather than counting everything in your warehouse all at once, the cycle count breaks the process down into a manageable chunk (Wijffels, 2016).

### 2.1.4 Dead Notch

The dead notch stock inventory refers to those inventory that the company has bought but cannot be sold, however, also cannot be used anymore. Storing dead stock or dead notch can cost money and can also reduce the amount of profits the company can make.

## 2.2 FOOD PACKAGING INVENTORY REVIEW POLICY

Food packaging is used as a way to market, displaying the right information, appearing attractive to the eye, presenting the product in an attractive manner, properly representing your brand. (Ammar, 2013). Just this one aspect of food packaging involves (Hawkes, 2010), designers, nutritionists, artists, printing, and other specialists, all having to work together to achieve details on each printed packaging (Wells, 2007).

Packaging can have an impact on many different parts, from raw material to finished goods, and then from finished goods to store ready (McDaniel, 1977). Many industries operate with inventory management in order to deal with complex supply chains. This reduces the risks of inventory gluts or shortages, or overload of inventory leading to challenges in the management process. In the report by Hayes (Hayes, 2019), it was alluded that there is a need for balance between inventory purchases, processing, and delivery systems to avoid any relatable issues in the inventory management process.

The following section highlights inventory purchases and stock management on 2 types of inventory review policy, periodically and continuously.



### 2.2.1 Periodic review policy

Periodic review policy refers to the tracking of inventory for every item in stock. The inventory level is reviewed at a regular time interval depending on the sizes of your business. For many decades, periodic review policy was much more popular than continuous review policy (Hadley, 1963). However, in this era, it has been noticed that periodic inventory review policies are only commonly used to manage inventory only in smaller retailers and grocery stores (Taylor, 2015). This is because periodic inventory review is simple to set up and conduct. It only relies on three simple records to implement periodic inventory review:

- The current inventory: refers to the current quantity of each of the items in your inventory.
- The buy-in inventory: refers to the purchase in inventory.
- The sell-out inventory: refers to the number of items being sold.

However, periodic inventory reviews are high in risk error since human error can occur in miscounting or double counting (Taylor, 2015).

### 2.2.2 Continuous review policy

Continuous inventory review policy is related to an inventory system that tracks and records stock on a real-time basis. The stock level of each product is recorded when the inventory is put away or pulled out.

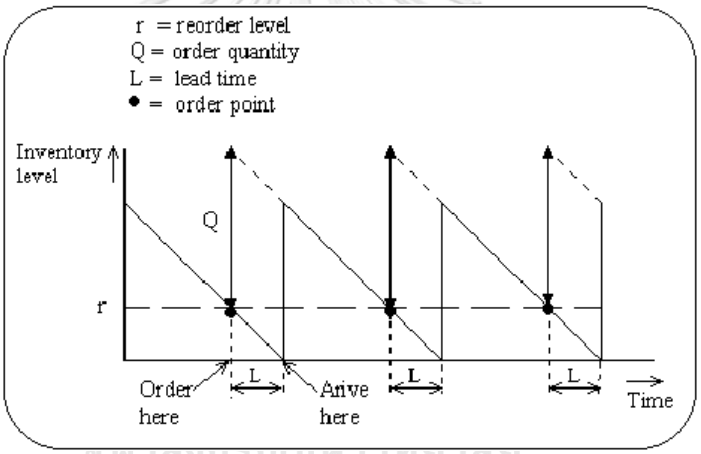


*Figure 2- 1: Continuous review model of inventory*



Continuous inventory constantly tracks the quantities, as illustrated in Figure 2-1. When the inventory level reaches the reorder point (r), the store orders more. By digitizing the continuous review policy, every time a sale happens, the computer records the transaction and notes the inventory down immediately, making it a more superior method compared to the periodic policy (Sherman, 2019).

The only downside of continuous review policy is that it involves additional costs, mainly from the servers and software required to get the system running. By being more expensive, businesses will be able to save time and effort while gaining more accuracy and real time updates (Stach, 2019).

A continuous review policy refers to the implementation of a systematic policy that allows inventory levels to be followed continuously and the replenishment does not have the need to be ordered during a specific period (reorder point or safety stock period) (Axsater, 1993). Axsater, 1993, further stated that, the use of continuous review policy is favorable in condition that inventory stocks have low demand value (slow moving inventory). In this research study, the continuous review (Q, r) policy is employed, aiming to study the reorder point and order quantity. Using the (Q, r) policy, the 'r' represents the reorder point, and 'q' represents the order quantity.

## 2.3 INVENTORY ANALYSIS

Inventory analysis refers to the technique to calculate the optimum level of inventory, as well as optimal amount of purchase in the company. Inventory analysis allows any company to be proactive with its inventory. Several advantages of inventory analysis include reduced stockout and project delays, improved cash flow, and less wasted inventory. All in all, the main purpose of inventory analysis is to run an efficient business, so that the company will not have to lose money on unnecessary items/goods or missing out on sales due to stock shortage (Tunney, 2019).

### 2.3.1 ABC Analysis



An organization may have over hundreds or thousands inventory stock keeping units (SKU). ABC analysis was first introduced by Pareto principle by using the "80-20 Rule", stating that 80% of the profits come from 20% of their total inventory (Tunney, 2019). ABC analysis is used to monitor a large multitude of inventory items by prioritizing and sorting certain inventory over others (Tunney, 2019). ABC analysis categorized all of the inventory into three subcategories, which enables one to make more strategic decisions. The three subcategories are:

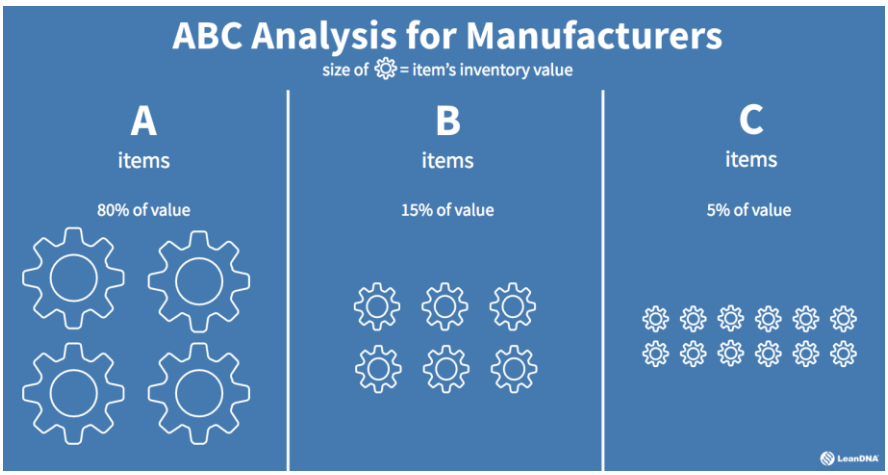


*Figure 2- 2: ABC Analysis categories (Adam Baker, 2021)*

- *A-Inventory*: Refers to the inventory that has the highest value, most often is the highest profit margins or sales revenue. It is the most important inventory for the company. Therefore, this A-inventory category should be the company's highest priority (Tunney, 2019).

- *B-Inventory*: Refers to the inventory that sells regularly but doesn't have as much value as A-inventory. Most of the time, this B- inventory will cost more holding inventory than the A-inventory category (Tunney, 2019).

- *C-Inventory*: Refers to the rest of inventory that doesn't sell much and generates the least revenue and makes up the bulk of the company inventory cost (Tunney, 2019).

ABC Analysis allows the company to separate the most important inventory from the rest so the company can better focus on the important inventory. This enables the company to reduce obsolete inventory, optimize inventory turnover rate, as well as forecast demand.

After in depth analysis, simulation will need to perform in order to validate the concept.

### 2.3.1 Monte Carlo Simulation

Simulation refers to the imitation of the operation of the real-world process over time. It involves the generation and observation of the past data to draw inferences concerning the operating characteristics of the real system that is represented (Gashaw, 2014). Simulation is also used to describe and analyze the behavior or trends of the system, and answer the uncertain questions about the real system. Simulation also aids in designing the real system.

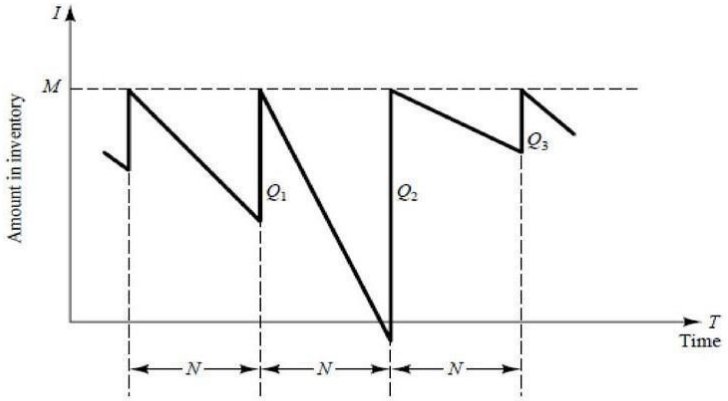


*Figure 2- 3: Simulation of Inventory System*

Figure 2-3 refers to the simulation of the inventory system. N refers to the periodic review of length N, at which the inventory level is being checked. When there is any purchase of the inventory, it will bring the inventory level up to the level M (Campbell, 2018).

In the past years, simulations have been commonly used for inventory analysis in designing and forecasting the inventory system since many inventory processes are impossible to model mathematically and systematically without the use of computers. There are two types of simulation models that are commonly used for inventory analysis as follow:

#### 2.3.1.1 Discrete Event Time Simulation

In discrete time simulation, the system is assumed to change only at each discrete time tick. The smaller time tick, the more accurate simulation for a discrete event time system. The main advantage of discrete time simulation is that it is simpler

to conduct than continuous simulation. In addition, discrete time simulation is also faster if the system states change rapidly, or when many events occur in a short period of time (UCF, 2015).

#### 2.3.1.2 Continuous simulation

Continuous simulation is a method of simulating the behavior and performance of a real-life process, or system. It models the system as a series of 'events' that occurs over time.

### 2.3.2 Economic Order Quantity (EOQ)

The Economic Order Quantity (EOQ) in inventory management system is an informed management allowing the demonstration of the quantity of an item that would reduce the cost of handling of the inventory and ordering cost. The concept of EOQ was first introduced in 1913, as stated by Alamgir (Alamgir, 2018), that would emphasize on the handling and management, and minimizing the cost operated from the business. The EOQ model allows establishing an adequate amount of quantity that should be placed considering the minimizing the overall annual total cost of inventory handling. Using the EOQ in basic explanation, the EOQ allows determining the total costs that is required for holding the inventory, and furthermore allowing to interpret the sales demand. However, the model has been presented with certain assumptions for the initial understanding; and from that point onward, its extensions are used widely in businesses, especially in inventory management.

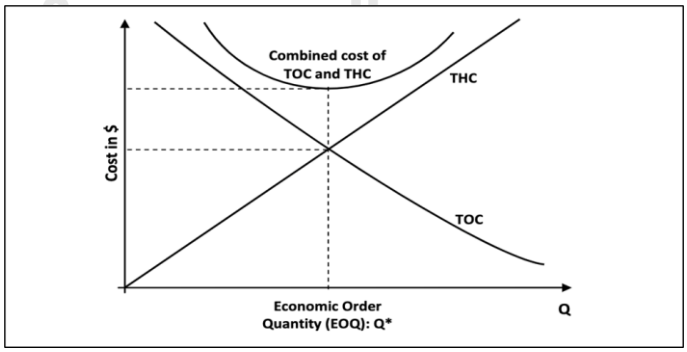


*Figure 2- 4: Economic Order Quantity*
Source: (Alamgir, 2018)

From purchasing point of view, Total Ordering Cost (TOC) and Total Handling Cost (THC) are the additional costs, which incur above cost of a material purchased. Therefore, the aggregation of both costs (TOC and THC) is known as

Total Incremental Cost, that is, TIC = TOC + THC. In the context of EOQ, TOC and THC are the additional costs incurred beyond the original purchasing cost of an item. Furthermore, in this study, the EOQ utilized refers to the study by (Kocer, 2011), measuring EOQ using the following formula:

$$Q = EOQ = \sqrt{\frac{2AS}{Ch}}$$

A = Annual Demand S = Order Cost
C = per unit cost h = holding rate

$$Holding\ Cost = \left(\frac{Q}{2} + SS\right)Ch \qquad Average\ Total\ Inventory = \left(\frac{Q}{2} + SS\right)$$

$$Cost = cylce\ stock\ holding\ cost + order\ cost = \left(\frac{Q}{2} \cdot SS\right) + \left(\frac{A}{Q} \cdot S\right)$$

$$R = \overline{U} + SS$$

$\overline{U}$ - average lead time demand

$$SS = n\sigma_{LT}$$

(2.1)

# CHAPTER 3:
# CASE STUDY COMPANY

## 3.1 BACKGROUND TO THE COMPANY

The case study company is a comprehensive agency and wholesale servicer of food and beverages (F&B) products manufactured in Southeast Asia, primarily Thailand. The company has been in the food industrial market for over 30 years, exporting high quality food products to more than 20 countries around the world. The company is not only recognized for its proper handling of food products and its standard packaging, but also recognized for the labeling and branding of various food products. The company is able to build and maintain a solid global customer and supplier network.

The company strategy is not only to maintain the standard of product, but also to increase its sales through excellent services to customers by offering OEM (original equipment manufacturer) and repackaging services. Those services that are offered by the researched company are as postulated below:

- **Export Services**: The company exports Thai food and beverages products globally, especially to other Southeast Asia countries. This provides a broad exposure to the firm across the market of Asia, with a wide product breadth.
- **OEM and Packaging Services**: The firm offers customers with a large variety of made-to-order OEM products, offering a range of agricultural products and also innovative products that have been newly developed. The firm is equipped with high quality food packaging services that are able to be fully customizable to customers' needs.
- **Labeling:** The company also offers labeling services to ensure that everything in the food product is listed in the correct manner. Every country has their own requirement for important information such as importer labels, nutrition facts, and ingredients description.

### 3.1.1 History and Location

The operation of the company particularly takes place in Thailand. However, since this company exports food products to different countries, it must ensure that the exported product meets import requirements and guidelines that may differ in each country. The international sales representatives must provide clear guidelines for labor workers to put on the right labeling since the label will be in foreign language. For this reason, this company must maintain an efficient and effective operation process between all levels of the workforce.

### 3.1.2 Business Unit

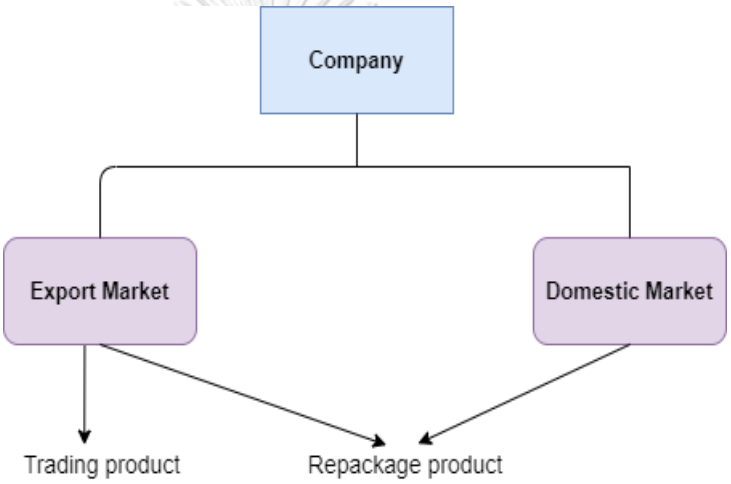


*Figure 3- 1: Business and its structure*



The company mainly has two associated business units, export market and domestic market. First of all, the company mainly exports two categories of product, trading product and repackaged product. The detailed difference between these types of products is mentioned in section 1.1.2. Trading products are only sold to the export market while repackage products are sold to both export and domestic markets.

## 3.2 ORGANIZATION CHART

An organization chart refers to a graphical illustration of an organization showing the relationship that initiates from the head of the organization to various classifications and jobs assigned to individual employees. Figure 3-2 depicts the organization chart for the case company.

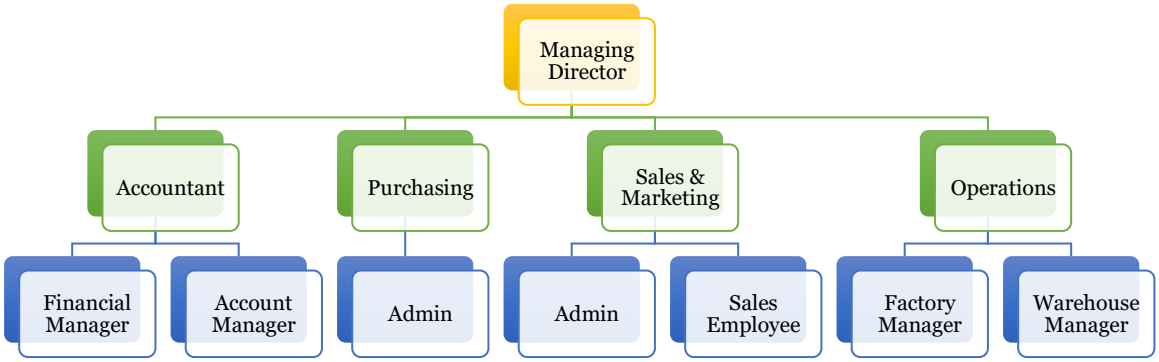


*Figure 3- 2: Organization chart*

This chart provides a brief overview of the organizational structure of the firm. As with most companies the CEO is at the top (Estevez, 2018), this organization holds the *managing director* as the supervisory executive who works closely with an advisory committee who provides them with information from different legs of the company and makes suggestions on how to improve performance in different sectors.

There are mainly four departments in the company: Accountant, Purchasing, Sales & Marketing, and Operation. Sales & Marketing department is the one that contacts customers and ensures the delivery of products according to customers' request. The responsibility of the Purchasing department is to order products according to sales' requests. The operation department is responsible for producing the product according to the customer's requirement. Lastly, the Accountant department records and manages monetary transactions within the company.

### 3.3 PRODUCT AND SALES

As the focal point of this study, the repackaged product categories can be grouped further into three sub-categories: seafood, processed fruit, and snack.

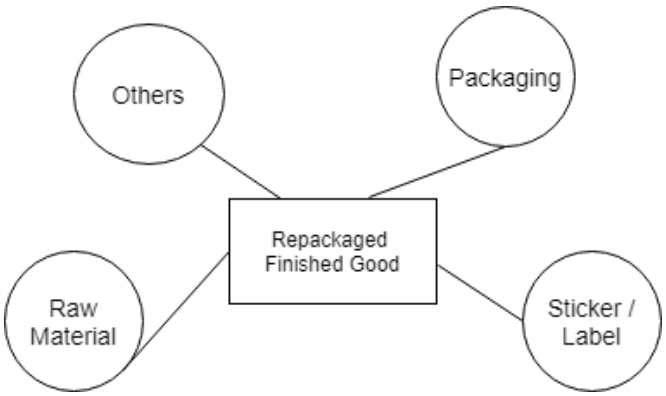


*Figure 3- 3: Finished good components*

Figure 3-3 refers to the products flow and components of the repackaged product. Any of the repackaged finished goods product composed of raw material, packaging, sticker / labeling, and other accessories such as a tray or silica gel. Examples of the products associated with this case study are Roasted satay fish (Figure 3-4), Roasted Sea bass Fish, Roasted Dried Grilled Trevally Fish sesame (Figure 3-5), and Thaistyle Dehydrated Mango (Figure 3-6) etc. Each packaging design initiates from the original raw material, following up with the packaging bag, tray, and sticker in the final process. Figures 3-4, 3-5 and 3-6 illustrate the finished product. One raw material can be repackaged into different packaging according to different demand.




*Figure 3- 4: Roasted Satay Fish*

a) Sea bass Fish b) Trevally Fish

*Figure 3- 5: Examples of roasted fish products*


*Figure 3- 6: Thaistyle Dehydrated Mango*

### 3.3.1 Product Overview

There are many different types of seafood, and each type can also be packaged and processed in a variety of different ways as mentioned previously. Figure 3-5 refers to two different types of fish product, packed with almost the same packaging and labeling. This shows that one type of fish could either be packed into different sizes of packaging, or stick with different labeling that seems almost identical. This illustrates that without careful or proper inventory management, it is very easy for any worker to misplace any packaging, or even count the wrong product during stock count.

| | | | | | | |
|---|---|---|---|---|---|---|
| | *S00411* | *Roasted Satay Fish 170g.* | | | | |
| **Product Code** | **Code** | **Type** | **Items** | **Price** | **Quantity / 1** | **Unit** |
| *S00411* | Raw-S004 | Raw material | Roasted Satay Fish | 13.90 | 170.00 | grams |
| *S00411* | B-002 | Bag | Plastic bag size 8" x 12" | 1.15 | 1.00 | pcs |
| *S00411* | S-003 | Sticker | Santa satay sticker | 0.25 | 1.00 | pcs |
| *S00411* | P-015 | Packaging | Tray J-5 | 0.40 | 1.00 | pcs |
| | *S00211* | *Grilled Sea bass Fish 35 g.* | | | | |
| **Product Code** | **Code** | **Type** | **Items** | **Price** | **Quantity / 1** | **Unit** |
| *S00211* | Raw-S002 | Raw Material | Grilled Sea bass Fish Original | 15.75 | 35.00 | gram |
| *S00211* | B-018 | Bag | Hot Food Bag (size 12*18) | 0.40 | 1.00 | pcs |
| *S00211* | B-006 | Bag | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 1.40 | 1.00 | pcs |
| *S00211* | S-109 | Sticker | Grilled Sea bass Fish 35g. (Black Logo On Front) | 0.35 | 1.00 | pcs |
| *S00211* | S-110 | Sticker | Grilled Sea bass Fish 35g. (White Logo On Behind) | 0.15 | 1.00 | pcs |
| | *S00113* | *Roasted dried grilled travelly fish 35 g. (Sesame)* | | | | |
| **Product Code** | **Code** | **Type** | **Items** | **Price** | **Quantity / 1** | **Unit** |
| *S00113* | Raw-S001E | Raw Material | Travelly Fish- Sesame Original | 10.15 | 35.00 | gram |
| *S00113* | B-018 | Bag | Hot Food Bag (size 12*18) | 0.40 | 1.00 | pcs |
| *S00113* | B-006 | Bag | Golden Bag Ziplock 6 x 7 (Pack 35 g.) | 1.40 | 1.00 | pcs |
| *S00113* | S-107 | Sticker | Travelly Fish 35g.(Logo Fish Golden Bag Ziplock ) (Black | 0.35 | 1.00 | pcs |
| *S00113* | S-108 | Sticker | Travelly Fish 35g.(Logo Fish Golden Bag Ziplock) (Black | 0.15 | 1.00 | pcs |
| | *F00811* | *ThaiStyle Dehydrated Mango 200g* | | | | |
| **Product Code** | **Code** | **Type** | **Items** | **Price** | **Quantity / 1** | **Unit** |
| *F00811* | Raw-F008 | Raw Material | Dehydrated Mango low sugar grade A | 44.00 | 200.00 | gram |
| *F00811* | B-013 | Bag | Dehydrated Mango | 1.50 | 1.00 | pcs |
| *F00811* | P-015 | Packaging | Tray Sweet Roaasted Fish J-5 (carton 2,000) | 0.40 | 1.00 | pcs |
| *F00811* | A-003 | Accessories | Silica Gel (1cartonx6,000) Oxygen Absorber | 0.05 | 1.00 | pcs |

*Figure 3- 7: Product and its packaging*

Figure 3-7 shows the finished products and its packaging components. One finished product is composed of a few related packaging. Figure 3-4 refers to the first row item in Figure 3-7, Roasted Satay Fish 170 g. The product consists of 170 grams of raw material, placed in a tray, and then packaged with a plastic bag, followed by a sticker label.

### 3.3.2 Sales and Customers

This case study will use only 2019 sales data as shown in Table 3-1. Since the company's customers are importer and wholesalers, the company mainly produces batch production, its inventory turnover rate of the finished product is relatively low, of the average of only 0.185.

*Table 3- 1: Product 2019 sales and inventory turnover rate*

| Code | Product description | unit | 2019 sales | Inventory turnover |
|---|---|---|---|---|
| F00111 | FSS DURIAN CAKE 50g | pcs | 555,552 | 0.005 |
| S00411 | Roasted Satay Fish 170 g. | bag | 305,560 | 0 |
| F00511 | FSS DURIAN MILK CANDY 240g. | pcs | 72,737 | 0.007 |
| F00411 | FSS MANGOSTEEN MILK CANDY 240g. | pcs | 46,962 | 0.038 |
| F00211 | FSS COCONUT MILK CANDY 240g. | pcs | 43,638 | 0.055 |
| F00311 | FSS MANGO MILK CANDY 240g. | pcs | 41,947 | 0.043 |
| N00221 | ChipMe Salted Eggs Banana Chips 60g | bag | 24,837 | 0.003 |
| F00711 | FSS MILK CANDY 240g. | pcs | 30,737 | 0.042 |
| F00811 | ThaiStyle Dehydrated Mango 200g | bag | 11,100 | 0.002 |
| F00611 | FSS TAMARIND MILK CANDY 240g. | pcs | 19,793 | 0.075 |
| F00521 | ThaiStyle Durian Milk Candy ThaiStyle 110 g. | bag | 380 | 1.795 |
| F00911 | Thai style Freeze Dried Durian 60g | bag | 4,853 | 0.057 |
| N00111 | CIP PORK FLOSS SALTED EGG 150g. | pcs | 4,241 | 0.051 |
| F01011 | Gi Bee Durian Chewy Candy 270g. | bag | 5,192 | 0 |
| N00321 | ChipMe Salted Eggs Crepe Roll 60g | bag | 6,607 | 0.124 |
| F00121 | Durian Cake 480 g. | bag | 58 | 0.397 |
| S00111 | Roasted dried grilled trevally fish 35 g. (Original) | pcs | 3,391 | 0.057 |
| F00531 | Durian Milk Candy 180 g. | bag | 8,496 | 0.106 |
| S00112 | Roasted dried grilled trevally fish 35 g. (Spicy) | pcs | 2,396 | 0.313 |
| S00211 | Grilled Sea bass Fish 35 g. | pcs | 5,126 | 0.026 |
| N00211 | CIP SALTED EGG BANANA CHIPS 60g. | pcs | 3,402 | 0.112 |
| S00311 | Grilled Grouper Fish 35 g. | pcs | 4,099 | 0.042 |
| F00221 | Coconut Milk Candy 180 g. | bag | 4,992 | 0.065 |
| S00113 | Roasted dried grilled trevally fish 35 g. (Sesame) | pcs | 3,592 | 0.084 |
| S00312 | Grilled Grouper Fish 35 g. Spicy | pcs | 2,897 | 0.084 |
| N00311 | CIP CREPE ROLL - SALTED EGG 120g. | pcs | 1,879 | 0.129 |
| S00122 | Roasted dried grilled trevally fish - Spicy flavor 100 g. | pcs | 1,540 | 0.028 |
| S00121 | Roasted dried grilled trevally fish - Original flavor 100 g. | pcs | 1,480 | 0.044 |
| N00411 | ChipMe Salted Eggs Durian Chips 60g | bag | 278 | 0.547 |
| F00621 | Tamarind Milk Candy 180 g. | bag | 864 | 0.567 |

## 3.4 INVENTORY

The centralized warehousing system of the company plays a major role in integrating a strong operation management. Nevertheless, there is no specific reorder point or a time-phased ordering strategy of inventory in the purchasing department. Thus, every order of customer is treated distinctively and independently.

In general, the warehouse of the company categories inventory by its channels and types into four groups:

### 3.4.1 Export Inventory (Trading products)

As mentioned in Section 3.1.2, the export market consists of trading products and repackaged products; hence, two distinguish product categories. The export inventory group is equivalent to the trading product category for the export market. The trading product arrives at the company as a retail product, and the company exports the original packaging without modification or additional labeling. The company tends to keep a minimum of such inventory. The study omits the group as its inventory turnover days is less than three days.

### 3.4.2 Raw Material

As an important component of repackaged product categories, the raw materials are ordered as bulk packs in order to repackage products into different pack sizes. Due to the product shelf life, the amount of raw materials ordered is more or less equal to the amount of sales orders as the company tries to avoid excess raw materials and ensure their freshness.

### 3.4.3 Packaging Inventory

The packaging inventory group refers to any peripheral that accompanies and transforms repacked raw material into finished goods. This includes sticker labels, printed bags or clear plastic bags, plastic tray, silica gel, carton, or any related packaging, as depicted in Figures 3-4 to 3-6.

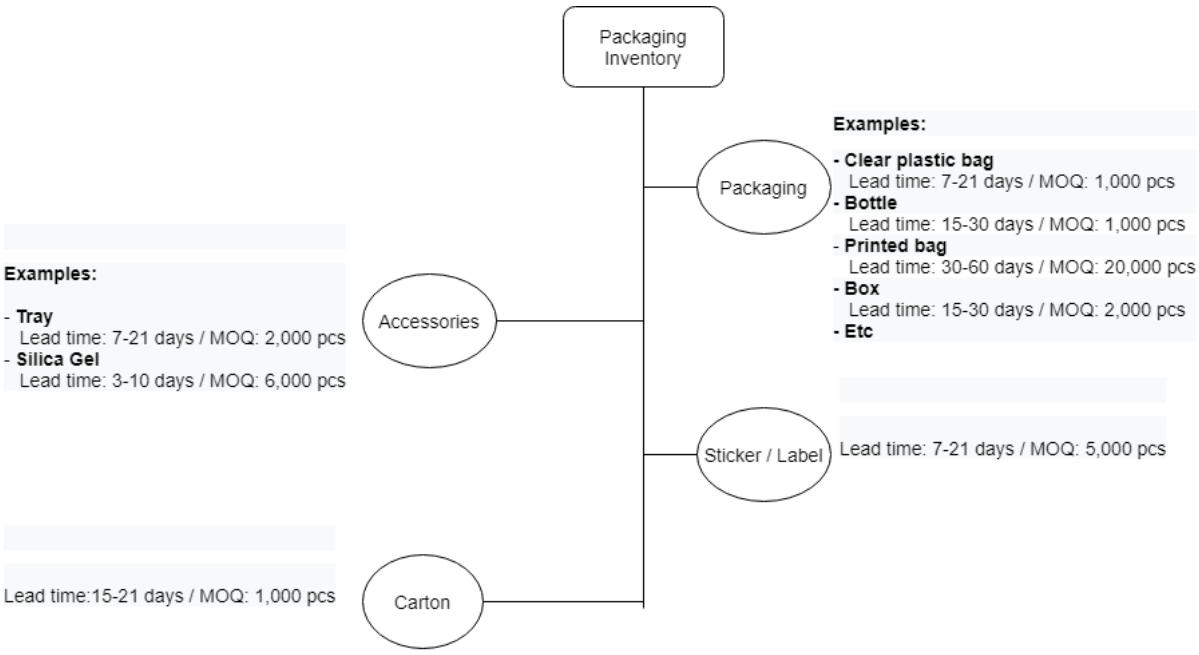


*Figure 3- 8: Packaging inventory and its lead time / MOQ*

Figure 3-8 refers to the packaging inventory and its approximate lead time, as well as its minimum order quantity (MOQ). The packaging inventory group is viewed as the source of major inventory issues as it requires a long lead time and exists high minimum order quantity. This is a clear indication that without a proper reorder point, it will cause a delay in shipment, as well as packaging shortage or overstocking.



### 3.4.4 Finished Goods

Finished goods refer to the completed repackaging products that combine raw material with its related packaging products upon customer order. In general, the inventory level of finished goods is relatively low as they wait for shipments.

## 3.5 BUSINESS PROCESS

In the section, the comprehensive business process of each of the four departments is extended and explained further than the scope mentioned in Section 3.2. In fact, the focus of the business process is on repackaging product categories.

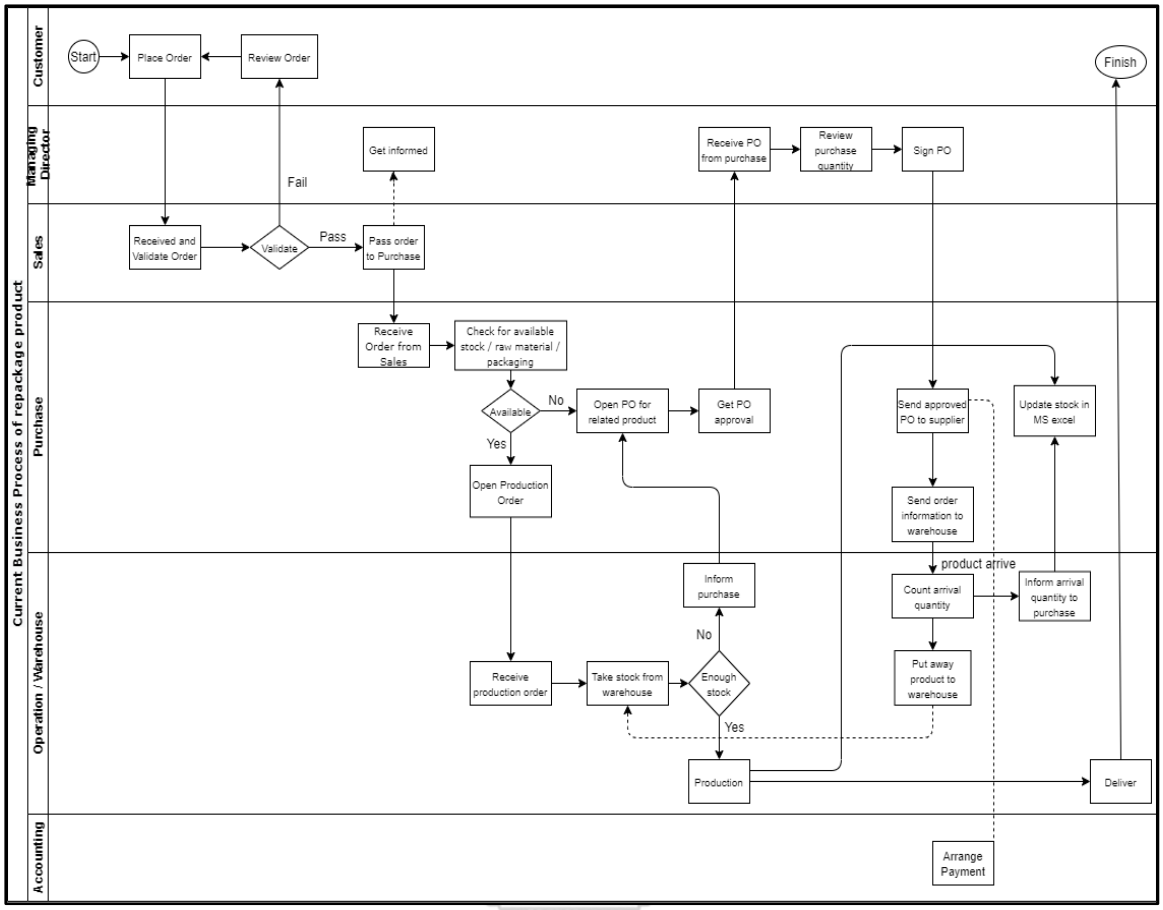


*Figure 3- 9: Business process on repackaging product category*

The figure shows the roles and responsibilities of each department, as discussed in the following subsections.



### 3.5.1 Sale Ordering Process

Sales are mainly responsible for answering customers enquiries and taking down their request in order to pass clear information to the purchase team.

### 3.5.2 Purchasing Process

Figure 3-9 referred to the current business process focusing on the purchasing system of the company. The details of the purchasing process workflow was mentioned in Section 1.1.4. The purchase will issue a production order (as shown in Figure 3-10) whenever *all* product components in the inventory file are ready.

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| | |
|---|---|
| เลขที่ใบสั่ง | 202004001 |
| วันที่สั่งผลิต | 7 ม.ย. 63 |
| ลูกค้า | TGW |
| กำหนดส่ง | 23 ม.ย. 63 |

| ลำดับ | ผลิตภัณฑ์ | ขนาด | จำนวน | หน่วย | หมายเหตุ |
|---|---|---|---|---|---|
| 1 | Thai Sytle Dried Durian - ทุเรียนอบกรอบของแดงไทยสไตล์ | 60g x 30bags | 30.00 | ลัง | STOCK |
| 2 | ปลาข้างเหลืองย่างเล็กใส่งา -รสเผ็ด | 100g x 24bags | 50.00 | ลัง | วัตถุดิบเข้า 13/04/2563 |
| 3 | ปลาข้างเหลืองย่างเล็กใส่งา -รสดั้งเดิม | 100g x 24bags | 40.00 | ลัง | วัตถุดิบเข้า 13/04/2563 |
| 4 | ***ThaiStyle Dehydrated Mango - มะม่วงอบแห้ง **** | 200g x 20bags | 50.00 | ลัง | ถุงใหม่สีเขียว |
| 5 | | | | | |
| 6 | ***บรรจุลงลัง ถ่ายรูปให้คอนเฟิร์มก่อนนะคะ** | | | | |
| 7 | | | | | |
| 8 | Revised | | | | |
| 9 | | | | | |
| 10 | | | | | |

หมายเหตุ :

*Figure 3- 10: Production Order form*

### 3.5.3 Operation and Warehousing Process

Operation team and warehouse will receive production orders form (Figure 3-10) from the purchase department. Production team will plan their production and retrieve all associated items from the warehouse. If any of the required items is inadequate for the retrieval due to inaccurate inventory information, the operation team will inform the purchaser to buy in.

### 3.5.4 Accounting Process

The accountant is mainly responsible for all monetary transactions within the organization. They will arrange payment to all suppliers once a signed PO is sent to them.



## 3.6 PROBLEM ANALYSIS

This section extends the preliminary analysis of repackaging product categories in Section 1.2. Apart from the inventory analysis problems mentioned, the comprehensive analysis discovers more evidences and reveals further issues as follows:

### 3.6.1 Low Inventory Turnover

The visual inspection of the warehouse indicates over stock and lack of storage locations. As a result, the ratio of 2019 sales to the average monthly inventory, called *inventory turnover ratio*, is analyzed to quantify the problem, as shown in Figure 3-11.

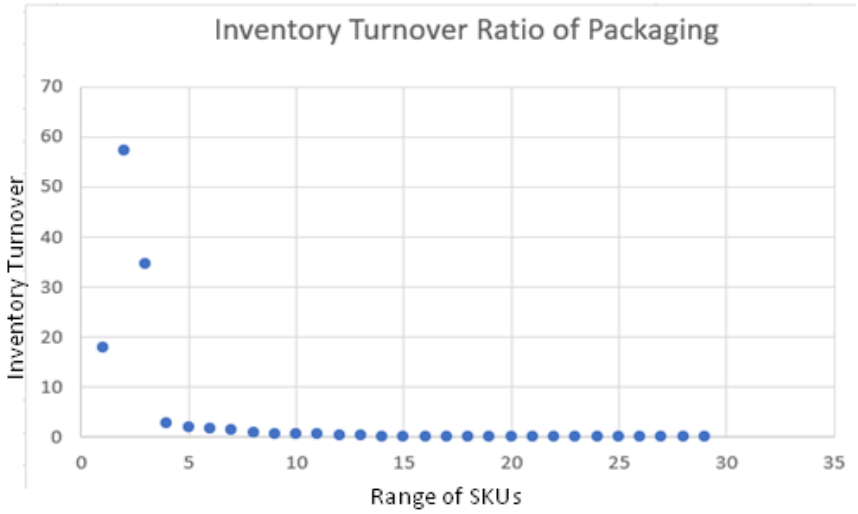


*Figure 3- 11: Inventory turnover ratio of packaging related products*

The scattered graph in Figure 3-11 shows the inventory turnover ratio of the related packaging for the repackaged product category. The majority products of the repackaged category exhibit low ratios, implying its large inventory relative to the sales, whereas some products have the ratios exceed twenty, indicating possible shortage. Despite the high ratio, these products caused shipment delays as some of its components needed 30-60 days of lead time. According to Louise Balle (2019), the inventory turnover ratio in the wholesale food business industry should be approximately 8.0 to 9.0. This inventory issue may link to the lack of visibility and the centralization of information of the case study company.

### 3.6.2 Analysis of Slow Inventory

*Table 3- 2: Six slowest sales of finished goods in 2019*

| Product Code | items | unit | 2019 sales amount | Inventory turnover |
|---|---|---|---|---|
| S00122 | Roasted dried grilled travelly fish - Spicy flavor 100 g. | pcs | 1,540 | 0.028 |
| S00121 | Roasted dried grilled travelly fish - Original flavor 100 g. | pcs | 1,480 | 0.044 |
| F00621 | Tamarind Milk Candy 180 g. | bag | 864 | 0.567 |
| F00521 | ThaiStyle Durian Milk Candy ThaiStyle 110 g. | bag | 380 | 1.795 |
| N00411 | ChipMe Salted Eggs Durian Chips 60g | bag | 126 | 1.206 |
| F00121 | Durian Cake 480 g. | bag | 58 | 0.397 |

One of the serious issues that can be seen in the context of packaging is that it is critically overstock on low sales items. Table 3.2 shows the six slowest sales items in 2019. Table 3-3 shows those six lowest sales products and its related packaging inventory and its inventory turnover rate. It is clarified that the inventory turnover is relatively very close to zero, which is a clear indication of an overstocked based on the annual usage.

*Table 3- 3: Lowest sales packaging and its stock quantity*

| Product / Packaging | Average of 2019 sales | Average of stock | Average of inv |
|---|---|---|---|
| **S00122** | **1,540** | **9,386** | **0.191** |
| Golden Bag Ziplock size L (Pack 100 g.) | 1,540 | 5,871 | 0.262 |
| Hot Food Bag (size L) | 1,540 | 12,900 | 0.119 |
| **S00121** | **1,480** | **9,386** | **0.183** |
| Golden Bag Ziplock size L (Pack 100 g.) | 1,480 | 5,871 | 0.252 |
| Hot Food Bag (size L) | 1,480 | 12,900 | 0.115 |
| **F00621** | **864** | **1,280,208** | **0.018** |
| Tamarind milk candy 180g outer bag | 864 | 1,091,616 | 0.001 |
| Tamarind milk candy wrapper | 864 | 1,468,800 | 0.035 |
| **F00521** | **380** | **2,061,105** | **0.012** |
| Durian milk candy 110g outer bag | 380 | 18,210 | 0.021 |
| Durian milk candy wrapper OLD | 380 | 4,104,000 | 0.003 |
| **N00411** | **126** | **5,680** | **0.022** |
| Bag Ziplock ChipMe Durian | 126 | 5,680 | 0.022 |
| **F00121** | **58** | **11,000** | **0.005** |
| NANA sticker 480g durian | 58 | 11,000 | 0.005 |

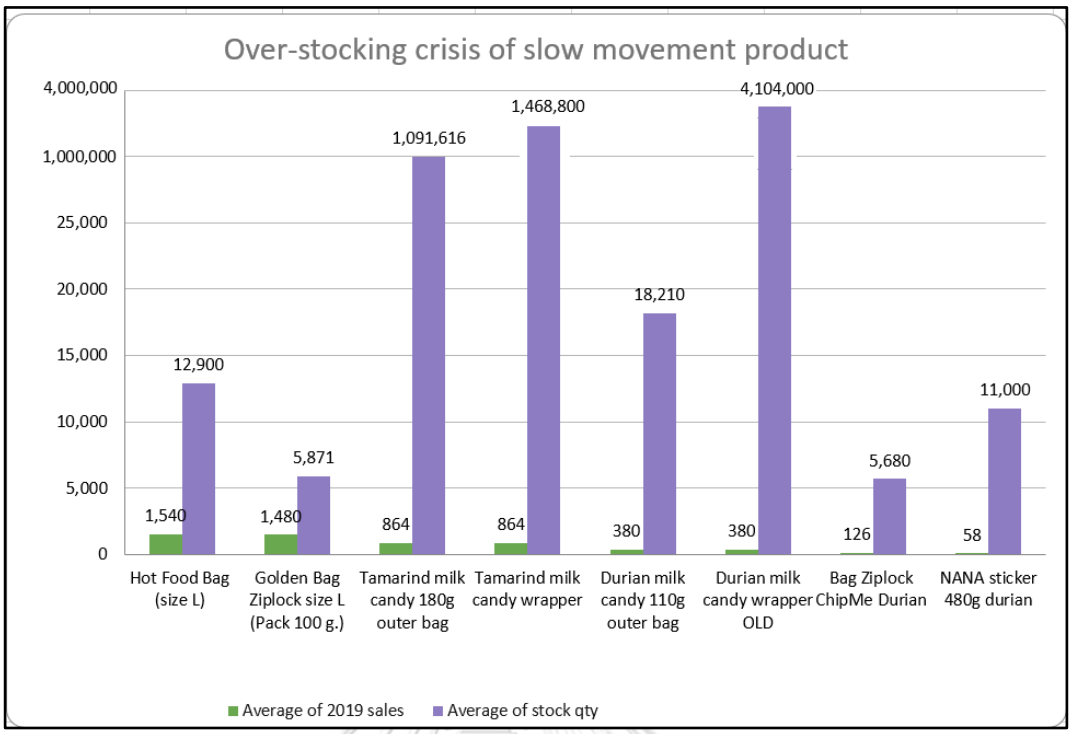


*Figure 3- 12: Over-stocking crisis (comparison of sales and packaging stock)*

Figure 3-12 illustrated bar chart comparison of the sales that are much lower compared to that of the inventory packaging stock. The Tamarind Milk Candy 180 g. were among the fifth lowest sales, but its packaging stock is of a very high figure. This would seriously increase with the rise of the continuous purchase. This requires a serious reconsideration and adoption of a new standard system to record the sales and packaging information together.

# CHAPTER 4:
# ANALYSIS OF INVENTORY

This chapter focuses on presenting the ABC analysis, Min-Max analysis, and safety stock analysis to have a comprehensive understanding of the inventory of the case company. The implications of the findings are further presented to guide the proposed method and policy recommendations.

## 4.1 FINDINGS AND KEY ANALYSIS

To perform the subsequent analysis, a total of 293 unprocessed data were collected and acquired from the case study company. For the 293 unprocessed data, a total of 83 unique SKU was presented. These 83 unique SKUs data were tested for normality with Anderson Darling test before performing the inventory analysis. The P-value of Anderson darling test were far less than 0.05, this imply that the data are normal distributed. Although the distribution of inventory are less than ideal, the further analysis, including safety stock, should provide a useful insight.

The 83 items categorized from the inventory stock mainly were distributed as Packaging (PAC), Carton (CAR), Bag (BAG), Sticker (STI), and others (OTH) as follows:

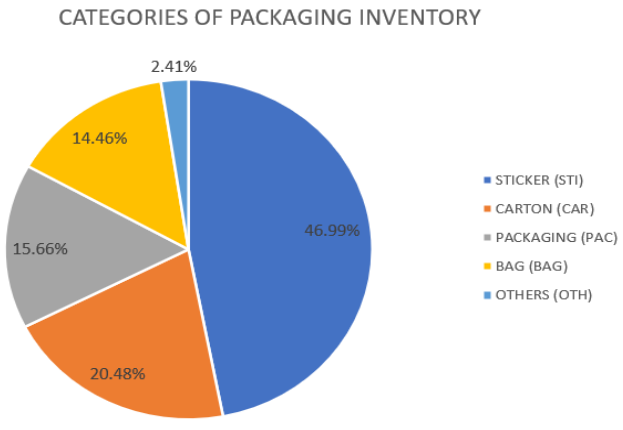


*Figure 4- 1: Categorization of Packaging Inventory*

Based on Figure 4-1, it was seen that the ‘STI’ (Sticker) category had the most volume comprising of 46.99% (39 items) of the total inventory, followed by ‘CAR’ (Carton) with 20.48% (17 items), PAC (Packaging) with 15.66% (13 items), ‘BAG’ (Bag) with 14.46% (12 items), and others (2 items) comprising of 2.41%. This information has been further utilized throughout the paper to understand how ABC analysis, min-max, reorder point, and safety stock is distributed based on the sales classification.

### 4.1.1 ABC Analysis

As mentioned in Section 2.3.1, ABC analysis separate inventory into three sub group based on the inventory value. ABC analysis in this section calculate inventory value of each of the 83 unique items in order to get the cost percentage so as to rank the inventory value.

Performing the ABC analysis for the 83 unique items, it was seen that (referring to Figure 4.2), 7 out of 83 of the total inventory items belonging to Class A. 16 items of the total inventory items belong to Class B. And finally, 60 of the total inventory items belong to Class C. The inventory value of Class A, B, and C was 70.29%, 19.69% and 10.02% respectively.

This research uses the 70-20-10 rule for categorization for ABC class because majority of the A-Class were being categorized under the Packaging and Bag (PAC and BAG). The company PAC and BAG inventory required a higher MOQ and a longer lead time (as shown in Figure 3-8), and it also has high value. This led to it being characterized in the A class item. While other Packaging and Bag (PAC and BAG) class items in B and C class were characterized as the low movement inventory. This indicates that the first 7 items representing the Class-A inventory stock requires a strong and tight inventory control, and thus, the inventory should be strictly monitored. Similarly, the following 16 items in class B have greater flexibility. Finally, the 60 items under Class C require the simplest control possible (under a low budget financing) with minimal records.

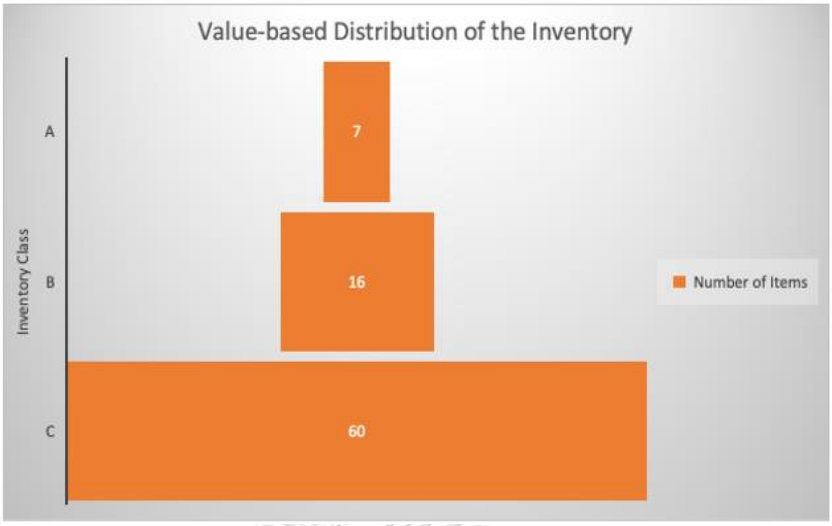


*Figure 4- 2: Values of Inventory under 70-20-10 Rules*

The ABC analysis performed for the case company was developed under the 70-20-10 rule, whereby the cost percentage was derived from the ratio of cost of the inventory unit by the total cost of the inventory stock (n=83). The cost percentage for each SKU was sorted in descending order for the MS Excel to create a Pareto chart (shown in figure 4-3 below).

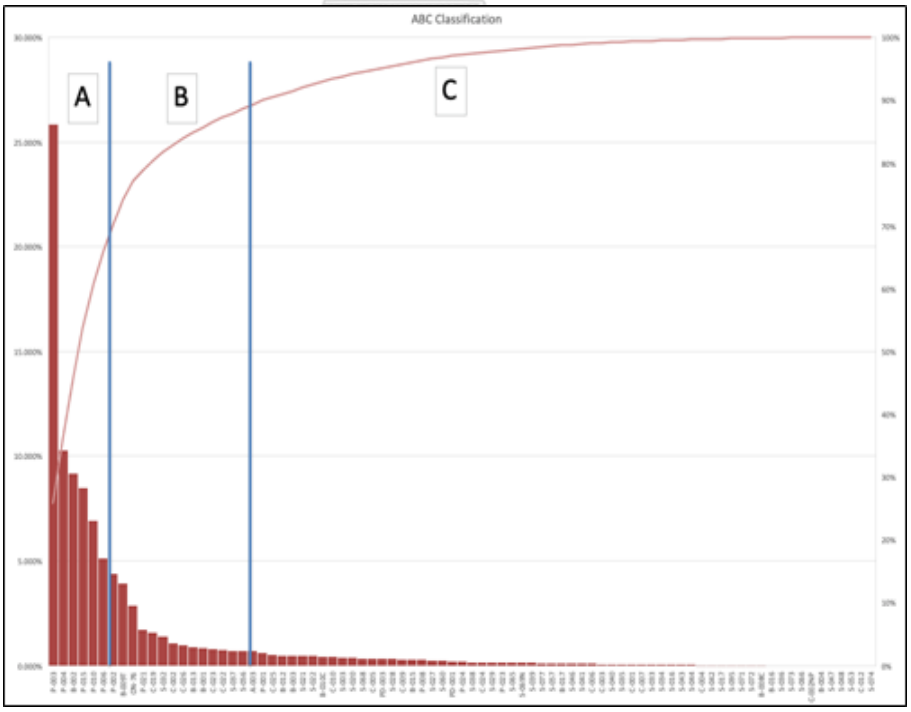


*Figure 4- 3: The Pareto Classification of Inventory*

The focus of this research is on the high-value products, items that particularly belong to the Class-A. In Figure 4-3, 7 items from the total 83 items represent the 70.29% worth of the overall inventory. Due to the expensiveness and the comparatively high usage volume of Class-A items, it is important to reduce its potential shortages, and consider the potential inventory optimization, based on financial performances and inventory quantity optimizing.

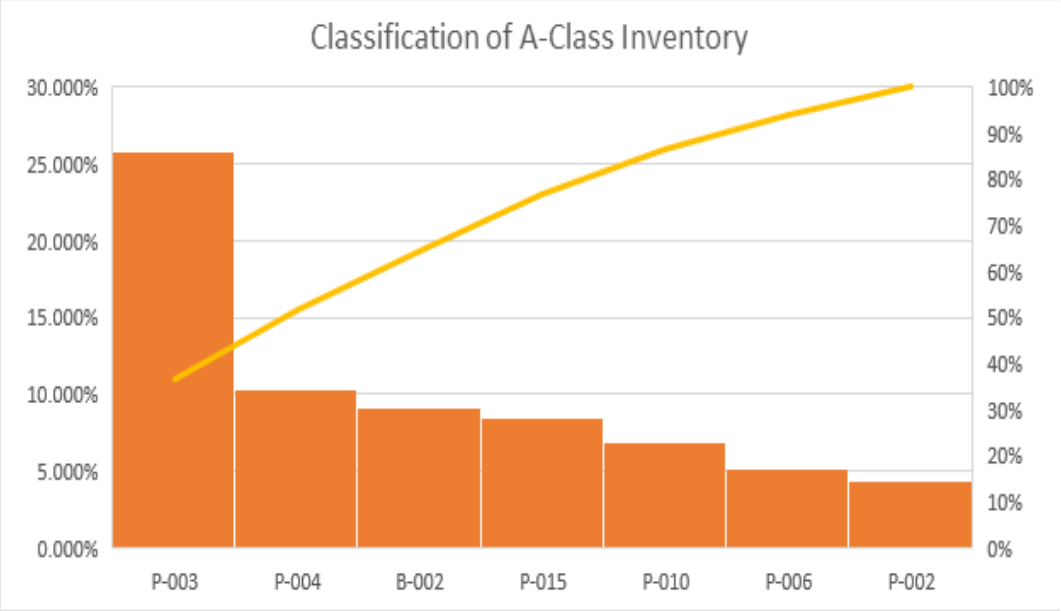


*Figure 4- 4: Pareto Analysis (Q,r) for high-controlled inventory*



For further analysis, Figure 4-4 was developed to assess the inventory of the tightly regulated products of Class A. Amidst the Class A items, it was seen that the SKU P-003 indicates the 80-90% of the Class A inventory stock. Therefore, the SKU P-003 should be monitored and managed closely to enhance the service level from the current service level of the firm. In addition to that, out of 13 PAC items, 6 items are categorized in A class, 2 in B class, and 5 items are in C class.

#### 4.1.1.1 CLASS A IN FINISHED GOOD

*Table 4- 1: A class in finished good*

| SKU | Finished Good |
|---|---|
| P-003 | 8 |
| P-004 | 9 |
| B-002 | 2 |
| P-015 | 1 |
| P-010 | 1 |
| P-006 | 3 |
| P-002 | 5 |

Table 4-1 depicts how many finished goods use the respective A class items. It is found that P-003 and P-004 were used in 8 and 9 finished goods respectively. Therefore, the stock / delivery of all these finished goods is dependent on the availability of its packaging inventory.

### 4.1.2 Min-Max Strategy

A min-max strategy is implemented in this research to assess the reorder point, whereby it can be understood when a new order should be placed for replenishment. A min-max policy refers to an inventory management strategy, whereby, if an inventory position of the firm (y) falls below the reorder level (s), then an order (S) is placed based on S – y. This is also termed as the (s, S) model of reorder point.

The study by Liu (Liu, 2017) has employed the lead time method to integrate into the Min-Max inventory system to manage inventory. Calculating the lead time can allow an understanding of the maximum days required for an order to arrive upon the ordering process established. The lead time for the company is characterized between 7 days to 45 days with an interval period stated as follows.

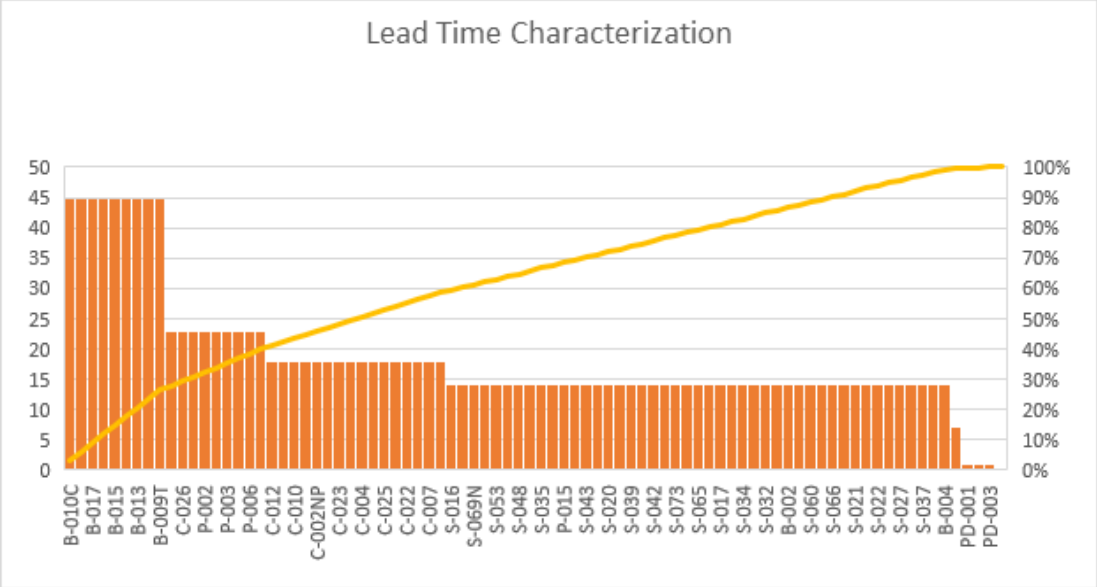


*Figure 4- 5: Lead time development*

Considering the lead time illustration, it can be seen that a vast majority of the lead time, stands for 14 days (referring to Figure 4-5). A further lead time of all 83 items is performed and shown as follows.

*Table 4- 2: Class based lead time*

| **Lead Time (Days)** | A | B | C | **Total (n)** |
|---|---|---|---|---|
| **1 - 7** | 0 | 2 | 2 | **4** |
| **8 - 14** | 2 | 3 | 40 | **45** |
| **15 - 21** | 0 | 5 | 11 | **16** |
| **22 - 29** | 5 | 3 | 1 | **9** |
| **30 ++** | 0 | 3 | 6 | **9** |

Table 4-2 shows that the longest lead time is 30 days and longer (up to 60 days). Further investigation found that those 9 items with 30++ days ordering lead time are all categorized under BAG. On top of that, all 9 items are made to order products that are imported from overseas. 1 - 7 days is the shortest lead time. Simultaneously, it can be seen that between 8-14 days consists of the greatest stock replenishment period.

Special emphasis is required for Class A items as it represents the greatest level of the inventory cost. If Class A items were out of stock for 20 days before replenishment can create a significant loss in terms of sales and efficiency. In addition to that, the lead time can be classified based on the category as shown in Table 4-3.

*Table 4- 3: Leadtime based on categories*

| Lead Time (Days) | Packaging | Sticker | Bag | Carton | Others |
|---|---|---|---|---|---|
| **1 - 7** | 0 | 0 | 0 | 0 | 4 |
| **8 - 14** | 3 | 39 | 3 | 0 | 0 |
| **15 - 21** | 0 | 0 | 0 | 16 | 0 |
| **22 - 29** | 8 | 0 | 0 | 1 | 0 |
| **30++** | 0 | 0 | 9 | 0 | 0 |

Table 4-3 shows lead time for each class in each category. The packaging category indicates class A items being in a 4-week (22 - 29 days) lead time interval. Most of the Packaging is under A class with a significantly long lead time. This is because the case study company tends to purchase those made to order Packaging inventory from overseas.

Secondly, the sticker of all 39 items indicated a lead-time of 8-14 days (2 week), with Class B of 3 items and the rest are of Class C. The BAG category has a 8-14 days lead time and 30++ days lead time due to the fact that some bags need to be uniquely customized while some do not. No customization bag, like a clear plastic bag, required only 8-14 days lead time. While those with 30++ days lead time are items with customization. Further analysis with the company found that all 12 Bag items are purchased internationally. Finally, the Cartons are mainly in B and C class with the majority in 15-21 days ordering lead time.

On the basis of the above findings, it was noted that the lead time for BAG class inventory stocks was the highest for 30++ days, followed by PAC class for packaging. In addition to this, the lead time for class A product for Packaging has the highest lead of 4 weeks (22- 29 days). The reason that PAC and BAG have the highest lead time is due to the fact that these two categories need to be customized.

And the researched company purchases these two product categories from China to lower the unit cost. Still, these 2 elements can be improved by the inventory management practices to reduce lead time. Being that the above products also are the highest composition for 'A' class products. It is imperative for a new solution to be identified to reduce the lead time. Based on the lead times indicated, the reorder point has been further calculated for the respective inventory stocks.

#### 4.1.2.1 Reorder Points

The following Figure 4-7 indicates the reordering point (ROP) for the SKUs. Since the nature of the research company is export business, the demand and lead time does not quantify on a daily basis. Instead, the demand and lead time arrives on a week-based basis. The Reorder point is calculated using the variable demand and constant lead time expression using the formula:

$$\mathbf{R} = \boldsymbol{đLT} + \boldsymbol{z\sigma\sqrt{LT}} \tag{4.1}$$

Where $\boldsymbol{d}$ = average weekly demand (52 weeks in calculated year)

LT = lead time

$\sigma$ = standard deviation of weekly demand, assuming 52 weeks per year

Z = number of standard deviations (SD) corresponding to service level where 95% service level is used for A class and 90% service level is used for B and C class items.

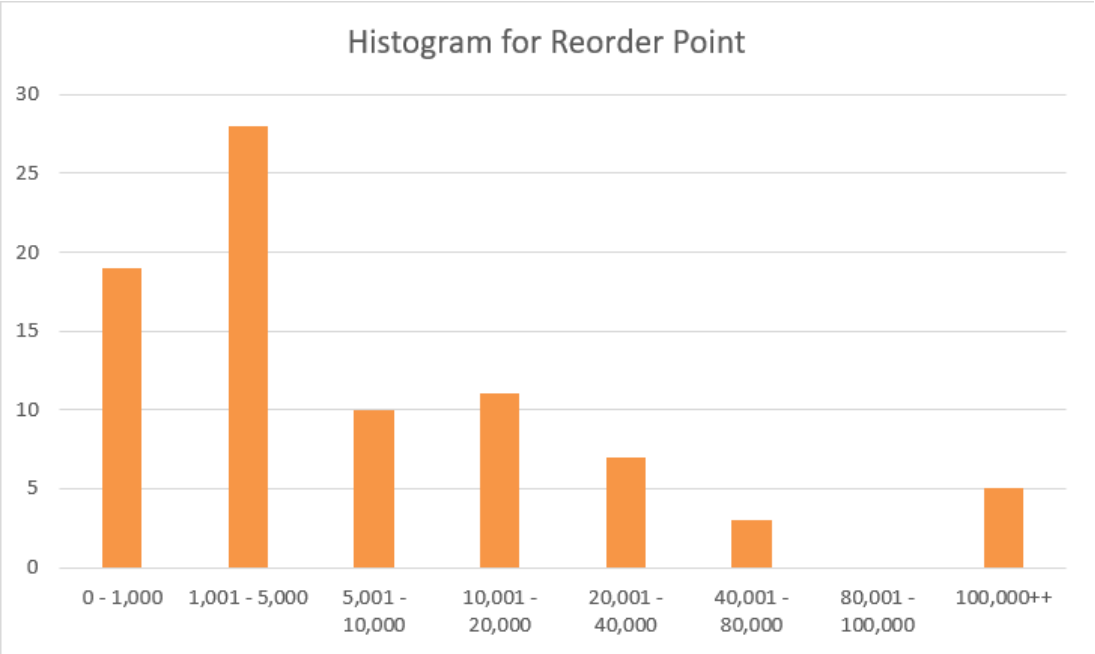


*Figure 4- 6: Histogram for reorder point*

Based on the Histogram chart presented in Figure 4-6, over 50% of the units are reordered or replenished when the quantity drops below 10,000 units. The trend shows the highest ROP of over 100,000 units comprising five items. This implies that the research company must have an inventory of over 100,000 pieces in order to place new orders to prevent stock out. Further analysis of reorder point based on ABC class are as follows:



*Table 4- 4: Reorder point based on class*

| ROP Point | A | B | C |
|---|---|---|---|
| 0 - 1,000 | 0 | 2 | 17 |
| 1,001 - 5,000 | | 6 | 22 |
| 5,001 - 10,000 | | 1 | 9 |
| 10,001 - 20,000 | 1 | 3 | 7 |
| 20,001 - 40,000 | 3 | 2 | 2 |
| 40,001 - 80,000 | | | 3 |
| 80,001 - 100,000 | | | |
| 100,001 ++ | 3 | 2 | |

Table 4-4 indicates that the lowest ROP value revolves around the 'item Class C', with almost 50% of the total ROP being within 0 – 5,000 range. This is because C Class mostly consists of Sticker categories, which require very low MOQ and are also purchased locally and easily with no complication. Simultaneously, it can be seen that the higher Class-A indicates a higher range of ROP (due to its customization), with three out of seven items of class A items being reordered at the higher range of over 100,000 pieces. This indicates that class A has a higher minimum value, indicating that a greater lead time can be expected.

However, for Class B, a mixed range of ROP can be viewed, which in correspondence to Table 4-2. With the utilization of the average demand value in order to attain the point of reorder for each individual item does not necessarily provide a solution, however what it does it helps in giving key knowledge, thereby assisting reducing possible stock-out crisis. Moreover, it should be also understood that the point of reorder is the minimum stock quantity that is required, regardless of the low in demand during that particular period, as an immediate change in this demand can be catered effectively.

### 4.1.3 Safety Stock Analysis

Safety stock calculations are often utilized as a means to ensure that there is a buffer between the product and supply. In this study, the safety stock analysis is calculated using the following formula:



$$\text{Safety Stock (SS)} = ROP - (D \; x \; LT) \tag{4.2}$$

Where ROP = Reorder point
D = Average weekly demand
LT = Lead Time

To analyze the safety stock, this report takes into consideration all of the class A variables. This is because class A items affect many finished goods and have high

inventory values. In order to identify the key safety stocks, this research makes use of the 16-outlier data indicated from the high reorder point.

The selection criteria for 16 inventory data is as follows: This encompasses all Class A (7 items), and other items within the highest ROP, including Class B (4 items), Class C (5 items). The items from Classes B and C were selected because of its high ROP, and also because it was deemed to be able to improve. With such stated, the following table indicates the safety stocks for all 16 selected data.

*Table 4- 5: Key safety stock for 16 selected inventories*

| No. | SKU | rev_class | SS | ROP |
|---|---|---|---|---|
| 1 | B-002 | A | 33,114 | 117,136 |
| 2 | P-002 | A | 8,439 | 17,453 |
| 3 | P-003 | A | 28,353 | 101,741 |
| 4 | P-004 | A | 15,258 | 33,038 |
| 5 | P-006 | A | 7,601 | 20,318 |
| 6 | P-010 | A | 10,125 | 21,191 |
| 7 | P-015 | A | 26,170 | 114,740 |
| 8 | A-003 | B | 114,171 | 118,709 |
| 9 | B-009T | B | 40,976 | 134,543 |
| 10 | S-032 | B | 18,246 | 32,461 |
| 11 | S-056 | B | 17,320 | 30,350 |
| 12 | B-010C | C | 14,368 | 47,737 |
| 13 | S-003 | C | 16,569 | 40,799 |
| 14 | S-020 | C | 9,835 | 23,776 |
| 15 | S-057 | C | 21,416 | 37,989 |
| 16 | S-068 | C | 22,762 | 45,209 |

Figure 4-7 further simplifies Table 4.5 data for easy interpretation. It can be seen that Class B of Bags inventories have a very high safety stock of over 50,000++ pieces.

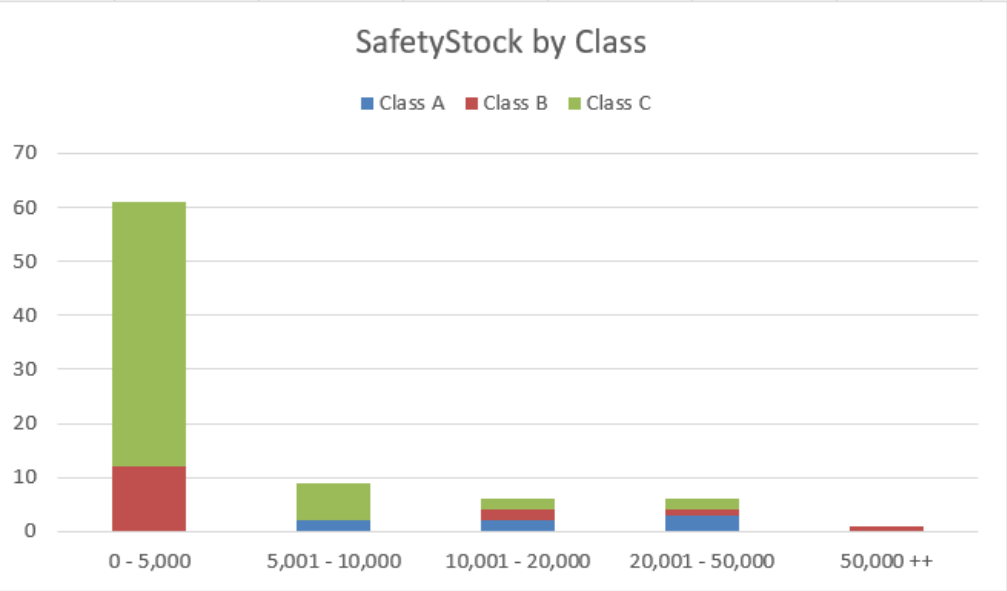


*Figure 4- 7: Distribution of safety stock grouped by class*

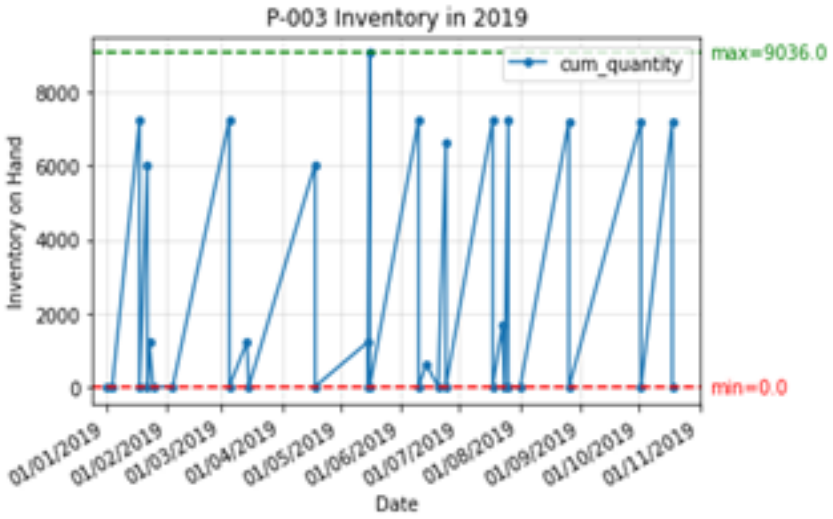


*Figure 4- 8: Min-Max graph for class A P-003*

Figure 4-8 refers to the min-max graph of the most valuable inventory, Class A – P-003. It can be seen at so many periods of time, the stock is of minimum value, which in fact the safety stock of this item is supposed to be of 28,353. By understanding these values, it becomes possible to attain a guideline that assists in the optimization of the stock levels, in regard to the varying situations. This ultimately avoids the stock-out crisis.

Moreover, during less demanding months, and with min value reached, it is important to closely consider whether the re-stocking procedure is not immediately initiated as it reaches the value. In contrast, the max value or the highest level of stock to be retained in the warehouse, should not be exceeded. This ensures sufficient and efficient production levels. However, the above max number per item could be utilized as a limitation during restocking procedure.

In addition to the above data, two conditional formatting is employed, based on the ABC analysis and characterization to further interpret the safety stock in the outlier data of 16 inventory stocks. Figure 4-9 shows the safety stock for Class A stock inventories.


*Figure 4- 9: Pareto chart for safety stock class A*



On the basis of Figure 4-9, it can be seen that safety stock for Class-A items were characterized to be within the limits of 30,000 – 35,000 units. The inventory B-002 (BAG) and P-003 and P-015 (PAC) indicate that there is a high level of safety stock and a high reorder point. This indicates that the inventory B-002, P-003 and P-015 can incur a high holding cost for the inventory, and increased holding cost, if liquid sales is not achieved at an optimal pace. While other products in the category including P-004, P-010, P-002, and P-006 have a comparatively low safety stock. P-006 in particular should be monitored, as lack of products in shelves/stock can result in loss of sales, and thus, dissatisfied customers, as these products are within a common Class A.

## 4.2 IMPLICATIONS OF THE FINDINGS

The analysis performed in this chapter mainly corresponds to the conventional method of measuring the value of the inventory stock, as well as assigning and recommending the management of safety stocks, cycle counts, reorder points, as an attempt to introduce policies to minimize the holding costs.

First of all, after sorted out 83 unique SKUs, the study approached the use of ABC analysis. The ABC analysis indicated that 7 items out of the total 83 were categorized as 'A' class items, which should be highly prioritized throughout inventory-management decisions. Other items include class B with 16 items, and class C with 60 items with comparatively less priority respectively.

Secondly, the min-max analysis indicated that the majority of the lead-time was in the range of 14 days. However, in the context of Class-A items, the majority of the product (5 out of 7) were within 22-29 days ordering lead time. The lead time of 4 weeks interval for class A items could potentially imply an inefficient management system. Furthermore, this can negatively influence the sales of the Class A items, while increasing the storage costs, if the warehouse is left empty without designated products being stocked.

Thirdly, the reorder point analysis indicated that about 50% of 83 items were within a lower reorder point range, while 16 of the total items acted as a selected inventory data for further analysis. These 16 selected items were determined from all 7 A-Class items and those with the highest ROP were selected (5 items from class B and 4 items from class C).



The safety stock analysis indicated that Class-A items had a significantly high safety-stock and a high reorder point. Although 3 items out of Class-A inventory indicated a low safety stock, and had a comparatively average reorder point, the items B-002, P-003, and P-015 had a high safety stock value with a high reorder point. This implies a higher cost for inventory management, including holding costs. Although this provides customers with satisfaction of readily available stocks, it creates high costs for the firm. While, lower anticipated safety stock, for instance, for products like item P-006, it is presumed that the sales can be low upon demand. Therefore, a

consistent ROP point, and Safety Stock should be held across the Class-A items, ensuring a tight control over the products.

The implications of the findings guide the direction for the report, leading to the development of the proposed method for storage management and recommendations for policy for purchasing, reporting, cycle count, and approaching a low movement inventory.

# CHAPTER 5:
# PROPOSED METHOD AND POLICY RECOMMENDATIONS

The purpose of this chapter is to provide integrative policy management and policy recommendations, as well as inventory management tactics. Findings from chapter 4 are utilized to establish justified problems within the firm and policy revolving around improving over-stock, stock shortage, shipment delays, as well as reducing inventory costs. In order to perform such, new policies in the inventory management system for the case study company are recommended.

## 5.1 SLOW-MOVING INVENTORY GOODS

The dynamic nature of demand itself tends to create a significant degree of challenge for maintaining a stable inventory level (Silver, 1981). The lack of accurate estimation may lead to fluctuating lead times, and a complication in stock-in/out approaches in inventory management. The high volatility in inventory management, especially food related companies, also invites a large demand fluctuation with a high proportion of zero-demand environments (Silver, 1981; Willemain, 2004). (Porras, 2008; Silver, 1981) defines the fluctuation of inventory and recurring zero-demand environment as slow-moving items, and control of such items is imperative to control the high costs of inventory holdings.



As mentioned in Section 3.6.1, one of the serious issues that the company faces is its overstocked on the low sales items. This is an example of slow-moving inventory. Analysis from Section 4.1.2 also shows that BAG and PAC categories have a long lead time with high minimum order quantity due to the fact that the company purchases these item categories from overseas. Therefore, one of the key factors in eliminating the slow-moving inventory goods is forecasting or calculating the inventory turnover ratio for each unit. A turnover ratio, according to (Kocer, 2011), is the “speed of sale of the products in the stock throughout the year”. Kocer (Kocer, 2011) also states that, the products with low turnover (unpopular items in the inventory) often tend to hold high costs of holding.

Once forecasted or calculated inventory turnover ratio for each item, the company should only order in quantity that matches with the usage instead of bulk purchase from overseas to obtain lower prices. A higher unit cost with lower quantity purchase in inventory will save company warehouse spaces as well as lower holding costs.

The company should also keep monitoring this slow-moving inventory, if there is no movement over a period of 12 months, this slow-moving inventory can be considered dead stock. Inventory management policies on dead stock should also be ensured. Some of the dead stock policies can be put on sale, bonus (give away) items, or even destroyed.

## 5.2 VENDOR SELECTION

Amidst many forms of inventory management tactics, the study by Ben-Ammar (Ammar, 2013) claims that, assessing the lead times is an imperative criterion in order to improve inventory. The assessment of lead time is not only important in performing on-time delivery, but also is imperative in measuring the minimum inventory. These lead times are defined based on the ability of the vendor to deliver any given inventory that is running out of stock. Data Profit (Profit, 2021) suggests three techniques to forecast the vendor lead time, which includes, utilizing the vendor quoted lead time, manually forecasting the lead time, and utilizing a system that can calculate lead time based on past inventory stock periods.



In the analysis of lead-time indicated in Table 4-3, the vendor selection would be a primary factor. It can be seen that the tightly regulated items for ‘packaging’ and ‘bag’ are indicated to have the highest lead-time within Class-A inventory. The lead time forecast from Table 4-3 indicated that Class A items for Packaging had 22-28 days of lead time and Bags required over 30++ days of lead time, increasing the trade costs and stockouts.

The rationale for the high lead time for Class A items is due to the fact that the vendors are situated in China. As indicated from (Profit, 2021), it is important to assess the vendor quoted lead time, and based on the manual assessment, the 3-4 weeks period suggests a high lead time period for tightly controlled products.

Therefore, an alternative strategy for choosing vendors within Thailand (the origin country of the firm) is imperative in decision-making. Class A materials like Packaging and Bag should be sourced locally to reduce the optimal lead time.

All class A items should be sourced locally to prevent any stock out that would lead to customer dissatisfaction. Once a local supplier is chosen, the company should also create some agreement with the supplier to ensure a smooth process. Further recommendations in improved policies could include:

- Create a legally binding contract with the local suppliers. A class item is items with high turnover ratio, thus a legally binding contract on lead time and creating penalizing contracts could reduce risks of lead time, reduced unit price and much accurate deliveries.
- The firm should invest in stickers / labeling machines. Even though the unit cost of the sticker / label is not high, investing in a sticker / labeling machine will allow the firm to eliminate the holding cost for the sticker. And will print stickers for when it is in need only since 47% of the firm inventory comprise of sticker / label (as per figure 4.1 shown)

## 5.3 PURCHASING PROCESS AND STORAGE POLICY

Using the analysis in Table 4-5, it was found that the firm was treating few items from class B and C the same (in terms of the stock held and the purchases made regardless of their category). For instance, item S-032 in B Class has a ROP of 32,500 pieces while item S-057 in C Class has a ROP of 38,000 pieces. These 2 items came from the same sticker category, they require the same MOQ and same ordering lead time. This means the firm is probably over and under-ordering on many product lines from item Classes B and C, or had categorized several products in the same category, despite their sales volume. This can lead to a conclusion that the firm has inefficient and expensive inventory policies.

In order to eliminate this problem, the firm should implement policies that can minimize the average time required for storing and retrieving items. For instance, the current purchasing and warehousing process from Figure 1-11 has no cycle count.

The purchaser will only order items whenever there is a sales order and the warehouse informs them of no stock. The new policy recommends the company to assign cycle count. For instance, monthly cycle count for Class A item, quarterly for Class B and biannual for Class C item. The reasoning behind this timeframe is due to the fact that it is practical to implement. Class A only has 7 items but it consists of very high sales/values. The packaging and bags tend to be stored in a stacked bundle of 100 pieces. Thus, cycle count does not necessarily need to count piece by piece, instead, it can be counted in a bundle, or, even weight it to get estimated quantities.

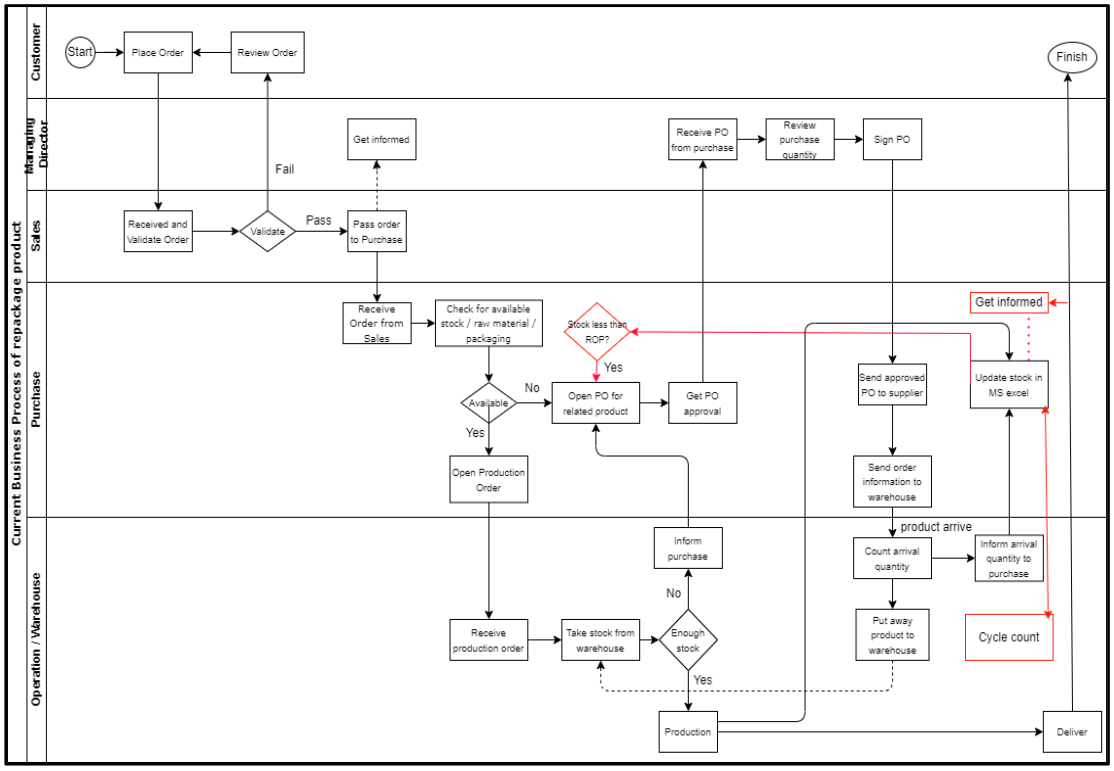


*Figure 5- 1: Work flowchart of repackaged products with cycle count policy*

Figure 5-1 shows the work process of the repackaged products with cycle count policy. The red work process is the additional process the company must enforce. Cycle count, as well as ordering when the quantity reaches reorder point, will allow more accurate inventory and also prevent stock out. Therefore, this will minimize the time for inventory distribution between the vendors, inventory warehouse, and the consumers.

In addition to that, the firm can study the inventory trends and complete accurate accounting records. Competent auditors are often hired and relied upon to

study and measure whether the cycle count inventory units are in line with existing number of inventories.

Proper storage policy should also be ensured. Currently, there is no storage policy within the company. The items are usually stored by product category. The company should consider storing the item by using Class-based storage. By doing so, the warehouse staff will be easier to spot check or cycle count based on the importance of the class category.

Therefore, a key factor in optimizing the inventory is by assessing the cycle count times and assessing the inventory turnover rates. Herein, it is imperative for businesses to consider the demand patterns. Several researches like Mattsson (Mattsson, 2010) and Ehrenthal (Ehrenthal, 2014) also recommends that businesses should identify historical patterns to study the volume of customers who purchase the product.

## 5.4 CALCULATION OF NEW POLICIES

In an attempt to apply a new policy as recommended, two key factors should be taken into consideration. The first consideration should be to determine the inventory costs, service level, and reorder point for the current system. The second factor should be the consideration of the same variables (inventory costs, service level, reorder points) for the optimized policy framework.



From the above model, the key policy employed in this research is the continuous review (Q, r) policy model. A continuous review policy refers to the implementation of a systematic policy that allows inventory levels to be followed continuously and the replenishment does not have the need to be ordered during a specific period (reorder point or safety stock period) (Axsater, 1993). Axsater (Axsater, 1993) further states that, the use of continuous review policy is favorable in condition, whereby, inventory stocks have low demand value (slow moving inventory).

In this research study, the continuous review (Q, r) policy is employed, aiming to study the reorder point and order quantity. Using the (Q,r) policy, the ‘r’ represents the reorder point, and ‘q’ represents the order quantity. Only 16 selected data from

section 4.1.3 are used in this calculation section since these 16 items are items that can be improved.

### 5.4.1 EOQ

Kocer and Tamer (2011) states that the order quantity can be measured by using EOQ model. The EOQ can be calculated using the following equation:

$$EOQ = \sqrt{\frac{2xDxS}{H}} \tag{5.1}$$

Where:

- D = Total Annual Demand
- S = Ordering cost per order
- H = Annual holding cost per unit

Ordering cost per order in this research paper consisted of expense for a purchase order, employee cost in ordering and issuing supplier's invoice, as well as handling supplier payment and inspection of the incoming goods. Transportation cost is excluded from ordering cost for this paper due to the nature of the research company business are mainly bulk purchasing. Bulk purchase often gets free delivery charge from local supplier, whereas, international purchase's transportation cost is very varied. A holding cost in this paper equivalent to 20% of the unit cost, which was suggested in the article by McCue (McCue, 2020).

The firm can calculate the optimal order quantity for minimizing its total cost related to holding cost, material cost and ordering cost by using this EOQ formula.

The calculation is further proposed as follows:

*Table 5- 1: The EOQ for 16 inventory items*

| CLASS | SKU | Annual Demand | Unit cost | Ave Purchase QTY | Ordering Cost | Holding Cost | EOQ |
|---|---|---|---|---|---|---|---|
| A | B-002 | 312,079.00 | 1.21 | 13,383.00 | 600 | 0.242 | 39,338.27 |
| A | P-015 | 328,974.00 | 0.98 | 12,617.00 | 1700 | 0.196 | 75,542.65 |
| A | P-003 | 165,922.00 | 5.6 | 4,451.68 | 600 | 1.12 | 13,333.18 |
| A | P-004 | 40,200.00 | 8.25 | 2,669.33 | 600 | 1.65 | 5,407.07 |
| A | P-010 | 25,020.00 | 7.7 | 6,000.00 | 600 | 1.54 | 4,415.44 |
| A | P-006 | 28,752.00 | 4.5 | 2,119.38 | 600 | 0.9 | 6,191.61 |
| A | P-002 | 20,380.00 | 7.8 | 2,544.00 | 600 | 1.56 | 3,959.41 |
| B | A-003 | 33,713.00 | 0.54 | 12,000.00 | 300 | 0.108 | 13,685.56 |
| B | B-009T | 108,122.00 | 2.9 | 16,550.00 | 3800 | 0.58 | 37,640.02 |
| B | S-032 | 52,799.00 | 0.7 | 13,639.67 | 300 | 0.14 | 15,042.65 |
| B | S-056 | 48,398.00 | 0.7 | 20,300.00 | 300 | 0.14 | 14,402.08 |
| C | S-068 | 83,376.00 | 0.09 | 30,000.00 | 300 | 0.018 | 52,718.12 |
| C | S-057 | 61,557.00 | 0.12 | 20,424.00 | 300 | 0.024 | 39,229.13 |
| C | S-003 | 90,000.00 | 0.25 | 99,276.00 | 300 | 0.05 | 32,863.35 |
| C | B-010C | 27,600.00 | 2.85 | 27,325.00 | 3800 | 0.57 | 19,183.33 |
| C | S-020 | 51,780.00 | 0.24 | 29,365.00 | 300 | 0.048 | 25,441.11 |

Herein from the Table 5-1, for each of the inventory units, the annual demand, the ordering costs, and the holding costs are presented. The ordering cost is an expense incurred to purchase and receive the products. This research uses 300 Thai baht as an ordering cost for item purchase locally without much customization, and 600 Thai baht for item with customization. For international purchase, this research uses 1,700 Thai baht for item with no customization and 3,800 Thai baht for item with customization. Holding cost is equivalent to 20% of the material cost.

On average, it was seen that the firm must invest on 24,900 units during the processing of the specific order. Based on the analysis, an average 24,900 units per order allows to reduce the holding costs, and increase the efficiency towards inventory management. The ideal economic order quantity for this study versus the average purchase from the company is presented in Figure 5-2 as follows:

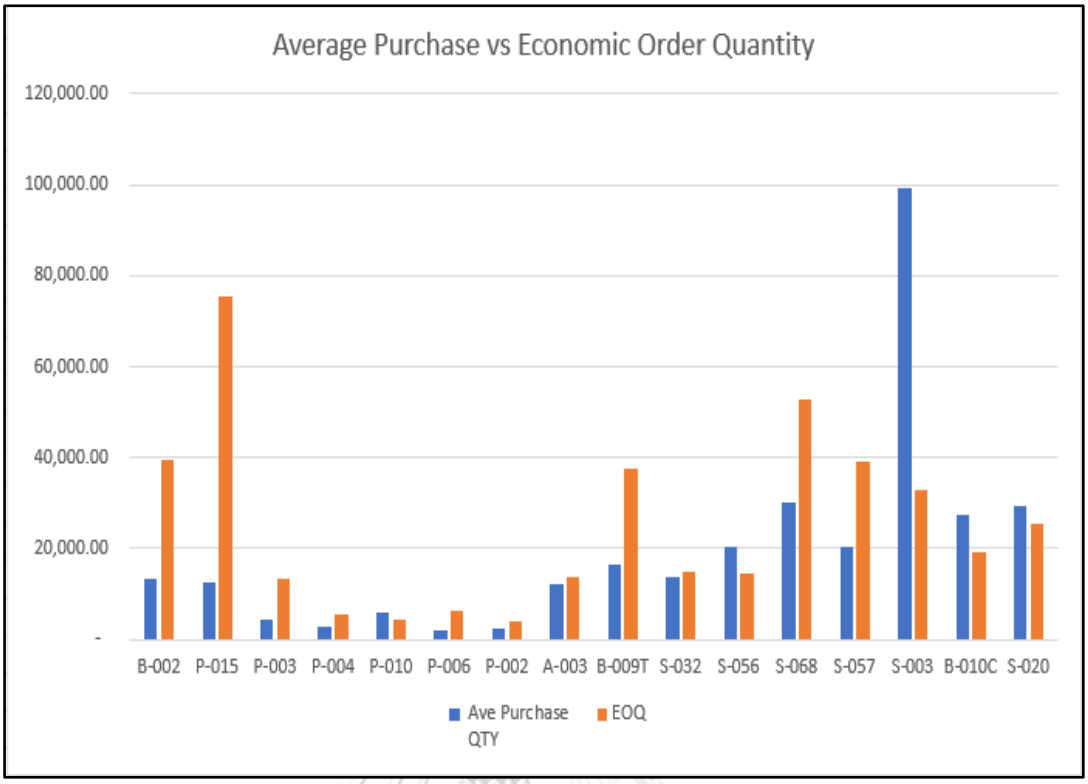


*Figure 5- 2: The average purchase versus EOQ*

From Figure 5-2, it can be seen that the company under orders A class items like B-002 and P-015, while over order C class items like S-003 by a great deal.

### 5.4.2 Revised Reorder Point

In this section, the new reorder points are calculated based on Section 5.2 proposed new model policies. The differences between current reorder points and inventory costs are calculated against the new implemented policy re-order point and inventory costs.

The reorder point (ROP) defines the period of time required for a firm to replenish a stock. When a firm is able to ideally define the ROP, a firm won't run out of stocks. Several advantages and characteristics of the ROP require the right identification of re-order points, specifically those within class A. In research on inventory management, inventory class A are those inventory items that have fast-moving inventory and high investment characteristics. Being such, it is imperative that the reorder point for class A inventory items is reduced.

#### *5.4.2.1 Locally Sourcing Class-A Inventory Items From Thailand*

- Expected Results – Reduced lead time by 50%

*Table 5- 2: Comparison of ROPs (rounded number) – Reduced lead time for class A inventory by 50%*

| sku | Lead time_old | lead time_x | Old_ROP | rop_x | rev_class |
|---|---|---|---|---|---|
| P-015 | 14 | 7 | 115,000 | 62,500 | A |
| B-002 | 14 | 7 | 117,000 | 65,500 | A |
| P-003 | 23 | 12 | 101,800 | 56,500 | A |
| P-004 | 23 | 12 | 33,000 | 19,500 | A |
| P-006 | 23 | 12 | 20,500 | 11,500 | A |
| P-010 | 23 | 12 | 21,000 | 12,500 | A |
| P-002 | 23 | 12 | 17,500 | 10,500 | A |

Table 5-2 depicts the new lead time if the company locally sources class A items instead of purchase from overseas as recommended in section 5.2. The new lead time will be half of the original lead time, thus new rop_x was presented.


*Figure 5- 3: Comparison of reorder point for class A*

Interpreting the results from Figure 5-3, it can be seen that all Class A items should be locally sourced. The rationale to this is due to the fact that local sourcing allows faster distribution channel systems. The above analysis and results indicated

that, overall, the inventory class-A had a significantly lower reorder point compared to sourcing the materials from China.

***5.4.2.2 Renegotiating with Vendors for Class-B and Class C Inventory Items, as well as Invest in Sticker / Labeling Machine***

- Expected Results – Reduced lead time by 30%

*Table 5- 3: Comparison of ROPs (rounded number) – Reduce lead time for Class B and Class C by 30%*

| sku | lead time_old | lead time_x | Old_ROP | rop_x | rev_class |
|---|---|---|---|---|---|
| A-003 | 7 | 5 | 118,000 | 98,500 | B |
| B-009T | 45 | 32 | 135,000 | 100,000 | B |
| S-032 | 14 | 7 | 32,500 | 20,000 | B |
| S-056 | 14 | 7 | 30,500 | 18,500 | B |
| S-068 | 14 | 7 | 45,000 | 27,500 | C |
| S-057 | 14 | 7 | 38,000 | 23,500 | C |
| S-003 | 14 | 7 | 40,800 | 24,000 | C |
| B-010C | 45 | 32 | 47,500 | 35,500 | C |
| S-020 | 14 | 7 | 23,800 | 7,500 | C |

Table 5-3 refers to the new lead time and new reorder point once the company renegotiates with the vendor for selected class B and class C inventory asking for 30% reduction in lead time. Whereas for the sticker category, the company was recommended to invest in sticker/labeling machines, therefore, the lead time was reduced from 2 weeks to 1 week.


*Figure 5- 4: Comparison of reorder point*

Figure 5-4: shows a bar chart of selected class B and class C inventory focusing on ROP if renegotiating with the vendor, specifically to reduce the lead time by 30%. Herein, the results indicate that the overall reorder point is reduced, along with the reduction in the total lead time.

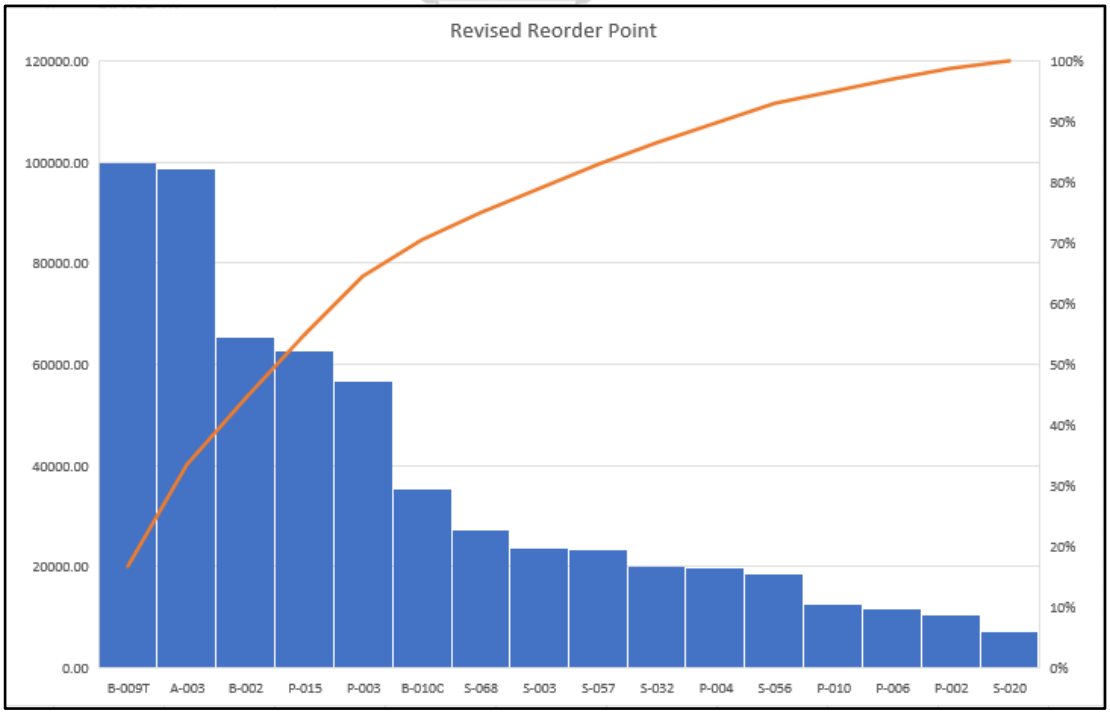


*Figure 5- 5: Revised reorder point inventory management of 16 selected SKUs*

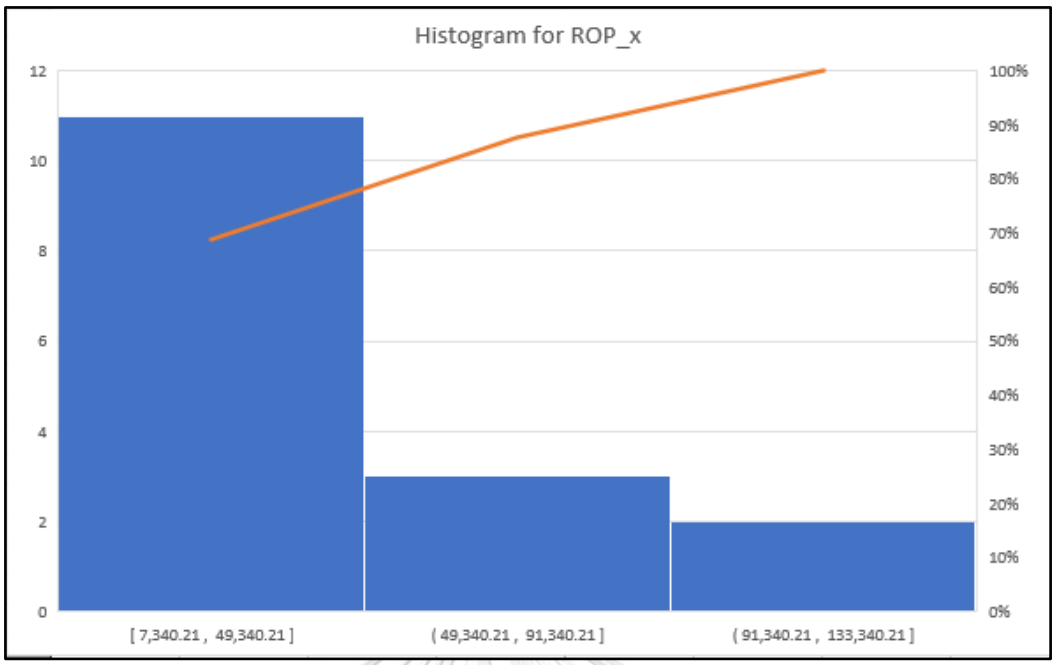


*Figure 5- 6: Histogram for new reorder point*

The illustrated Figure 5-5 and 5-6 provide a review to the overall revised reorder point, and the histogram chart for 16 selected SKUs. Once the recommended policies are implemented, the reorder point will significantly be lesser, which can imply a lesser holding cost and lower possibility of stockout.

All in all, this chapter focuses on the proposed method and recommendations the company should implement in order to align with the main objectives of this thesis. This paper suggested policy on slow moving inventory such as forecasting or calculating the inventory turnover ratio in order to minimize dead stock. Cycle count should be endorsed in order to maintain accuracy in the stock system. Vendor selection, local purchasing was suggested to shorten ordering lead time, thus, lower reorder points.

# CHAPTER 6:
# SIMULATION

In the context of this chapter, the simulation section is performed to ensure that the suggested recommendation from Chapter 5 aids the researched company to lower its inventory cost. Since the research company has no ordering policy prior to this research, this section will simulate new demand to compare the inventory value of the company's current purchasing versus new suggested policy. The ROP and EOQ from Section 5.4 will be used as a current purchasing policy, while the new reorder points and the EOQ is proven with simulation of the new simulated data set to validate if the inventory cost is lowered with suggested policies. The inventory costs accounts for the total costs of inventory, total cost of holding the stocks in inventory as well as stock out and ordering cost.

The main assumption use in this simulation are as follows:

- The simulation is developed based on the continuous review policy.
- The demand (input data) will be sorted into a 52 weeks basis.
- The holding cost is set at 20% of the material cost.
- The stockout cost is an opportunity cost of late delivery to the client, it is set at 10,000 thb per week per finished good.
- The ordering cost is the expense incurred to purchase and receive products. Transportation cost is excluded in ordering cost.
    - Items that purchase locally without much customization ordering cost will be set at 300 thb.
    - Items that purchase locally with customization ordering cost will be set at 600 thb.
    - Items that purchase internationally without much customization ordering cost will be set at 1,700 thb.
    - Items that purchase internationally with customization ordering cost will be set at 3,800 thb.

The process of the simulation is divided into three main parts, which are input analysis, process analysis and output analysis as shown on the following diagram:

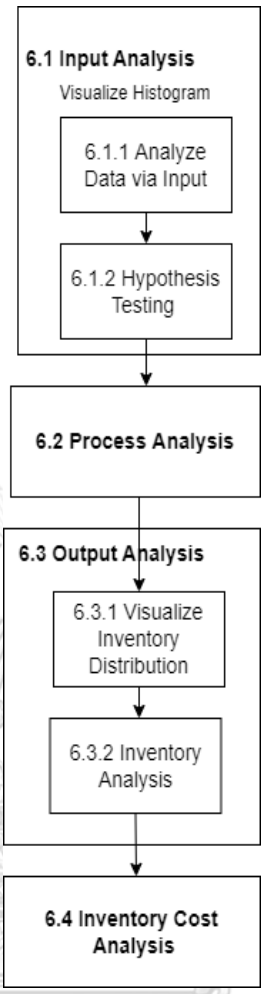


*Figure 6- 1: Flow of simulation*

Figure 6-1 depicts the process and their associated sections as follow:



**6.1 Input analysis (Demand analysis)**

1. The histogram of the demand for 16 SKUs that are being focused are being plotted to observe the data range during the 52 weeks interval.
2. The demand data was analyzed using Input Analyzer tools to compare with appropriate data distribution.
    a. The data does not fit in any distribution; therefore, an empirical distribution method is used.

b. Box and whiskers plots are used to compare the consistency in order to validate the original demand data with the generated demand data.

3. Hypothesis testing to validate the generated demand data.

**6.2 Process analysis (week base process)**

4. Verify that the process used in simulation matches with the current process.

**6.3 Output analysis**

5. Perform inventory distribution of the simulated inventory and validate histogram of 16 SKUs
6. Perform analysis of inventory, order quantity, as well as stock out, if any.

**Inventory Cost analysis**

7. Compare inventory cost.

After the brief explanation of simulation procedure, the remaining sections will discuss and illustrate each step-in detail.

## 6.1 INPUT ANALYSIS



The company's demand was being sorted into 52 weeks-based data due to the nature of the research company business. This input analysis section involves the observation of actual distribution of the demand in a form of histogram. Figures 6-2 to 6-5 show the histogram of the demand of 16 SKUs inventory separated by each group.

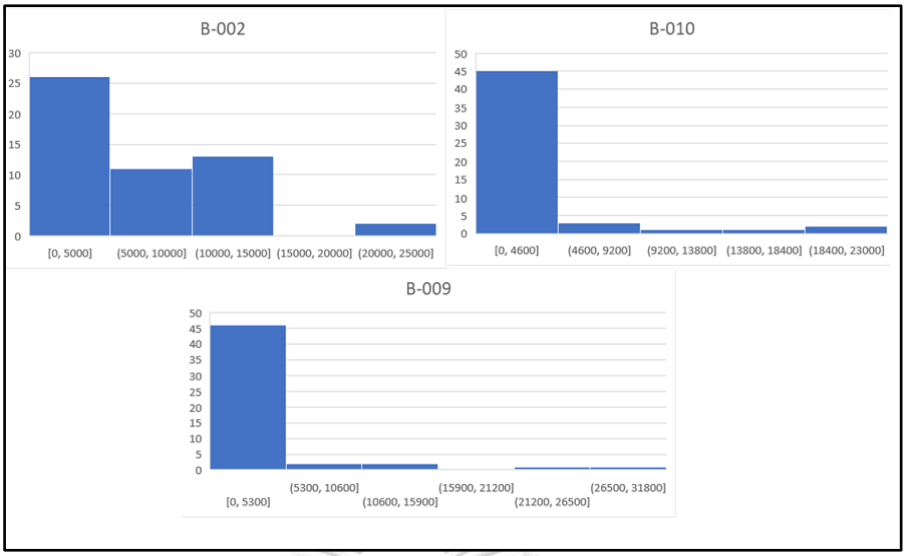


*Figure 6- 2: Histogram of demand of BAG group*

The demand histogram for BAG group is illustrated in Figure 6-2. Item B-002 has a consistently widely distributed demand ranging from zero to five thousand, to over twenty thousand pieces per week. Whereas for item B-009 and B-010 the demand is more from the lower ranges.

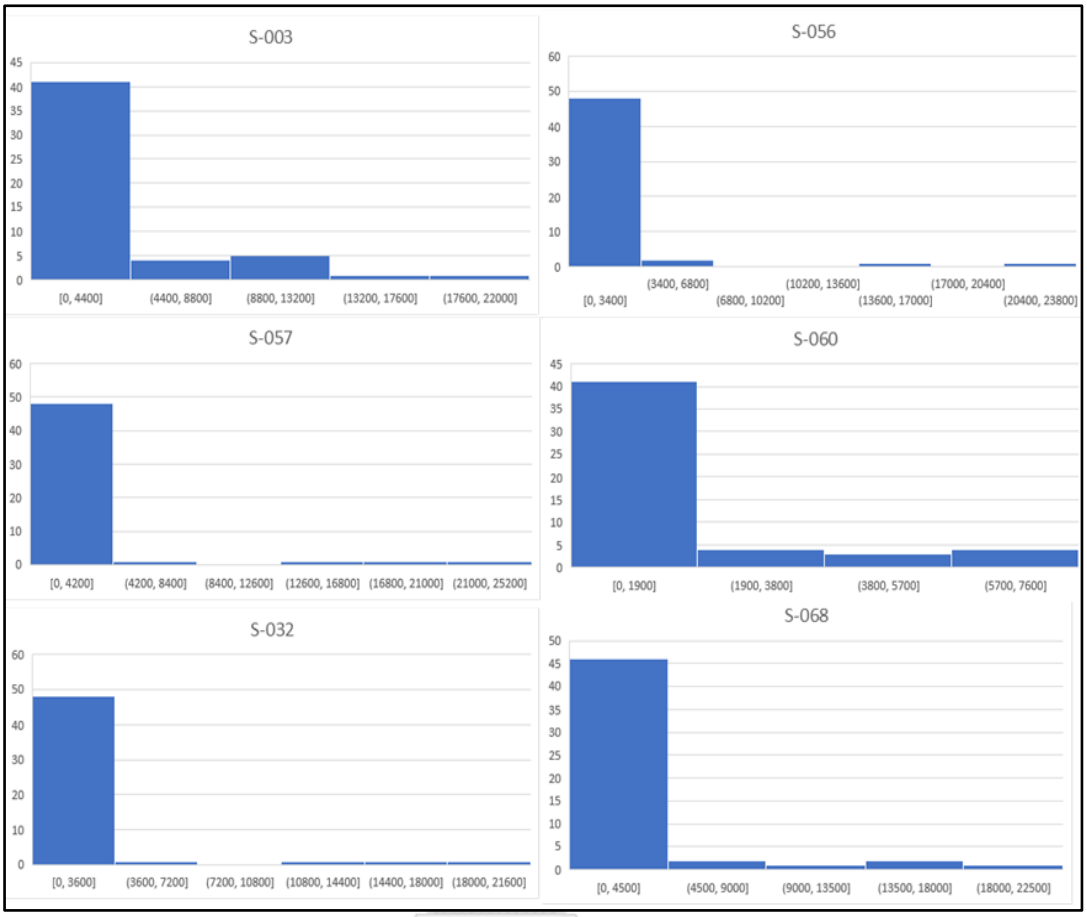


*Figure 6- 3: Histogram of demand of STI group*

Figure 6-3 represents the histogram of the Sticker Group. It can be clearly seen that Stickers items for all six items mostly the demand will come from lower ranges.

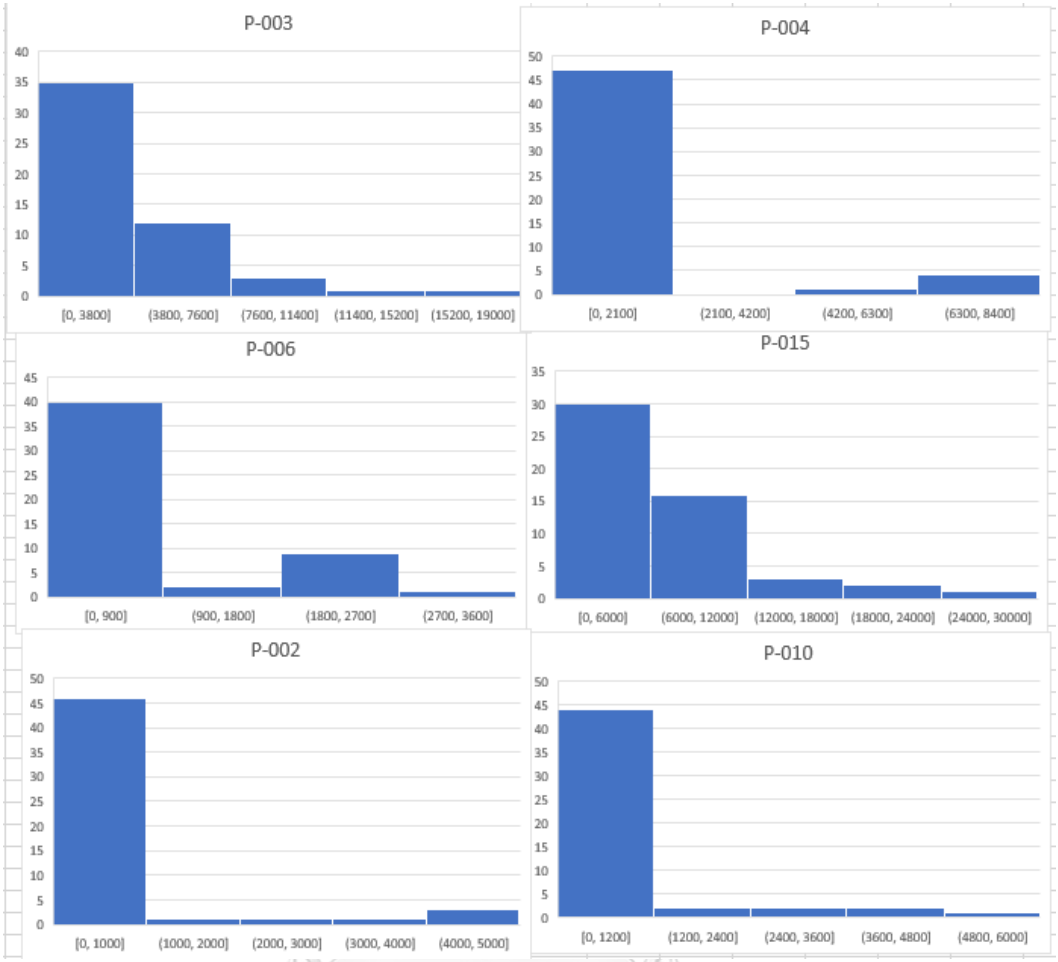


*Figure 6- 4: Histogram of demand of PAC group*

Figure 6-4 refers to the histogram of the Packaging group. Items P-003 and P-015 which are in A class, the demand ranges from thousand to almost twenty to thirty thousand, which makes it very difficult for the company to plan the inventory.

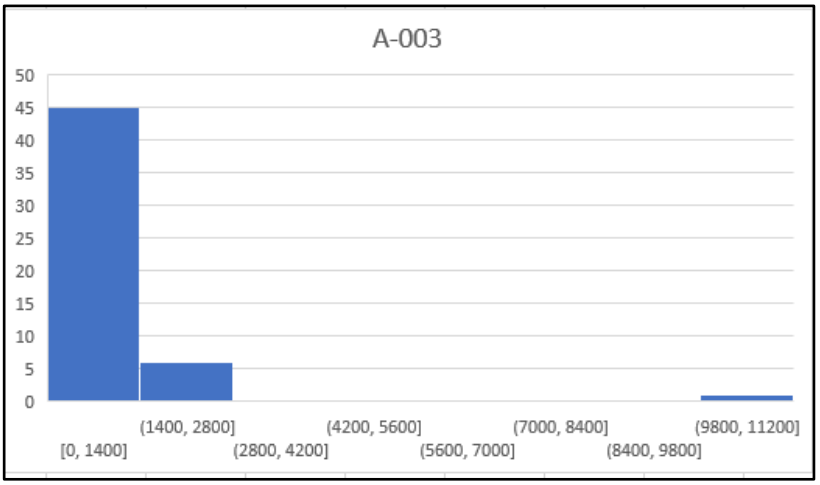


*Figure 6- 5: Histogram of demand of OTH group*

Figure 6-5 refers to the histogram of item A-003 which belongs to the OTH group. The majority of demand for item A-003 was from zero to two thousand eight hundred pieces, but during some weeks, the demand might suddenly rise to over ten thousand pieces. This implies a very unpredictable demand for the item.

Once all the 16 selected items' demand (input) are plotted, the next step would be to consider its distribution.

### 6.1.1 Demand Data Distribution

Arena Input Analyzer software was used to analyze the distribution of the demand for all 16 selected items. The example of the result of item B-002 from Arena Input Analyzer is shown in Figure 6-6.

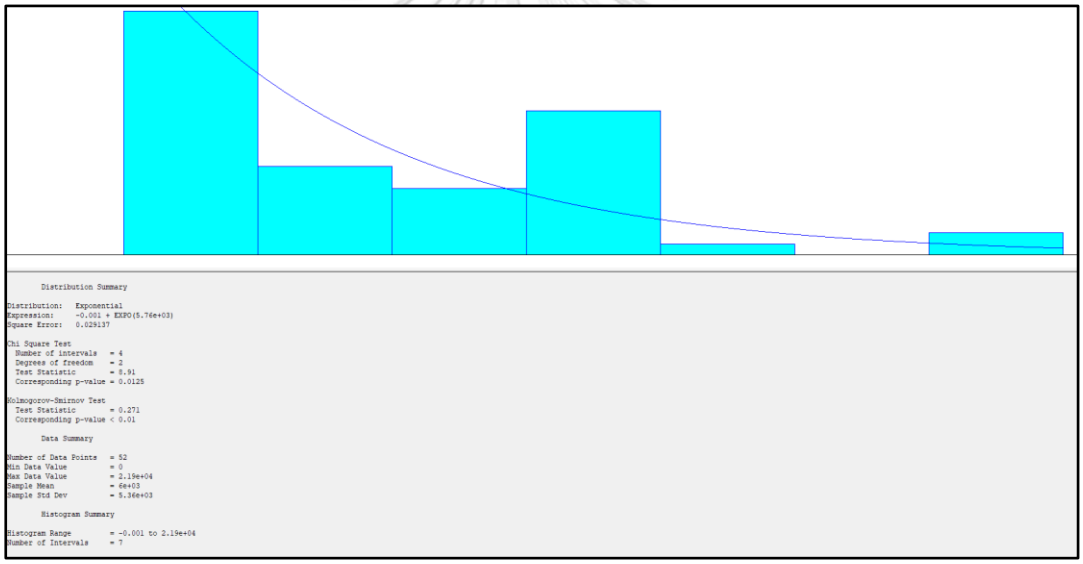


*Figure 6- 6: Example result of distribution for item B-002*

The results of all 16 selected data were simplify and shown in Table 6.1:

*Table 6- 1: Distribution of Data*

| No. | SKU | Distribution | Expression | P-value | Square Error | No. of data |
|---|---|---|---|---|---|---|
| 1 | A-003 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 2 | B-002 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 3 | B-009 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 4 | B-010 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 5 | P-002 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 6 | P-003 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 7 | P-004 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 8 | P-006 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 9 | P-010 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 10 | P-015 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 11 | S-003 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 12 | S-020 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 13 | S-032 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 14 | S-056 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 15 | S-057 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |
| 16 | S-068 | Exponential | -0.01+EXPO(5.76e + 03) | 0.0125 | 0.0291 | 52 |

From Table 6-1 of distribution of data at 90% confidence interval, the P-value of all 16 items is less than 0.1. Therefore, the displayed exponential distribution was rejected for all.

Therefore, this research will instead use an empirical distribution method to get the new simulated data set. Empirical distribution in this research will generate a random number of plus minus 20% of the actual demand value as a fluctuation in demand. This step is repeated for 30 replications to get its average data set. Table 6-1 shows the example of the actual demand and the simulated demand from each group.

*Table 6- 2: Example of the actual demand and simulated demand for each group*

| Item | P-015 | | B-002 | | S-003 | | A-003 | |
|---|---|---|---|---|---|---|---|---|
| WEEK | Actual Demand | Simulated Demand | Actual Demand | Simulated Demand | Actual Demand | Simulated Demand | Actual Demand | Simulated Demand |
| week1 | 4,775 | 4,716 | 13,225 | 13,092 | - | - | 1,200 | 1,228 |
| week2 | 3,260 | 3,236 | 3,260 | 3,353 | 6,000 | 6,311 | 1,200 | 1,155 |
| week3 | - | - | 9,040 | 8,973 | - | - | - | - |
| week4 | 14,000 | 13,654 | 560 | 528 | - | - | 500 | 521 |
| week5 | 9,040 | 9,149 | 10,950 | 10,881 | - | - | - | - |
| week6 | 560 | 541 | - | - | - | - | - | - |
| week7 | 2,900 | 2,875 | 2,900 | 2,768 | 9,040 | 9,118 | 900 | 973 |
| week8 | 10,000 | 10,241 | 10,950 | 11,311 | - | - | - | - |
| week9 | 10,360 | 10,776 | 10,360 | 10,971 | 14,280 | 14,640 | 1,200 | 1,204 |
| week10 | 5 | 6 | 5 | 5 | 10,360 | 10,694 | 930 | 982 |
| week11 | 10,000 | 10,062 | 10,950 | 11,018 | - | - | 1,560 | 1,601 |
| week12 | 4,600 | 4,558 | 4,000 | 3,715 | 8,140 | 8,150 | - | - |
| week13 | 8,140 | 8,497 | 8,140 | 8,326 | - | - | - | - |
| week14 | - | - | 260 | 252 | - | - | 900 | 861 |
| week15 | - | - | 2,140 | 2,019 | 21,537 | 22,174 | 300 | 304 |
| week16 | 10,320 | 10,530 | 10 | 9 | 2,140 | 2,057 | - | - |
| week17 | - | - | 7 | 7 | - | - | - | - |
| week18 | 19,697 | 19,368 | 10,950 | 10,656 | 4,300 | 4,230 | - | - |
| week19 | 10 | 10 | 4,300 | 4,408 | 10,540 | 10,764 | 30 | 31 |
| week20 | - | - | 10,950 | 10,549 | 20 | 19 | 1,500 | 1,598 |
| week21 | 27,057 | 26,894 | 10 | 10 | 3,000 | 2,983 | 600 | 617 |
| week22 | 23,140 | 23,509 | 7 | 7 | 9,780 | 9,805 | 30 | 31 |
| week23 | 1,100 | 1,038 | 10 | 10 | 1,100 | 1,124 | - | - |
| week24 | - | - | 10,950 | 10,847 | - | - | - | - |
| week25 | 16,000 | 16,136 | 10,540 | 10,049 | 1,100 | 1,141 | 600 | 595 |
| week26 | 8,320 | 8,234 | 10,950 | 10,853 | - | - | 30 | 30 |
| week27 | - | - | 3,000 | 3,071 | - | - | - | - |
| week28 | 3,000 | 2,975 | 9,780 | 9,701 | - | - | - | - |
| week29 | - | - | - | - | - | - | 1,500 | 1,510 |
| week30 | 600 | 575 | 3,060 | 3,074 | 7,220 | 7,486 | 60 | 59 |
| week31 | 630 | 619 | 1,100 | 1,113 | - | - | - | - |
| week32 | - | - | 2,555 | 2,624 | - | - | 600 | 625 |
| week33 | 12,000 | 12,006 | 21,900 | 21,137 | - | - | 90 | 90 |
| week34 | 7,470 | 7,766 | 1,100 | 1,052 | - | - | 13 | 13 |
| week35 | 4,000 | 4,155 | 7,220 | 7,741 | - | - | - | - |
| week36 | 14,200 | 14,434 | 3,000 | 2,811 | - | - | 1,200 | 1,151 |
| week37 | 11,290 | 11,280 | 5,880 | 5,940 | 12,000 | 12,189 | 2,370 | 2,401 |
| week38 | - | - | 21,900 | 21,931 | - | - | - | - |
| week39 | 5,940 | 5,989 | 12,000 | 12,539 | - | - | 60 | 62 |
| week40 | 1,000 | 974 | 1,600 | 1,569 | - | - | - | - |
| week41 | 8,040 | 7,756 | 5,940 | 5,860 | - | - | 900 | 897 |
| week42 | 8,000 | 7,886 | - | - | 8,040 | 7,663 | 40 | 39 |
| week43 | 60 | 59 | 10,950 | 11,277 | - | - | - | - |
| week44 | 6,210 | 5,991 | 8,040 | 7,945 | - | - | - | - |
| week45 | - | - | 6,210 | 6,104 | - | - | - | - |
| week46 | 8,000 | 7,993 | 10,950 | 10,833 | - | - | 100 | 102 |
| week47 | 100 | 100 | 760 | 770 | - | - | 10,560 | 10,234 |
| week48 | 760 | 786 | 5,700 | 5,542 | - | - | - | - |
| week49 | 5,700 | 5,704 | 9,020 | 9,321 | - | - | 2,100 | 2,032 |
| week50 | 2,100 | 2,182 | 4,830 | 4,980 | - | - | 240 | 248 |
| week51 | 8,000 | 8,074 | 7,200 | 7,012 | - | - | 1,500 | 1,472 |
| week52 | 9,020 | 8,956 | 2,960 | 3,039 | - | - | 900 | 921 |

The 16 generated demand data set is then further analyzed and compared with its original demand data using a box and whiskers plot as shown in Figure 6-6 - Figure 6-9:

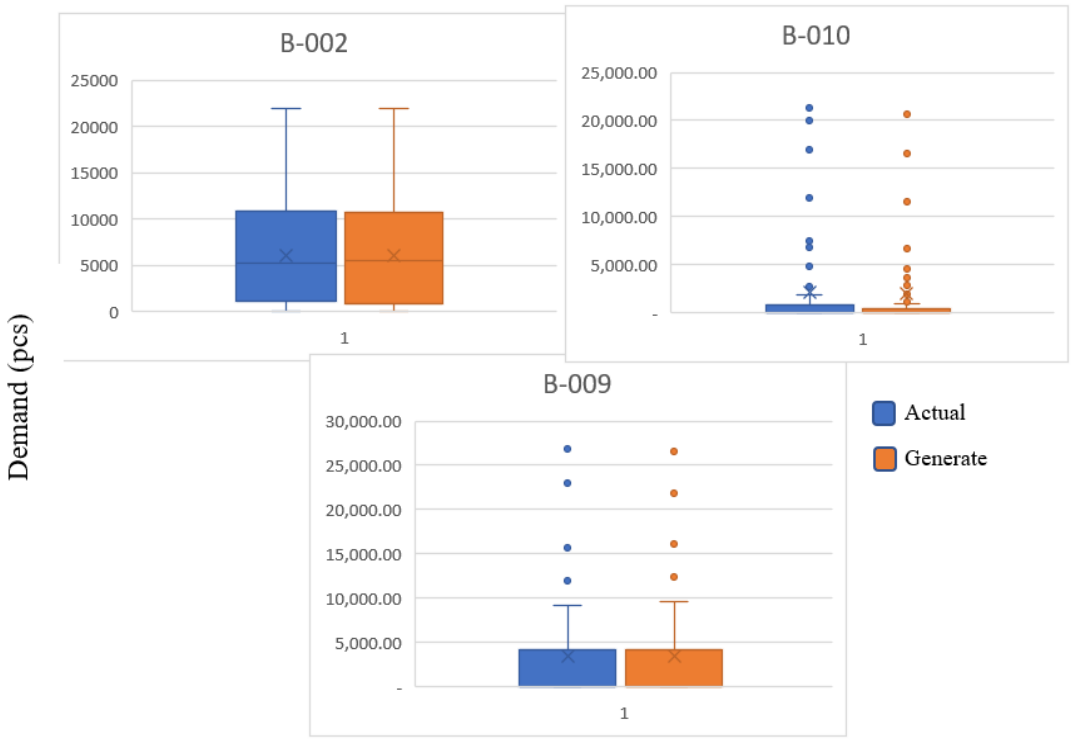


*Figure 6- 7: Box-and-Whisker plot of actual and generated data of BAG group*

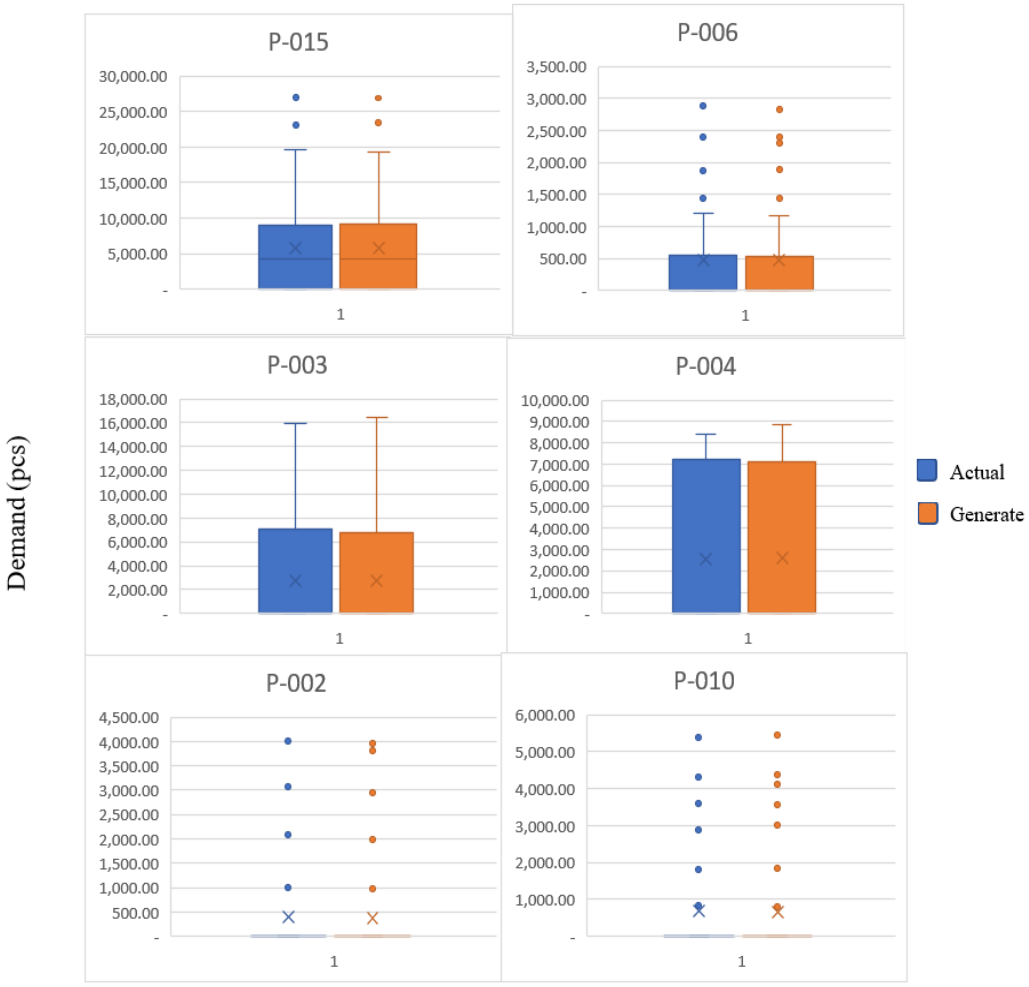


*Figure 6- 8: Box-and-Whisker plot of actual and generated data for PAC group*

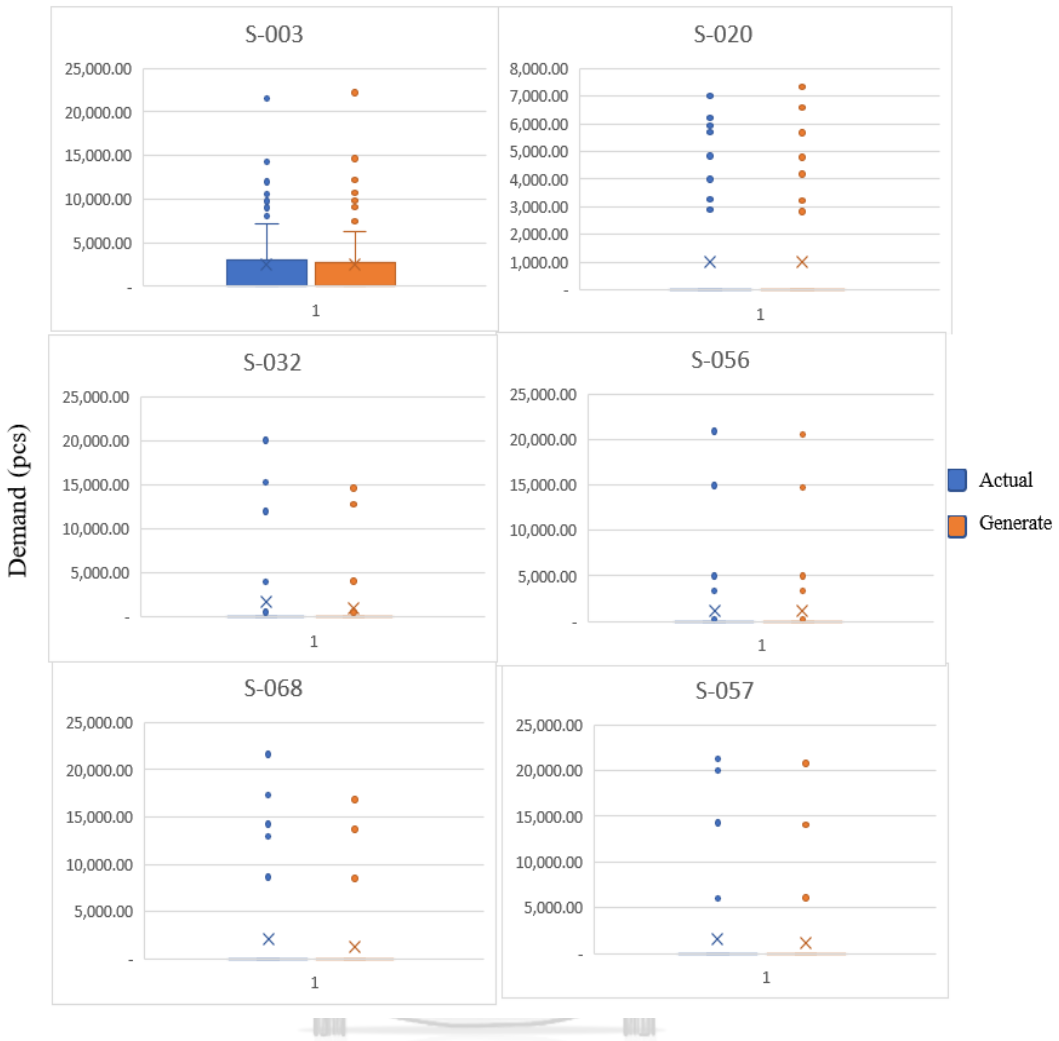


*Figure 6- 9: Box-and-Whisker plot of actual and generated data for STI group*

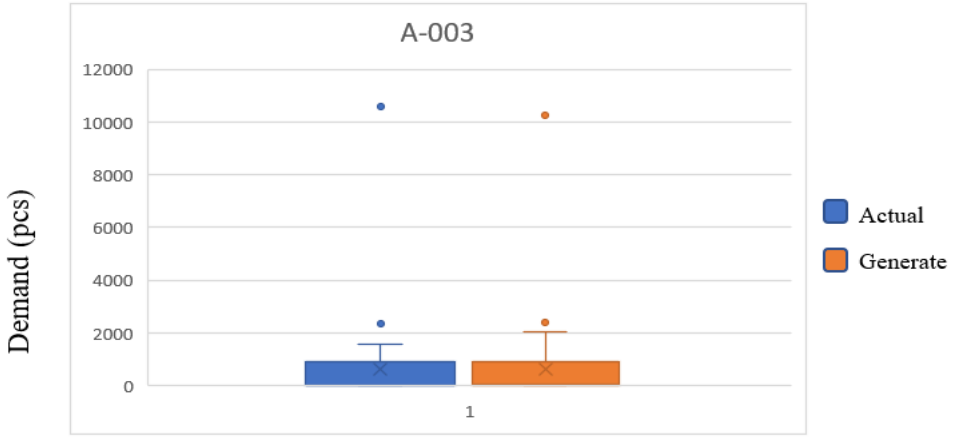


*Figure 6- 10: Box-and-Whisker plot of actual and generated data of OTH group*

From Figure 6-7 to 6-10, the distribution of actual and generated data are aligned with one another. This simulated data set can be further tested with hypothesis testing.

### 6.1.2 Hypothesis Testing

This research then uses the generated data to perform a chi-square test to test if these 2 data sets have significant differences or not by setting hypothesis as follow:

$H_0$ : There is no significant difference between expected and observed value

Ha : There is significant difference between expected and observed value

The result of the chi-square test is shown in Table 6-3.

*Table 6- 3: Chi square test of actual and generated data*

| SKU | P-VALUE | Chi Square Test |
|---|---|---|
| A-003 | 0.00 | Reject Null Hypothesis |
| B-002 | 0.00 | Reject Null Hypothesis |
| B-009 | 0.00 | Reject Null Hypothesis |
| B-010 | 0.00 | Reject Null Hypothesis |
| P-002 | 0.00 | Reject Null Hypothesis |
| P-003 | 0.00 | Reject Null Hypothesis |
| P-004 | 0.00 | Reject Null Hypothesis |
| P-006 | 0.00 | Reject Null Hypothesis |
| P-010 | 0.00 | Reject Null Hypothesis |
| P-015 | 0.00 | Reject Null Hypothesis |
| S-003 | 0.00 | Reject Null Hypothesis |
| S-020 | 0.00 | Reject Null Hypothesis |
| S-032 | 0.00 | Reject Null Hypothesis |
| S-056 | 0.00 | Reject Null Hypothesis |
| S-057 | 0.00 | Reject Null Hypothesis |
| S-068 | 0.00 | Reject Null Hypothesis |

Table 6-3 showed all P-values of Zeros. This means that we must reject the null hypothesis, thus we can use the generated data as a simulated demand for those 16 SKUs.

## 6.2 PROCESS ANALYSIS

Process analysis is performed after obtaining simulated data from the input analysis. The purpose of this process analysis is to prove that the process in simulation matches with the current process in the company.

The simulation of lead time in this research is calculated based on week-based lead time due to the nature of the researched company business. Once the order arrives, the purchase will take 1-2 days to manage with the order. If there is any inventory needed to purchase, the purchase order will be sent to management level for approval, which will take another 1-2 days. And after the signed purchase order is issued to the respective supplier, the ordering lead time will range from 7 - 45 days. Even if there is some delay in the purchasing process, the lead time will still fall within the time frame. Therefore, this research paper will focus on using week-based simulation as the same as the real process within the company.

## 6.3 OUTPUT ANALYSIS

This section of output analysis will analyze the simulated data's inventory and compare it with the actual data inventory in order to verify its output. All the related costs, such as material cost, stock out cost, ordering cost as well as holding cost, are also being analyzed.



### 6.3.1 Inventory Distribution

First of all, the average inventory of the actual demand is calculated. Table 6-4 shows the example of inventory calculation of item P-015.

*Table 6- 4: Inventory of item P-015*

| SKU | WEEK | Actual Demand | Inventory | Purchase in | Order in | Material Cost | Holding Cost | Stockout Cost | Ordering Cost |
|---|---|---|---|---|---|---|---|---|---|
| P-015 | week1 | 4,775 | 45,225 | 75,540 | | 74,029 | 8,864 | 0 | 1700 |
| P-015 | week2 | 3,260 | 41,965 | | | - | 8,225 | 0 | 0 |
| P-015 | week3 | - | 117,505 | - | 75,540 | - | 23,031 | 0 | 0 |
| P-015 | week4 | 14,000 | 103,505 | 75,540 | - | 74,029 | 20,287 | 0 | 1700 |
| P-015 | week5 | 9,040 | 94,465 | | - | - | 18,515 | 0 | 0 |
| P-015 | week6 | 560 | 169,445 | - | 75,540 | - | 33,211 | 0 | 0 |
| P-015 | week7 | 2,900 | 166,545 | - | - | - | 32,643 | 0 | 0 |
| P-015 | week8 | 10,000 | 156,545 | - | - | - | 30,683 | 0 | 0 |
| P-015 | week9 | 10,360 | 146,185 | - | - | - | 28,652 | 0 | 0 |
| P-015 | week10 | 5 | 146,180 | - | - | - | 28,651 | 0 | 0 |
| P-015 | week11 | 10,000 | 136,180 | - | - | - | 26,691 | 0 | 0 |
| P-015 | week12 | 4,600 | 131,580 | - | - | - | 25,790 | 0 | 0 |
| P-015 | week13 | 8,140 | 123,440 | - | - | - | 24,194 | 0 | 0 |
| P-015 | week14 | - | 123,440 | - | - | - | 24,194 | 0 | 0 |
| P-015 | week15 | - | 123,440 | - | - | - | 24,194 | 0 | 0 |
| P-015 | week16 | 10,320 | 113,120 | 75,540 | - | 74,029 | 22,172 | 0 | 1700 |
| P-015 | week17 | - | 113,120 | | - | - | 22,172 | 0 | 0 |
| P-015 | week18 | 19,697 | 168,963 | - | 75,540 | - | 33,117 | 0 | 0 |
| P-015 | week19 | 10 | 168,953 | - | - | - | 33,115 | 0 | 0 |
| P-015 | week20 | - | 168,953 | - | - | - | 33,115 | 0 | 0 |
| P-015 | week21 | 27,057 | 141,896 | - | - | - | 27,812 | 0 | 0 |
| P-015 | week22 | 23,140 | 118,756 | - | - | - | 23,276 | 0 | 0 |
| P-015 | week23 | 1,100 | 117,656 | - | - | - | 23,061 | 0 | 0 |
| P-015 | week24 | - | 117,656 | - | - | - | 23,061 | 0 | 0 |
| P-015 | week25 | 16,000 | 101,656 | 75,540 | - | 74,029 | 19,925 | 0 | 1700 |
| P-015 | week26 | 8,320 | 93,336 | | - | - | 18,294 | 0 | 0 |
| P-015 | week27 | - | 168,876 | - | 75,540 | - | 33,100 | 0 | 0 |
| P-015 | week28 | 3,000 | 165,876 | - | - | - | 32,512 | 0 | 0 |
| P-015 | week29 | - | 165,876 | - | - | - | 32,512 | 0 | 0 |
| P-015 | week30 | 600 | 165,276 | - | - | - | 32,394 | 0 | 0 |
| P-015 | week31 | 630 | 164,646 | - | - | - | 32,271 | 0 | 0 |
| P-015 | week32 | - | 164,646 | - | - | - | 32,271 | 0 | 0 |
| P-015 | week33 | 12,000 | 152,646 | - | - | - | 29,919 | 0 | 0 |
| P-015 | week34 | 7,470 | 145,176 | - | - | - | 28,454 | 0 | 0 |
| P-015 | week35 | 4,000 | 141,176 | - | - | - | 27,670 | 0 | 0 |
| P-015 | week36 | 14,200 | 126,976 | - | - | - | 24,887 | 0 | 0 |
| P-015 | week37 | 11,290 | 115,686 | - | - | - | 22,674 | 0 | 0 |
| P-015 | week38 | - | 115,686 | - | - | - | 22,674 | 0 | 0 |
| P-015 | week39 | 5,940 | 109,746 | 75,540 | - | 74,029 | 21,510 | 0 | 1700 |
| P-015 | week40 | 1,000 | 108,746 | | - | - | 21,314 | 0 | 0 |
| P-015 | week41 | 8,040 | 176,246 | - | 75,540 | - | 34,544 | 0 | 0 |
| P-015 | week42 | 8,000 | 168,246 | - | - | - | 32,976 | 0 | 0 |
| P-015 | week43 | 60 | 168,186 | - | - | - | 32,964 | 0 | 0 |
| P-015 | week44 | 6,210 | 161,976 | - | - | - | 31,747 | 0 | 0 |
| P-015 | week45 | - | 161,976 | - | - | - | 31,747 | 0 | 0 |
| P-015 | week46 | 8,000 | 153,976 | - | - | - | 30,179 | 0 | 0 |
| P-015 | week47 | 100 | 153,876 | - | - | - | 30,160 | 0 | 0 |
| P-015 | week48 | 760 | 153,116 | - | - | - | 30,011 | 0 | 0 |
| P-015 | week49 | 5,700 | 147,416 | - | - | - | 28,894 | 0 | 0 |
| P-015 | week50 | 2,100 | 145,316 | - | - | - | 28,482 | 0 | 0 |
| P-015 | week51 | 8,000 | 137,316 | - | - | - | 26,914 | 0 | 0 |
| P-015 | week52 | 9,020 | 128,296 | - | - | - | 25,146.02 | 0 | 0 |

The EOQ calculation and data from Table 5-1 and reorder point from Table 5.2 were used in actual inventory calculation. The necessary data used for calculation for item P-015 are as follow:

- Material cost = 0.98 per piece
- Holding cost = 0.196 per piece (20% of material cost)

- Ordering cost = 1,700 (purchase internationally without much customization)
- Stockout cost = 10,000 (item P-015 were use to make 1 finished good)
- EOQ = 75,740 pieces
- Reorder point = 115,000 pieces
- Ordering lead time = 14 days (2 weeks)

Table 6-5 will depict another inventory example from BOX group, which is item B-010. The necessary data used for calculation of item B-010 are as follows:

- Material cost = 2.85 per piece
- Holding cost = 0.57 per piece (20% of material cost)
- Ordering cost = 3,800 (purchase internationally with customization)
- Stockout cost = 10,000 (item B-010 were use to make 1 finished good)
- EOQ = 19,180 pieces
- Reorder point = 47,500 pieces
- Ordering lead time = 45 days (7 weeks)

*Table 6- 5: Inventory of item B-010*

| SKU | SKU | WEEK | Actual Demand | Inventory | Purchase in | Order in | Material Cost | Holding Cost | Stockout Cost | Ordering Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| B-010 | B-010 | week1 | 7,474 | 12,526 | 19,180 | - | 54,663 | 7,140 | - | 3,800 |
| B-010 | B-010 | week2 | 1,200 | 11,326 | - | - | - | 6,456 | - | - |
| B-010 | B-010 | week3 | - | 11,326 | - | - | - | 6,456 | - | - |
| B-010 | B-010 | week4 | 20 | 11,306 | - | - | - | 6,444 | - | - |
| B-010 | B-010 | week5 | 24 | 11,282 | - | - | - | 6,431 | - | - |
| B-010 | B-010 | week6 | 48 | 11,234 | - | - | - | 6,403 | - | - |
| B-010 | B-010 | week7 | 6,792 | 4,442 | - | - | - | 2,532 | - | - |
| B-010 | B-010 | week8 | 16,968 | 6,654 | 19,180 | 19,180 | 54,663 | 3,793 | - | 3,800 |
| B-010 | B-010 | week9 | - | 6,654 | - | - | - | 3,793 | - | - |
| B-010 | B-010 | week10 | - | 6,654 | - | - | - | 3,793 | - | - |
| B-010 | B-010 | week11 | 11,952 | - 5,298 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week12 | 3,394 | - 8,692 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week13 | 4,800 | - 13,492 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week14 | 1,008 | - 14,500 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week15 | 21,277 | - 16,597 | 19,180 | 19,180 | 54,663 | - | 10,000 | 3,800 |
| B-010 | B-010 | week16 | 2,760 | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week17 | - | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week18 | - | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week19 | - | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week20 | - | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week21 | - | - 19,357 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week22 | 1,920 | - 2,097 | 19,180 | 19,180 | 54,663 | - | 10,000 | 3,800 |
| B-010 | B-010 | week23 | - | - 2,097 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week24 | 240 | - 2,337 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week25 | - | - 2,337 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week26 | - | - 2,337 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week27 | - | - 2,337 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week28 | - | - 2,337 | - | - | - | - | 10,000 | - |
| B-010 | B-010 | week29 | - | 16,843 | 19,180 | 19,180 | 54,663 | 9,601 | - | 3,800 |
| B-010 | B-010 | week30 | - | 16,843 | - | - | - | 9,601 | - | - |
| B-010 | B-010 | week31 | - | 16,843 | - | - | - | 9,601 | - | - |
| B-010 | B-010 | week32 | 96 | 16,747 | - | - | - | 9,546 | - | - |
| B-010 | B-010 | week33 | - | 16,747 | - | - | - | 9,546 | - | - |
| B-010 | B-010 | week34 | - | 16,747 | - | - | - | 9,546 | - | - |
| B-010 | B-010 | week35 | - | 16,747 | - | - | - | 9,546 | - | - |
| B-010 | B-010 | week36 | - | 35,927 | 19,180 | 19,180 | 54,663 | 20,478 | - | 3,800 |
| B-010 | B-010 | week37 | - | 35,927 | - | - | - | 20,478 | - | - |
| B-010 | B-010 | week38 | - | 35,927 | - | - | - | 20,478 | - | - |
| B-010 | B-010 | week39 | - | 35,927 | - | - | - | 20,478 | - | - |
| B-010 | B-010 | week40 | - | 35,927 | - | - | - | 20,478 | - | - |
| B-010 | B-010 | week41 | - | 35,927 | - | - | - | 20,478 | - | - |
| B-010 | B-010 | week42 | 144 | 35,783 | - | - | - | 20,396 | - | - |
| B-010 | B-010 | week43 | 20,000 | 34,963 | 19,180 | 19,180 | 54,663 | 19,929 | - | 3,800 |
| B-010 | B-010 | week44 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week45 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week46 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week47 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week48 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week49 | - | 34,963 | - | - | - | 19,929 | - | - |
| B-010 | B-010 | week50 | - | 54,143 | - | 19,180 | - | 30,862 | - | - |
| B-010 | B-010 | week51 | - | 54,143 | - | - | - | 30,862 | - | - |
| B-010 | B-010 | week52 | - | 54,143 | - | - | - | 30,862 | - | - |

From Table 6-4 and Table 6-5, the average inventory of actual demand before improvement of item P-015 would be 136,860 pieces, and 13,055 pieces for item B-

010. This average inventory will be used as a baseline of the accepted range of plus minus 10%. The accepted range of all 16 items are calculated and shown in Table 6-6.

*Table 6- 6: Inventory of accepted range of 16 SKUs*

| SKU | Average Inventory actual demand | Accepted range minus 10% | Accepted range plus 10% |
|---|---|---|---|
| A-003 | 122,938 | 110,644 | 135,232 |
| B-002 | 122,650 | 110,385 | 134,915 |
| B-009 | 143,028 | 128,725 | 157,331 |
| B-010 | 13,055 | 11,750 | 14,361 |
| P-002 | 18,196 | 16,376 | 20,016 |
| P-003 | 103,950 | 93,555 | 114,345 |
| P-004 | 26,526 | 23,873 | 29,179 |
| P-006 | 15,996 | 14,396 | 17,596 |
| P-010 | 20,274 | 18,247 | 22,301 |
| P-015 | 136,860 | 123,174 | 150,546 |
| S-003 | 57,736 | 51,962 | 63,510 |
| S-020 | 33,516 | 30,164 | 36,868 |
| S-032 | 39,800 | 35,820 | 43,780 |
| S-056 | 34,278 | 30,850 | 37,706 |
| S-057 | 54,304 | 48,874 | 59,734 |
| S-068 | 69,395 | 62,456 | 76,335 |

Table 6-6 shows the accepted range of inventory for each SKUs for 30 replications. For instance, item P-015 accepted inventory range is between 123,174 and 150,546. Therefore, the output analysis will not be practicable if any simulated inventory (30 replications) calculated and are not within the accepted range.

The average inventory of 30 simulated demands is further calculated and shown in Table 6-7.

*Table 6- 7: Average inventory of 30 replications of 16 SKUs*

| | AVERAGE INVENTORY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items /replications | A-003 | B-002 | B-009 | B-010 | P-002 | P-003 | P-004 | P-006 | P-010 | P-015 | S-003 | S-020 | S-032 | S-056 | S-057 | S-068 |
| 1 | 134,831 | 111,491 | 134,776 | 12,884 | 19,730 | 99,478 | 24,517 | 15,966 | 20,707 | 139,376 | 58,528 | 36,668 | 40,053 | 33,927 | 50,286 | 63,468 |
| 2 | 111,262 | 125,380 | 138,616 | 12,387 | 17,170 | 106,702 | 26,288 | 17,206 | 19,130 | 133,446 | 57,412 | 36,384 | 39,889 | 31,308 | 52,105 | 66,708 |
| 3 | 132,150 | 122,706 | 140,753 | 13,461 | 17,652 | 112,186 | 28,290 | 17,232 | 21,968 | 134,883 | 52,982 | 34,971 | 42,058 | 35,266 | 53,462 | 70,562 |
| 4 | 112,327 | 118,548 | 131,052 | 12,994 | 17,876 | 102,882 | 26,522 | 17,083 | 19,461 | 134,232 | 62,798 | 30,647 | 38,665 | 32,778 | 52,621 | 70,572 |
| 5 | 125,869 | 131,340 | 130,543 | 12,563 | 19,586 | 114,109 | 24,429 | 15,999 | 19,127 | 150,266 | 63,443 | 33,373 | 40,370 | 36,169 | 55,787 | 66,963 |
| 6 | 121,442 | 122,108 | 152,088 | 13,472 | 16,741 | 104,182 | 25,261 | 15,811 | 18,302 | 141,813 | 53,536 | 35,109 | 39,410 | 31,005 | 56,203 | 67,766 |
| 7 | 111,382 | 112,604 | 145,205 | 13,126 | 18,033 | 109,314 | 25,393 | 14,531 | 20,452 | 123,237 | 52,867 | 36,172 | 36,175 | 36,057 | 52,144 | 76,325 |
| 8 | 127,264 | 132,082 | 146,207 | 14,334 | 17,092 | 113,674 | 25,162 | 16,052 | 19,272 | 132,478 | 57,415 | 36,399 | 43,567 | 36,104 | 58,547 | 69,274 |
| 9 | 113,136 | 116,590 | 152,952 | 12,028 | 17,571 | 104,447 | 28,372 | 14,946 | 21,504 | 142,668 | 62,370 | 35,073 | 38,245 | 33,282 | 56,537 | 65,454 |
| 10 | 120,962 | 125,620 | 140,311 | 14,332 | 17,569 | 99,579 | 26,346 | 17,087 | 20,321 | 139,856 | 57,038 | 33,912 | 38,294 | 35,488 | 52,054 | 67,443 |
| 11 | 114,896 | 118,103 | 130,520 | 13,962 | 16,797 | 104,626 | 25,939 | 16,790 | 21,911 | 131,665 | 57,521 | 35,926 | 40,883 | 37,534 | 51,043 | 65,269 |
| 12 | 111,135 | 118,347 | 134,071 | 12,871 | 19,856 | 114,033 | 24,801 | 16,273 | 18,532 | 146,357 | 55,155 | 32,435 | 42,545 | 34,906 | 58,213 | 67,508 |
| 13 | 113,425 | 134,461 | 152,801 | 13,254 | 16,798 | 98,674 | 23,913 | 16,270 | 19,802 | 149,359 | 57,910 | 31,350 | 42,943 | 30,969 | 56,954 | 76,152 |
| 14 | 129,391 | 132,760 | 135,407 | 14,031 | 17,075 | 113,725 | 28,914 | 16,372 | 21,744 | 142,071 | 57,769 | 31,242 | 38,378 | 31,122 | 55,227 | 63,440 |
| 15 | 121,541 | 132,438 | 131,204 | 12,634 | 18,382 | 104,779 | 26,451 | 16,446 | 19,745 | 150,077 | 57,155 | 30,891 | 42,073 | 32,429 | 58,679 | 75,436 |
| 16 | 122,830 | 128,023 | 140,888 | 13,017 | 17,484 | 108,744 | 25,255 | 14,527 | 18,605 | 128,923 | 59,206 | 32,020 | 36,418 | 36,115 | 57,525 | 73,229 |
| 17 | 129,836 | 117,824 | 129,889 | 12,921 | 16,660 | 109,930 | 24,195 | 16,970 | 21,232 | 136,430 | 53,939 | 30,481 | 35,894 | 34,471 | 50,160 | 71,159 |
| 18 | 135,224 | 128,115 | 135,604 | 13,624 | 17,967 | 105,580 | 29,164 | 16,203 | 19,827 | 150,125 | 58,806 | 36,427 | 36,037 | 32,061 | 53,364 | 64,063 |
| 19 | 119,920 | 131,347 | 156,702 | 13,716 | 19,650 | 113,554 | 28,038 | 17,046 | 20,558 | 145,684 | 52,363 | 32,498 | 41,073 | 30,897 | 53,724 | 72,833 |
| 20 | 127,299 | 120,828 | 136,986 | 13,685 | 18,605 | 114,223 | 26,724 | 14,567 | 22,266 | 150,316 | 59,547 | 31,167 | 39,109 | 37,058 | 57,104 | 70,172 |
| 21 | 114,596 | 128,185 | 155,802 | 12,098 | 18,572 | 103,987 | 24,209 | 17,524 | 20,640 | 145,011 | 62,268 | 35,290 | 37,583 | 34,246 | 49,229 | 74,610 |
| 22 | 123,271 | 124,186 | 147,839 | 12,886 | 19,939 | 104,328 | 25,560 | 16,242 | 18,315 | 129,230 | 54,207 | 32,536 | 42,338 | 36,458 | 55,558 | 70,885 |
| 23 | 123,653 | 119,354 | 133,709 | 12,518 | 16,902 | 96,981 | 28,995 | 15,824 | 20,557 | 136,329 | 61,462 | 34,713 | 38,356 | 31,488 | 49,338 | 73,177 |
| 24 | 119,354 | 119,216 | 138,276 | 13,776 | 18,208 | 95,565 | 25,396 | 16,701 | 22,042 | 124,330 | 60,750 | 30,504 | 40,445 | 36,394 | 58,175 | 73,443 |
| 25 | 119,459 | 119,081 | 129,363 | 13,633 | 19,313 | 101,646 | 25,099 | 17,448 | 20,472 | 133,902 | 60,523 | 36,066 | 37,476 | 35,587 | 56,347 | 76,178 |
| 26 | 126,928 | 117,656 | 140,267 | 12,759 | 18,914 | 95,264 | 26,377 | 14,966 | 19,819 | 138,851 | 62,487 | 33,943 | 43,560 | 32,326 | 50,949 | 74,819 |
| 27 | 125,475 | 123,439 | 146,953 | 13,774 | 18,249 | 104,832 | 28,781 | 15,746 | 19,427 | 137,675 | 62,028 | 30,896 | 41,780 | 37,517 | 52,004 | 76,066 |
| 28 | 122,347 | 126,332 | 134,174 | 13,203 | 18,507 | 95,518 | 24,913 | 15,205 | 20,617 | 129,847 | 58,834 | 34,340 | 37,373 | 34,013 | 49,536 | 72,357 |
| 29 | 134,726 | 124,861 | 137,553 | 13,216 | 19,878 | 102,632 | 29,077 | 17,391 | 20,678 | 138,799 | 58,985 | 32,562 | 39,205 | 36,218 | 59,624 | 71,774 |
| 30 | 134,337 | 115,612 | 130,367 | 13,587 | 16,512 | 96,454 | 24,434 | 16,033 | 18,429 | 145,793 | 62,973 | 32,122 | 40,408 | 34,547 | 59,734 | 68,432 |

Table 6-7 shows the average inventory of 30 replications of simulated demand. Box and whisker plots are also being plotted to easily visualize the average inventory as shown in Figure 6-11 to 6-14. The green line represents the accepted range.

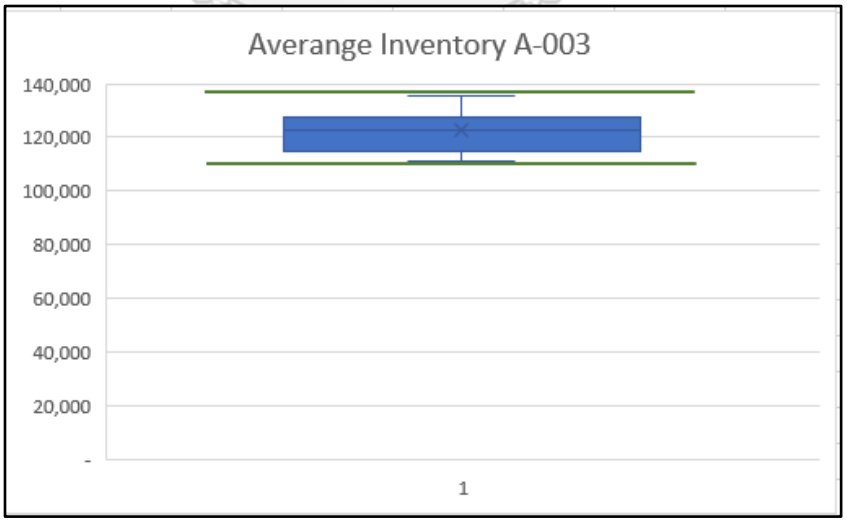


*Figure 6- 11: Box-and-Whisker plot of average inventory for OTH group*

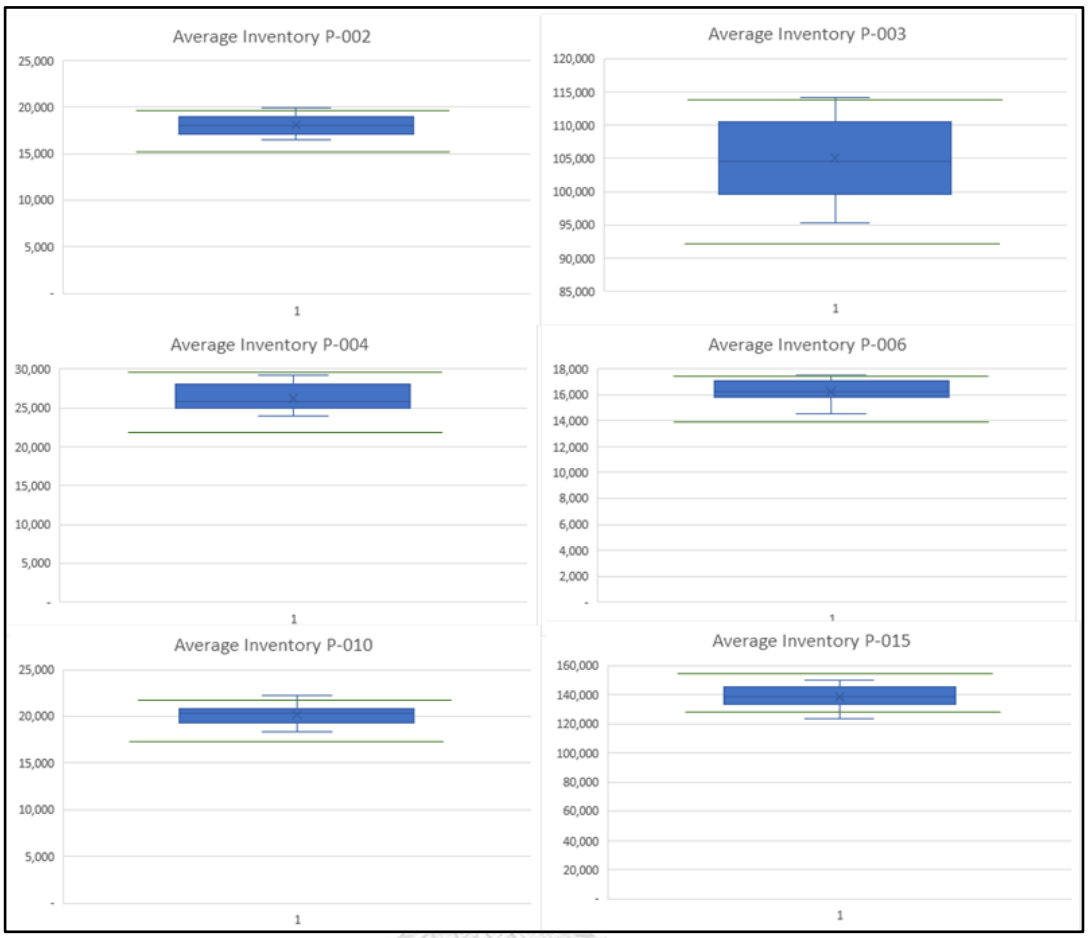


*Figure 6- 12: Box-and-Whisker plot of average inventory for PAC group*

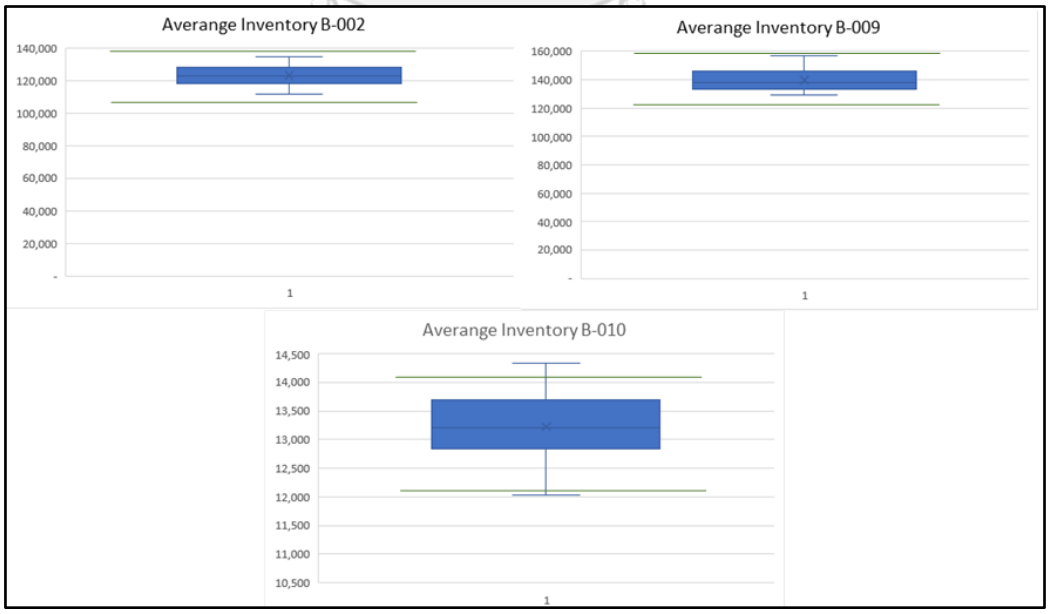


*Figure 6- 13: Box-and-Whisker plot of average inventory for BAG group*

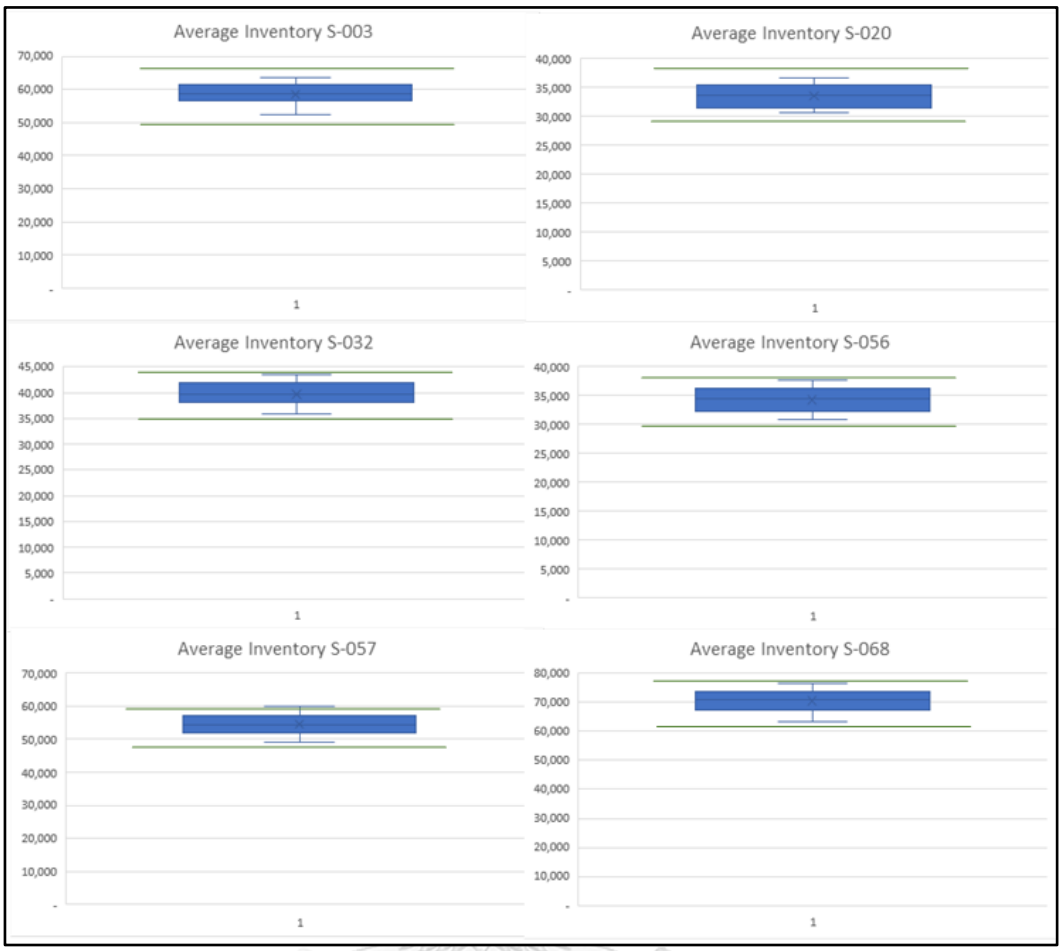


*Figure 6- 14: Box-and-Whisker plot of average inventory for STI group*

As shown in Figures 6-11 to 6-14, the 30 simulated average inventory lies within the accepted range; therefore, the empirical distribution method is applicable in this study and the output inventory is being verified.

The next step would be the calculation of the new suggested policy using average simulated demand. Table 6-8 shows an example of item P-015. Item P-015 were in A class, the revised ROP would be 62,500 with the new lead time of 7 days (1 week) (as calculated in Table 5-2). The material cost is 10% increase due to the fact that sourcing in Thailand is more expensive. The ordering cost is lowered. The new EOQ is also being calculated. The new EOQ for recommended policy would be 30,970 pieces.

*Table 6- 8: Simulated inventory of item P-015 (new policy)*

| WEEK | SKU | Ave. simulated demand | Inventory | QTY to order | order in | Material Cost | Holding Cost | Stockout Cost | Ordering Cost |
|---|---|---|---|---|---|---|---|---|---|
| week1 | P-015 | 4,716 | 45,284 | 30,970 | | 31,868 | 9,319 | - | 300 |
| week2 | P-015 | 3,236 | 73,018 | - | 30,970 | - | 15,027 | - | - |
| week3 | P-015 | - | 73,018 | - | - | - | 15,027 | - | - |
| week4 | P-015 | 13,654 | 59,364 | 30,970 | - | 31,868 | 12,217 | - | 300 |
| week5 | P-015 | 9,149 | 81,185 | - | 30,970 | - | 16,708 | - | - |
| week6 | P-015 | 541 | 80,645 | - | - | - | 16,597 | - | - |
| week7 | P-015 | 2,875 | 77,770 | - | - | - | 16,005 | - | - |
| week8 | P-015 | 10,241 | 67,529 | - | - | - | 13,897 | - | - |
| week9 | P-015 | 10,776 | 56,753 | 30,970 | - | 31,868 | 11,680 | - | 300 |
| week10 | P-015 | 6 | 87,717 | - | 30,970 | - | 18,052 | - | - |
| week11 | P-015 | 10,062 | 77,655 | - | - | - | 15,981 | - | - |
| week12 | P-015 | 4,558 | 73,096 | - | - | - | 15,043 | - | - |
| week13 | P-015 | 8,497 | 64,599 | - | - | - | 13,294 | - | - |
| week14 | P-015 | - | 64,599 | - | - | - | 13,294 | - | - |
| week15 | P-015 | - | 64,599 | - | - | - | 13,294 | - | - |
| week16 | P-015 | 10,530 | 54,070 | 30,970 | - | 31,868 | 11,128 | - | 300 |
| week17 | P-015 | - | 85,040 | - | 30,970 | - | 17,501 | - | - |
| week18 | P-015 | 19,368 | 65,671 | - | - | - | 13,515 | - | - |
| week19 | P-015 | 10 | 65,661 | - | - | - | 13,513 | - | - |
| week20 | P-015 | - | 65,661 | - | - | - | 13,513 | - | - |
| week21 | P-015 | 26,894 | 38,767 | 30,970 | - | 31,868 | 7,978 | - | 300 |
| week22 | P-015 | 23,509 | 46,229 | 30,970 | 30,970 | 31,868 | 9,514 | - | 300 |
| week23 | P-015 | 1,038 | 76,161 | - | 30,970 | - | 15,674 | - | - |
| week24 | P-015 | - | 76,161 | - | - | - | 15,674 | - | - |
| week25 | P-015 | 16,136 | 60,025 | 30,970 | - | 31,868 | 12,353 | - | 300 |
| week26 | P-015 | 8,234 | 82,761 | - | 30,970 | - | 17,032 | - | - |
| week27 | P-015 | - | 82,761 | - | - | - | 17,032 | - | - |
| week28 | P-015 | 2,975 | 79,786 | - | - | - | 16,420 | - | - |
| week29 | P-015 | - | 79,786 | - | - | - | 16,420 | - | - |
| week30 | P-015 | 575 | 79,211 | - | - | - | 16,302 | - | - |
| week31 | P-015 | 619 | 78,592 | - | - | - | 16,174 | - | - |
| week32 | P-015 | - | 78,592 | - | - | - | 16,174 | - | - |
| week33 | P-015 | 12,006 | 66,586 | - | - | - | 13,703 | - | - |
| week34 | P-015 | 7,766 | 58,821 | 30,970 | - | 31,868 | 12,105 | - | 300 |
| week35 | P-015 | 4,155 | 85,636 | - | 30,970 | - | 17,624 | - | - |
| week36 | P-015 | 14,434 | 71,202 | - | - | - | 14,653 | - | - |
| week37 | P-015 | 11,280 | 59,922 | 30,970 | - | 31,868 | 12,332 | - | 300 |
| week38 | P-015 | - | 90,892 | - | 30,970 | - | 18,706 | - | - |
| week39 | P-015 | 5,989 | 84,903 | - | - | - | 17,473 | - | - |
| week40 | P-015 | 974 | 83,929 | - | - | - | 17,273 | - | - |
| week41 | P-015 | 7,756 | 76,173 | - | - | - | 15,676 | - | - |
| week42 | P-015 | 7,886 | 68,287 | - | - | - | 14,053 | - | - |
| week43 | P-015 | 59 | 68,227 | - | - | - | 14,041 | - | - |
| week44 | P-015 | 5,991 | 62,236 | 30,970 | - | 31,868 | 12,808 | - | 300 |
| week45 | P-015 | - | 93,206 | - | 30,970 | - | 19,182 | - | - |
| week46 | P-015 | 7,993 | 85,213 | - | - | - | 17,537 | - | - |
| week47 | P-015 | 100 | 85,113 | - | - | - | 17,516 | - | - |
| week48 | P-015 | 786 | 84,327 | - | - | - | 17,354 | - | - |
| week49 | P-015 | 5,704 | 78,623 | - | - | - | 16,181 | - | - |
| week50 | P-015 | 2,182 | 76,441 | - | - | - | 15,732 | - | - |
| week51 | P-015 | 8,074 | 68,367 | - | - | - | 14,070 | - | - |
| week52 | P-015 | 8,956 | 59,412 | 30,970 | - | 31,868 | 12,227 | - | 300 |

*Table 6- 9: Simulation inventory of item B-010 (new policy)*

| WEEK | SKU | Ave. simulated demand | Inventory | QTY to order | order in | Material Cost | Holding Cost | Stockout Cost | Ordering Cost |
|---|---|---|---|---|---|---|---|---|---|
| week1 | B-010 | 7,261 | 12,739 | 19,180 | - | 54,663 | 7,261 | - | 3,800 |
| week2 | B-010 | 1,185 | 11,555 | - | | - | 6,586 | - | - |
| week3 | B-010 | - | 11,555 | - | - | - | 6,586 | - | - |
| week4 | B-010 | 20 | 11,535 | - | - | - | 6,575 | - | - |
| week5 | B-010 | 23 | 11,512 | - | - | - | 6,562 | - | - |
| week6 | B-010 | 46 | 30,646 | 19,180 | 19,180 | 54,663 | 17,468 | - | 3,800 |
| week7 | B-010 | 6,740 | 23,906 | - | - | - | 13,627 | - | - |
| week8 | B-010 | 16,546 | 7,361 | - | - | - | 4,196 | - | - |
| week9 | B-010 | - | 7,361 | - | - | - | 4,196 | - | - |
| week10 | B-010 | - | 7,361 | - | - | - | 4,196 | - | - |
| week11 | B-010 | 11,560 | 14,980 | 19,180 | 19,180 | 54,663 | 8,539 | - | 3,800 |
| week12 | B-010 | 3,611 | 11,369 | - | - | - | 6,480 | - | - |
| week13 | B-010 | 4,581 | 6,788 | - | - | - | 3,869 | - | - |
| week14 | B-010 | 1,004 | 5,784 | - | - | - | 3,297 | - | - |
| week15 | B-010 | 21,030 | (15,246) | - | - | - | - | 10,000 | - |
| week16 | B-010 | 2,824 | 1,110 | 19,180 | 19,180 | 54,663 | 633 | - | 3,800 |
| week17 | B-010 | - | 1,110 | - | - | - | 633 | - | - |
| week18 | B-010 | - | 1,110 | - | - | - | 633 | - | - |
| week19 | B-010 | - | 1,110 | - | - | - | 633 | - | - |
| week20 | B-010 | - | 1,110 | - | - | - | 633 | - | - |
| week21 | B-010 | - | 20,290 | 19,180 | 19,180 | 54,663 | 11,565 | - | 3,800 |
| week22 | B-010 | 1,950 | 18,340 | - | - | - | 10,454 | - | - |
| week23 | B-010 | - | 18,340 | - | - | - | 10,454 | - | - |
| week24 | B-010 | 233 | 18,107 | - | - | - | 10,321 | - | - |
| week25 | B-010 | - | 18,107 | - | - | - | 10,321 | - | - |
| week26 | B-010 | - | 37,287 | - | 19,180 | - | 21,254 | - | - |
| week27 | B-010 | - | 37,287 | - | - | - | 21,254 | - | - |
| week28 | B-010 | - | 37,287 | - | - | - | 21,254 | - | - |
| week29 | B-010 | - | 37,287 | - | - | - | 21,254 | - | - |
| week30 | B-010 | - | 37,287 | - | - | - | 21,254 | - | - |
| week31 | B-010 | - | 37,287 | - | - | - | 21,254 | - | - |
| week32 | B-010 | 98 | 37,189 | - | - | - | 21,198 | - | - |
| week33 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week34 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week35 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week36 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week37 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week38 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week39 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week40 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week41 | B-010 | - | 37,189 | - | - | - | 21,198 | - | - |
| week42 | B-010 | 144 | 37,044 | - | - | - | 21,115 | - | - |
| week43 | B-010 | 20,664 | 16,381 | 19,180 | - | 54,663 | 9,337 | - | 3,800 |
| week44 | B-010 | - | 16,381 | | - | - | 9,337 | - | - |
| week45 | B-010 | - | 16,381 | | - | - | 9,337 | - | - |
| week46 | B-010 | - | 16,381 | | - | - | 9,337 | - | - |
| week47 | B-010 | - | 16,381 | | - | - | 9,337 | - | - |
| week48 | B-010 | - | 35,561 | - | 19,180 | - | 20,270 | - | - |
| week49 | B-010 | - | 35,561 | - | - | - | 20,270 | - | - |
| week50 | B-010 | - | 35,561 | - | - | - | 20,270 | - | - |
| week51 | B-010 | - | 35,561 | - | - | - | 20,270 | - | - |
| week52 | B-010 | - | 35,561 | - | - | - | 20,270 | - | - |

Table 6-9 shows simulated inventory of new policy for item B-010. The average simulated demand is being used to calculate the inventory of new policies. B-

010 is in C class. From section 5.4.2.2, B and C class items with high reorder points are being negotiated with vendors. Therefore, according to Table 5-3, the new ROP for item B-010 would be 35,500 pieces with the new lead time of 5 weeks. The unit cost, ordering cost, as well as EOQ remains the same.

The steps are repeated for all 16 SKUs in order to evaluate the inventory of the suggested policy mentioned in section 5.4. The histogram of simulated inventory distribution for each group is shown in Figure 6-15 to Figure 6-18.

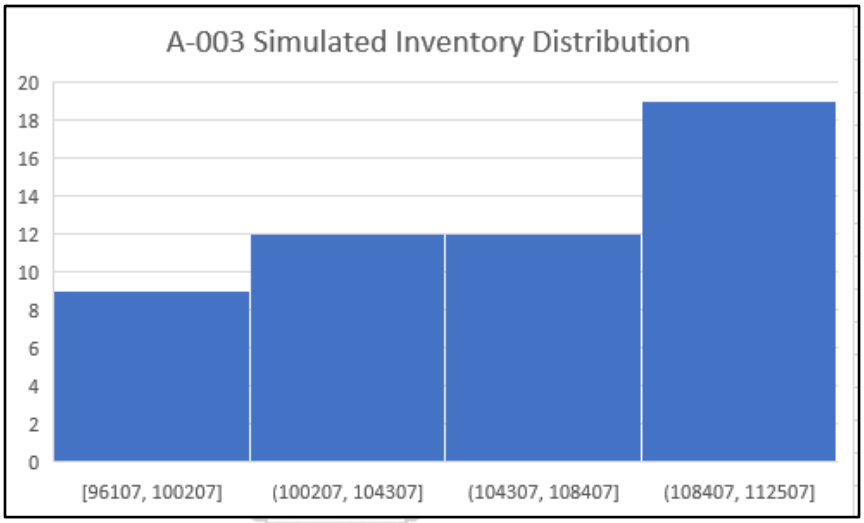


*Figure 6- 15: Simulated distribution of OTH group*

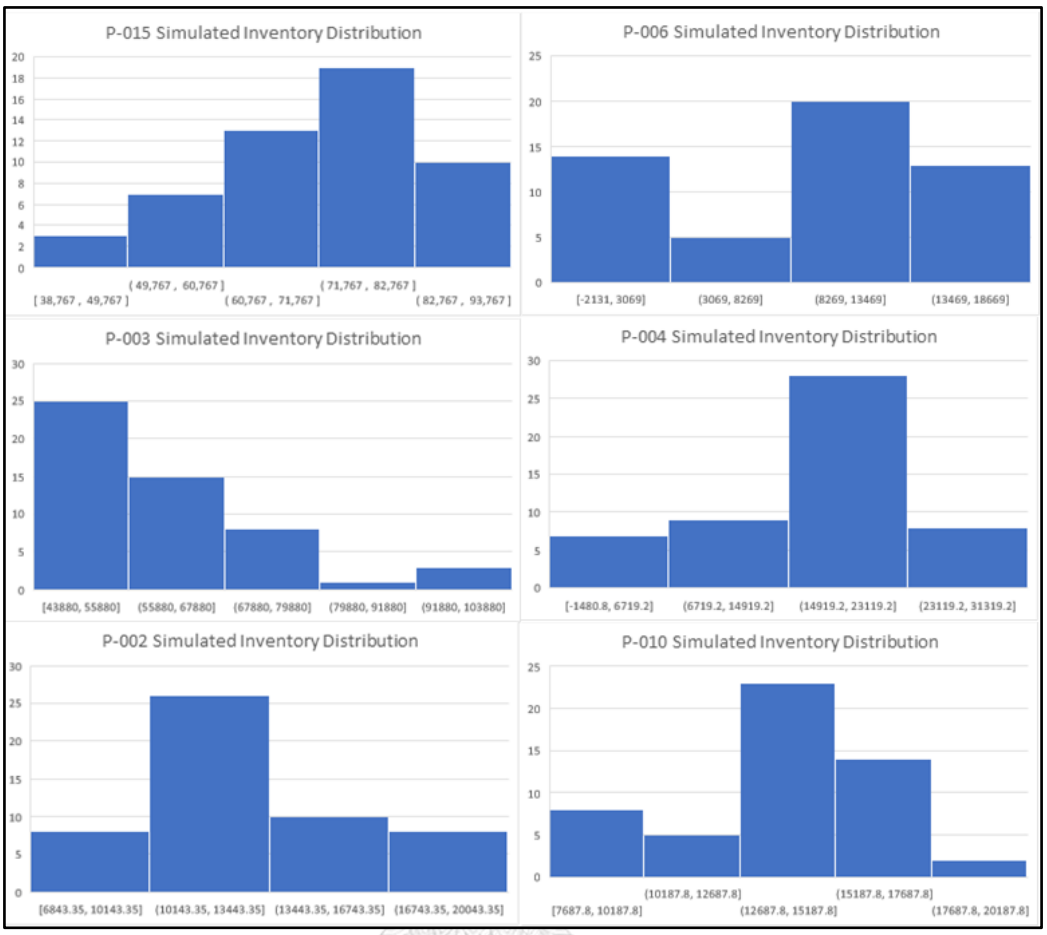


*Figure 6- 16: Simulated distribution of PAC group*

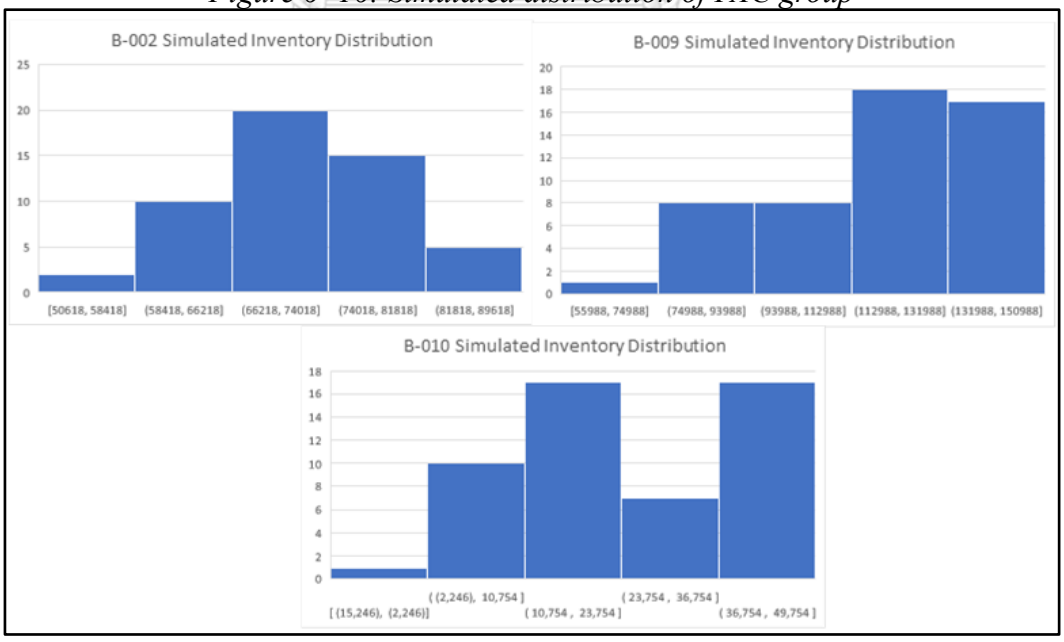


*Figure 6- 17: Simulated distribution of BAG group*

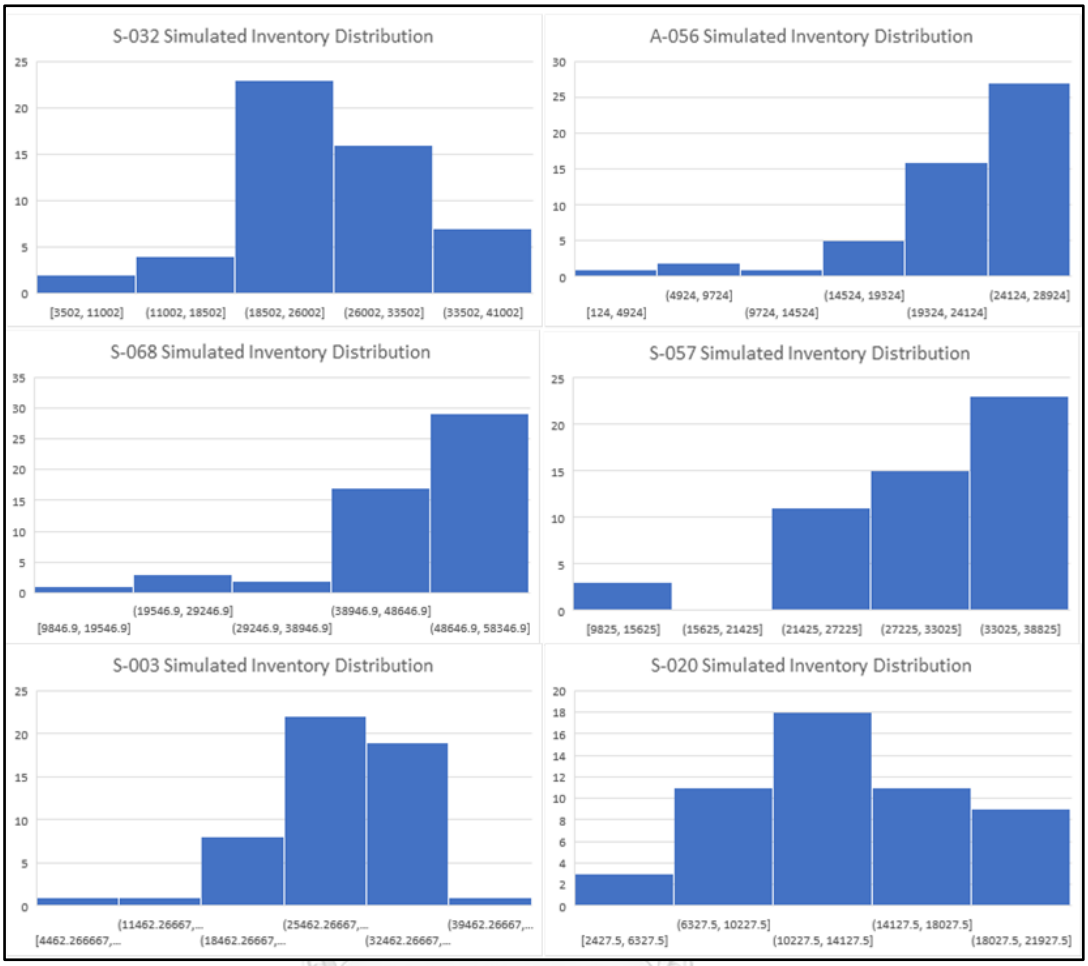


*Figure 6- 18: Simulated distribution of STI group*

Figure 6-15 to Figure 6-18 is the histogram of simulated inventory distribution grouped by inventory type. These new inventory distributions are then further calculated and compared with the old policy in the next section. All related costs, such as stock out cost, material cost, ordering cost, as well as material cost are taken into consideration in order to calculate the total inventory value of each SKU.

### 6.3.2 Comparison of Inventory Policy

This section of inventory analysis will compare histogram of simulated inventory (new policy), with the company's current policy. Four example, one from each group, will be illustrated:

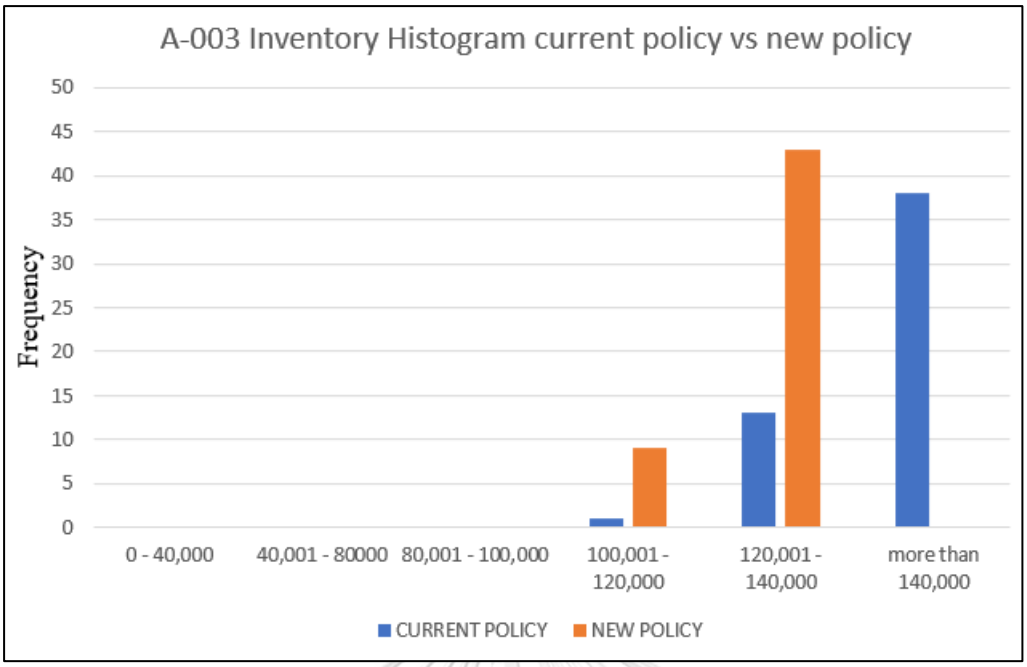


*Figure 6- 19: Comparison of A-003 inventory histogram (OTH group)*

Figure 6-19 illustrates the inventory histogram of the company purchasing policy versus the simulated inventory with its new purchasing policy. It can be seen that with the new policy, the inventory is relatively lower.

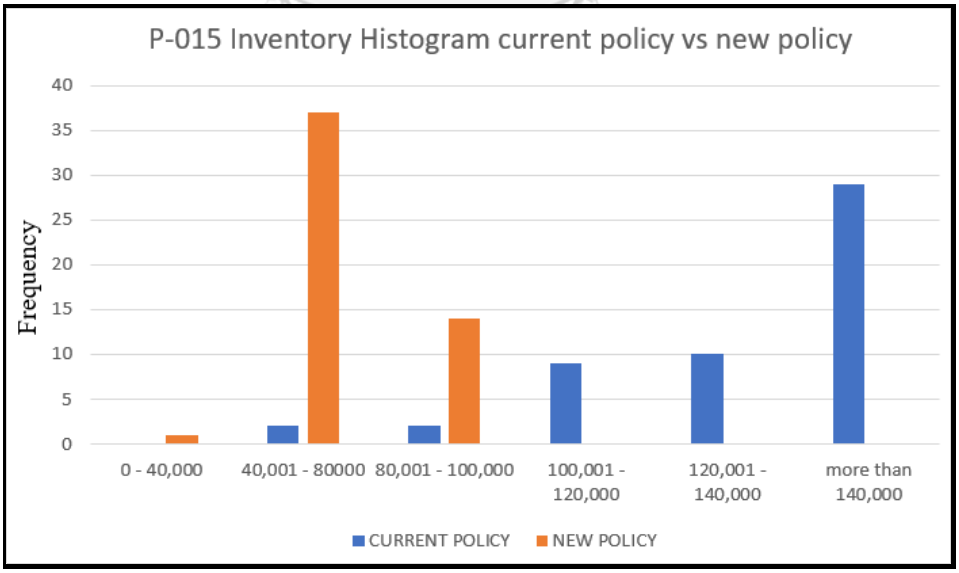


*Figure 6- 20: Comparison of P-015 inventory histogram (PAC group)*

Figure 6-20 depicts the histogram of P-015 inventory of company purchasing policy versus the simulated inventory with its new purchasing policy. It can be seen that before the improvement, P-015 inventory was relatively holding over 140,000 pieces of inventory. This means that they incur high holding costs. Whereas after the simulation (new policy), P-015 inventory is about 40,000 - 80,000 range, which is more than its safety stock.

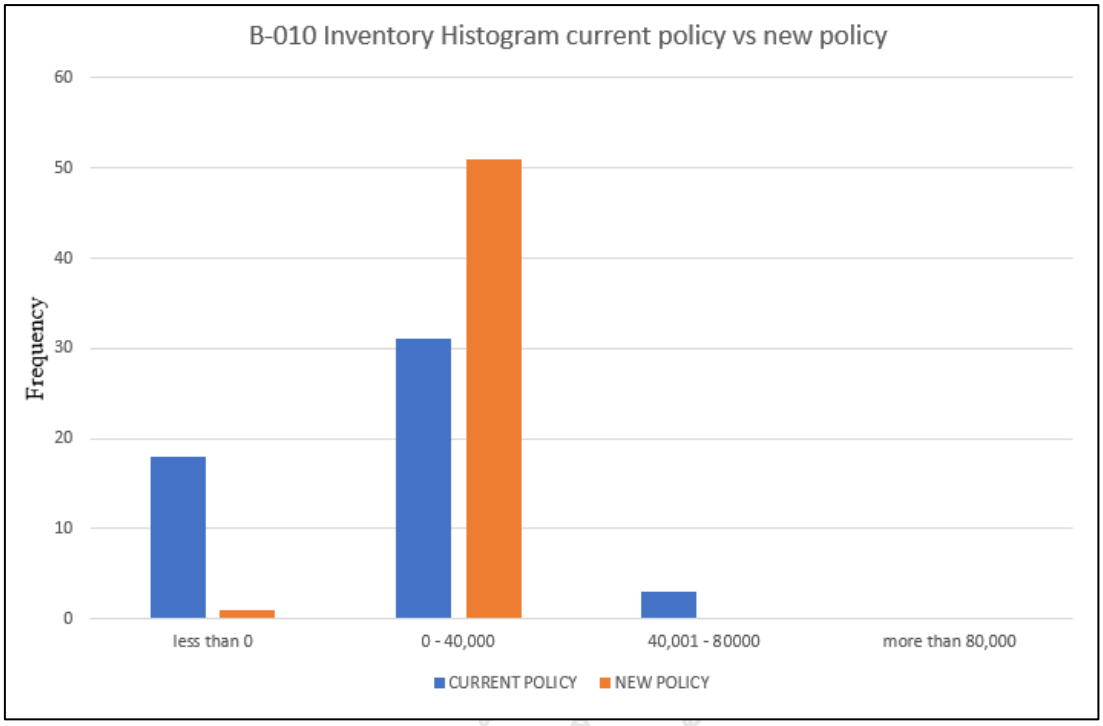




*Figure 6- 21: Comparison of B-010 inventory histogram (BAG group)*

Figure 6-21 refers to the histogram of B-010 current inventory policy and its simulated new policy. It can be seen that with the company's current purchasing policy, the B-010 inventory has a lot of negative inventory. This means that there is no safety stock during those weeks. Whenever there is an order during those periods, the company will have no B-010 for customers, and thus causing stock out to the company. Whereas after the new policy was implemented, the stock out was clearly improved.

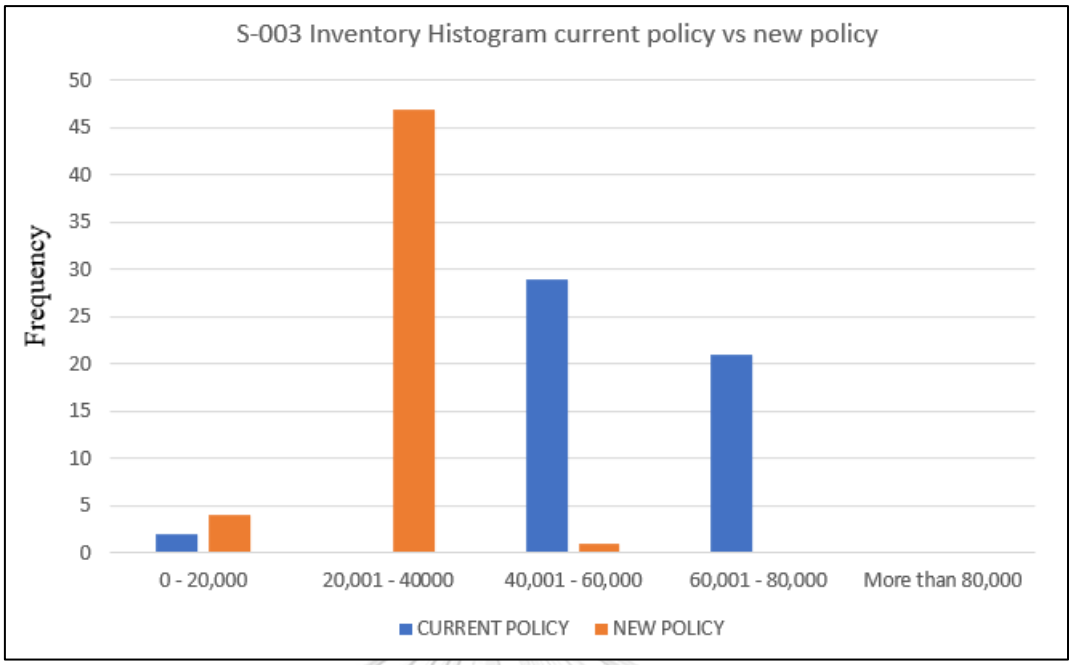


*Figure 6- 22: Comparison of S-003 inventory histogram (STI group)*

Figure 6-22 refers to the inventory histogram of S-003 of the company current purchasing policy versus the simulated inventory with its new purchasing policy. It can be seen that with the new policy, the inventory (stock) will be relatively lower, thus saving holding cost.

The new purchasing policies have shown the improvement in terms of inventory to the research company. The next section of this paper will illustrate the calculation for cost related terms.

## 6.4 INVENTORY VALUE ANALYSIS

This research further calculates both inventory costs of the company current purchasing policy and the new policy in order to prove that the suggested policies aid the company reduction of inventory cost. Inventory cost consists of material cost, holding cost, ordering cost and stock out cost. Table 6-10 shows the result of inventory cost of the current policies and inventory cost after implemented policies.

*Table 6- 10: Inventory value of company's current policy vs new policy*

| SKU | BEFORE (Current policy) | AFTER (new policy) | Percentage Save | Cost Save |
|---|---|---|---|---|
| A-003 | 721,178.54 | 630,387.74 | 12.59% | 90,790.80 |
| B-002 | 1,888,181.54 | 1,379,796.03 | 26.92% | 508,385.51 |
| B-009 | 4,765,547.90 | 3,854,524.02 | 19.12% | 911,023.88 |
| B-010 | 1,084,819.52 | 984,598.83 | 9.24% | 100,220.70 |
| P-002 | 1,633,574.40 | 1,268,958.41 | 22.32% | 364,615.99 |
| P-003 | 7,032,481.44 | 4,309,644.69 | 38.72% | 2,722,836.75 |
| P-004 | 2,182,800.00 | 2,187,664.17 | -0.22% | (4,864.17) |
| P-006 | 1,076,678.40 | 816,140.97 | 24.20% | 260,537.43 |
| P-010 | 1,831,114.92 | 1,314,779.59 | 28.20% | 516,335.33 |
| P-015 | 1,797,549.78 | 1,125,451.80 | 37.39% | 672,097.98 |
| S-003 | 192,694.70 | 122,846.07 | 36.25% | 69,848.63 |
| S-020 | 112,498.32 | 47,187.25 | 58.06% | 65,311.07 |
| S-032 | 333,061.74 | 210,521.81 | 36.79% | 122,539.93 |
| S-056 | 301,439.36 | 199,421.22 | 33.84% | 102,018.14 |
| S-057 | 80,958.87 | 47,870.94 | 40.87% | 33,087.93 |
| S-068 | 80,088.05 | 56,457.31 | 29.51% | 23,630.74 |
| | | **AVERAGE** | **28.36%** | **409,901.04** |

It can be seen that an average of 28.36% cost is saved with the new policy. Table 6-11 further breaks down the 16 SKUs inventory cost.

*Table 6- 11: Break down of inventory value of current policy vs new policy*

| SKU | CURRENT POLICY | | | | NEW POLICY | | | |
|---|---|---|---|---|---|---|---|---|
| | Material Cost | Holding Cost | Stockout Cost | Ordering Cost | Material Cost | Holding Cost | Stockout Cost | Ordering Cost |
| A-003 | 29,559.60 | 690,418.94 | - | 1,200.00 | 22,169.70 | 590,518.04 | - | 17,700.00 |
| B-002 | 428,390.82 | 1,454,390.72 | - | 5,400.00 | 388,279.32 | 988,216.71 | - | 3,300.00 |
| B-009 | 436,624.00 | 4,313,723.90 | - | 15,200.00 | 327,468.00 | 3,515,656.02 | - | 11,400.00 |
| B-010 | 382,641.00 | 495,578.52 | 180,000.00 | 26,600.00 | 327,978.00 | 623,820.83 | 10,000.00 | 22,800.00 |
| P-002 | 154,440.00 | 1,476,134.40 | - | 3,000.00 | 91,634.40 | 1,176,124.01 | - | 1,200.00 |
| P-003 | 970,642.40 | 6,054,039.04 | - | 7,800.00 | 609,162.40 | 3,697,182.29 | - | 3,300.00 |
| P-004 | 356,400.00 | 1,821,600.00 | - | 4,800.00 | 297,705.38 | 1,527,258.79 | 360,000.00 | 2,700.00 |
| P-006 | 223,200.00 | 758,678.40 | 90,000.00 | 4,800.00 | 185,996.25 | 537,444.72 | 90,000.00 | 2,700.00 |
| P-010 | 203,973.00 | 1,623,541.92 | - | 3,600.00 | 151,189.50 | 1,161,790.09 | - | 1,800.00 |
| P-015 | 370,146.00 | 1,418,903.78 | - | 8,500.00 | 350,549.43 | 771,602.37 | - | 3,300.00 |
| S-003 | 41,078.75 | 150,115.95 | - | 1,500.00 | 38,883.60 | 83,162.47 | - | 800.00 |
| S-020 | 24,423.36 | 86,874.96 | - | 1,200.00 | 10,858.76 | 36,028.49 | - | 300.00 |
| S-032 | 42,117.60 | 289,744.14 | - | 1,200.00 | 24,916.50 | 185,205.31 | - | 400.00 |
| S-056 | 50,400.00 | 249,539.36 | - | 1,500.00 | 35,787.15 | 163,034.07 | - | 600.00 |
| S-057 | 9,415.20 | 70,943.67 | - | 600.00 | 8,353.80 | 39,217.14 | - | 300.00 |
| S-068 | 14,233.86 | 64,954.19 | - | 900.00 | 11,226.60 | 44,830.71 | - | 400.00 |
| **TOTAL** | **3,737,685.59** | **21,019,181.89** | **270,000.00** | **87,800.00** | **2,882,158.79** | **15,141,092.05** | **460,000.00** | **73,000.00** |

Table 6-11 shows the breakdown of the related inventory cost for the current policy as well as the new policy. Material cost, holding cost, stockout cost, and

ordering cost for each item are shown. An example is item P-015, the holding cost was reduced from 1,418,900 Thai baht to 1,161,790 Thai baht. Item B-010 stockout cost were significantly improved with the new policy.

Item P-004, the new policy incurs stockout cost. Further analysis found that the stock out cost that incurred with the new policy is due to the fact that the ROP and EOQ of the new policy is lowered when compared with the old policy. A sudden rise in demand may cause the stock out. Table 6-12 further calculated the number of items being stock out and compare with its service level. All class A items yield over 95% service level.

*Table 6- 12: Stock out compare with service level*

| CLASS | SKU | Service Level |
|---|---|---|
| A | B-002 | 100.0% |
| A | P-015 | 100.0% |
| A | P-003 | 100.0% |
| A | P-004 | 97.4% |
| A | P-010 | 100.0% |
| A | P-006 | 95.3% |
| A | P-002 | 100.0% |
| B | A-003 | 100.0% |
| B | B-009 | 100.0% |
| B | S-032 | 100.0% |
| B | S-056 | 100.0% |
| C | S-068 | 100.0% |
| C | S-057 | 100.0% |
| C | S-003 | 100.0% |
| C | B-010 | 78.9% |
| C | S-020 | 100.0% |

All in all, the overall material cost, holding cost, as well as ordering cost were significantly improved with the new policies

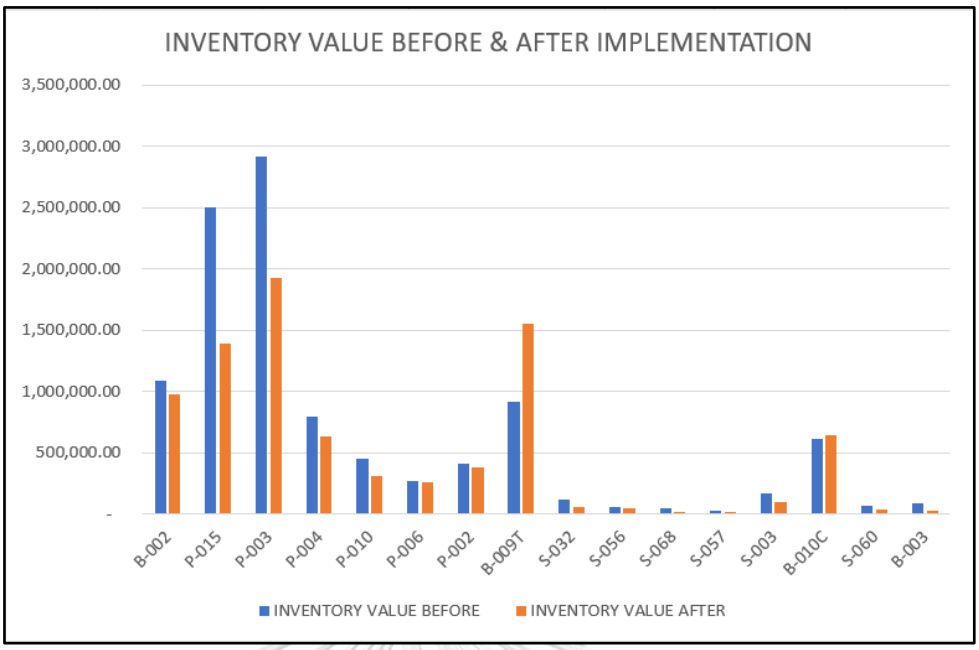


*Figure 6- 23: Comparison of inventory value before and simulated demand*

Figure 6-23 further displays the bar chart of inventory value before and after simulation (after improvement). The new purchasing policy implemented by the research company will help the company to save inventory cost as well as improve service level in the long run.

## 6.5 SENSITIVITY ANALYSIS



Sensitivity analysis is performed to test on the outcome if some parameter in the research is being changed. This sensitivity analysis will test on changeable parameters, which are holding cost, and ordering cost.

### 6.5.1 Holding Cost

The research company's holding cost and all calculations throughout this thesis was made based on 20% holding cost. This section will change the holding cost from 20% to 15% to test the outcome.

First of all, the new EOQ based on the holding cost of 15% was calculated in Table 6-13.

*Table 6- 13: EOQ of holding cost 15%*

| CLASS | SKU | Annual Demand | Unit cost | Ave Purchase QTY | Ordering Cost | Holding Cost | EOQ |
|---|---|---|---|---|---|---|---|
| A | B-002 | 312,079.00 | 1.21 | 13,383.00 | 600 | 0.1815 | 45,423.92 |
| A | P-015 | 328,974.00 | 0.98 | 12,617.00 | 1700 | 0.147 | 87,229.14 |
| A | P-003 | 165,922.00 | 5.6 | 4,451.68 | 600 | 0.84 | 15,395.83 |
| A | P-004 | 40,200.00 | 8.25 | 2,669.33 | 600 | 1.2375 | 6,243.54 |
| A | P-010 | 25,020.00 | 7.7 | 6,000.00 | 600 | 1.155 | 5,098.51 |
| A | P-006 | 28,752.00 | 4.5 | 2,119.38 | 600 | 0.675 | 7,149.45 |
| A | P-002 | 20,380.00 | 7.8 | 2,544.00 | 600 | 1.17 | 4,571.93 |
| B | A-003 | 33,713.00 | 0.54 | 12,000.00 | 300 | 0.081 | 15,802.72 |
| B | B-009T | 108,122.00 | 2.9 | 16,550.00 | 3800 | 0.435 | 43,462.95 |
| B | S-032 | 52,799.00 | 0.7 | 13,639.67 | 300 | 0.105 | 17,369.76 |
| B | S-056 | 48,398.00 | 0.7 | 20,300.00 | 300 | 0.105 | 16,630.09 |
| C | S-068 | 83,376.00 | 0.09 | 30,000.00 | 300 | 0.0135 | 60,873.64 |
| C | S-057 | 61,557.00 | 0.12 | 20,424.00 | 300 | 0.018 | 45,297.90 |
| C | S-003 | 90,000.00 | 0.25 | 99,276.00 | 300 | 0.0375 | 37,947.33 |
| C | B-010C | 27,600.00 | 2.85 | 27,325.00 | 3800 | 0.4275 | 22,151.00 |
| C | S-020 | 51,780.00 | 0.24 | 29,365.00 | 300 | 0.036 | 29,376.86 |

The EOQ of holding cost 15% was then being used in the simulation to calculate the inventory value of the company. Table 6-14 represents the result.

*Table 6- 14: Inventory cost before and after (holding cost 15%)*

| SKU | BEFORE (Current policy) | AFTER (new policy) | Percentage Save | Cost Save |
|---|---|---|---|---|
| A-003 | 558,695.16 | 491,777.58 | 11.98% | 66,917.58 |
| B-002 | 1,539,266.46 | 1,147,347.20 | 25.46% | 391,919.27 |
| B-009 | 3,214,085.33 | 2,829,376.52 | 11.97% | 384,708.81 |
| B-010 | 972,220.62 | 1,087,840.82 | -11.89% | (115,620.20) |
| P-002 | 1,318,458.90 | 1,010,903.34 | 23.33% | 307,555.56 |
| P-003 | 6,209,494.24 | 3,523,162.48 | 43.26% | 2,686,331.76 |
| P-004 | 2,001,624.00 | 1,885,196.65 | 5.82% | 116,427.35 |
| P-006 | 951,276.30 | 689,289.96 | 27.54% | 261,986.34 |
| P-010 | 1,521,833.64 | 1,073,970.50 | 29.43% | 447,863.14 |
| P-015 | 1,446,022.07 | 935,327.87 | 35.32% | 510,694.19 |
| S-003 | 164,529.84 | 106,317.78 | 35.38% | 58,212.06 |
| S-020 | 86,837.51 | 43,390.97 | 50.03% | 43,446.54 |
| S-032 | 252,974.66 | 177,892.96 | 29.68% | 75,081.70 |
| S-056 | 301,912.07 | 147,342.93 | 51.20% | 154,569.14 |
| S-057 | 70,122.03 | 44,013.35 | 37.23% | 26,108.68 |
| S-068 | 63,058.80 | 41,451.37 | 34.27% | 21,607.43 |
| | | **AVERAGE** | **27.50%** | **339,863.08** |

Once the holding cost was reduced from 20% to 15%, the EOQ increased. The result cost before and after simulation was as shown in Table 6-14. This shows that

even though the holding cost was being reduced, the simulation still gave a positive outcome for the cost saved by the company.

### 6.5.2 Ordering Cost

The ordering costs in this research paper are dependent on the source and the complexity of the product as mentioned in the beginning of Chapter 6. This sensitivity analysis on ordering cost multiplies the actual ordering cost by two times. The new EOQ were calculated as shown in Table 6-15:

*Table 6- 15: EOQ of ordering cost x 2*

| CLASS | SKU | Annual Demand | Unit cost | Ave Purchase QTY | Ordering Cost | Holding Cost | EOQ |
|---|---|---|---|---|---|---|---|
| A | B-002 | 312,079.00 | 1.21 | 13,383.00 | 1200 | 0.242 | 55,632.71 |
| A | P-015 | 328,974.00 | 0.98 | 12,617.00 | 3400 | 0.196 | 106,833.44 |
| A | P-003 | 165,922.00 | 5.6 | 4,451.68 | 1200 | 1.12 | 18,855.96 |
| A | P-004 | 40,200.00 | 8.25 | 2,669.33 | 1200 | 1.65 | 7,646.75 |
| A | P-010 | 25,020.00 | 7.7 | 6,000.00 | 1200 | 1.54 | 6,244.37 |
| A | P-006 | 28,752.00 | 4.5 | 2,119.38 | 1200 | 0.9 | 8,756.25 |
| A | P-002 | 20,380.00 | 7.8 | 2,544.00 | 1200 | 1.56 | 5,599.45 |
| B | A-003 | 33,713.00 | 0.54 | 12,000.00 | 600 | 0.108 | 19,354.30 |
| B | B-009T | 108,122.00 | 2.9 | 16,550.00 | 7600 | 0.58 | 53,231.03 |
| B | S-032 | 52,799.00 | 0.7 | 13,639.67 | 600 | 0.14 | 21,273.52 |
| B | S-056 | 48,398.00 | 0.7 | 20,300.00 | 600 | 0.14 | 20,367.62 |
| C | S-068 | 83,376.00 | 0.09 | 30,000.00 | 600 | 0.018 | 74,554.68 |
| C | S-057 | 61,557.00 | 0.12 | 20,424.00 | 600 | 0.024 | 55,478.37 |
| C | S-003 | 90,000.00 | 0.25 | 99,276.00 | 600 | 0.05 | 46,475.80 |
| C | B-010C | 27,600.00 | 2.85 | 27,325.00 | 7600 | 0.57 | 27,129.32 |
| C | S-020 | 51,780.00 | 0.24 | 29,365.00 | 600 | 0.048 | 35,979.16 |

The result cost simulation is as follow:

*Table 6- 16: Inventory cost before and after simulation (ordering cost x 2)*

| SKU | BEFORE (Current policy) | AFTER (new policy) | Percentage Save | Cost Save |
|---|---|---|---|---|
| A-003 | 740,511.68 | 624,096.44 | 15.72% | 116,415.24 |
| B-002 | 1,925,103.00 | 1,498,993.70 | 22.13% | 426,109.30 |
| B-009 | 4,947,246.50 | 3,599,945.62 | 27.23% | 1,347,300.88 |
| B-010 | 1,274,835.93 | 1,123,260.83 | 11.89% | 151,575.11 |
| P-002 | 1,736,337.60 | 1,294,217.33 | 25.46% | 442,120.27 |
| P-003 | 6,555,883.52 | 4,644,782.61 | 29.15% | 1,911,100.91 |
| P-004 | 2,794,792.50 | 2,086,224.84 | 25.35% | 708,567.66 |
| P-006 | 1,140,023.40 | 797,504.55 | 30.04% | 342,518.85 |
| P-010 | 2,025,614.52 | 1,438,116.99 | 29.00% | 587,497.53 |
| P-015 | 2,035,374.30 | 1,181,377.67 | 41.96% | 853,996.63 |
| S-003 | 262,595.45 | 145,253.86 | 44.69% | 117,341.59 |
| S-020 | 162,045.50 | 49,819.07 | 69.26% | 112,226.44 |
| S-032 | 375,714.94 | 222,805.21 | 40.70% | 152,909.73 |
| S-056 | 274,829.96 | 234,263.32 | 14.76% | 40,566.64 |
| S-057 | 117,017.59 | 55,431.40 | 52.63% | 61,586.18 |
| S-068 | 96,131.45 | 66,568.47 | 30.75% | 29,562.98 |
| | | **AVERAGE** | **31.92%** | **462,587.25** |

Table 6-16 implies that even though the ordering cost was being increased by two times, the result of the simulation is still positive.

Therefore, from the sensitivity analysis of holding cost and ordering cost, it can be concluded that the new policy can improve company inventory cost regardless if some parameters are changed.

# CHAPTER 7:
# CONCLUSIONS AND RECOMMENDATIONS

## 7.1 CONCLUSION

Founded in 1989, the case study company has served as an integrator who provides comprehensive services for foods and beverages products that are manufactured in Thailand. Currently, the company offers two distinctive product categories: repackaged products and trading products. The trading product category was omitted from this research analysis since its nature yields little inventory in the warehouse after shipments. Whereas, the repackage product were composed of raw material, that is a perishable item, and its packaging inventories. The raw material is purchase base on lot-for-lot policy in order to maintain the longest shelf life for their customers, this will also leave no inventory in the warehouse after shipments.

Therefore, this research paper focuses only on repackage products since bulk-purchasing was applied to packaging inventories, such as labels and plastic bags, to realize the economy of scale. Seasonal demand product also has an effect on the demand of packaging inventory; thus, it is crucial for the company imposed proper purchasing standard in order to prevent unnecessary cost.

The bulk purchasing inventory policy led to the deadstock and obsolete packaging inventories as the company lacks purchasing standards and the warehouse fails to monitor packaging inventories constantly. As a result, this research aims to propose and apply a suitable inventory policy for packaging inventories to reduce the inventory cost, as well as prevent stock out, and also to improve service level.

This thesis retrieved the company's 2019 production, purchasing and shipping data from the company record, each packaging inventory are denoted based on their categories into sticker (STI), carton (CAR), packaging (PAC), bag (BAG) and others (OTH). ABC analysis, Min-Max analysis, as well as safety stock analysis was performed on the retrieved data and found that the company did not properly prioritize the inventory. Items in Class B and C were being prioritized the same as A class items. The ordering lead time for some of the A Class items were relatively

long, leading to stock out. The safety stock analysis indicated that Class-A items had a significantly high safety-stock and a high reorder point. This implies a higher cost for inventory management, including holding costs. Although this provides customers with satisfaction of readily available stocks, it creates high costs for the firm. The implications of the findings guide the direction for the report, leading to the development of the proposed method for storage management and recommendations for policy for purchasing.

Because of the Make-to-Order of repackaged products, the revised inventory policy relies on the synchronization of raw materials and packaging inventory as well as the communication to suppliers. As a result, this thesis proposed two interdependent approaches. First is local sourcing. This approach urges the company to source from local suppliers for category-PAC and invest in Sticker/Labeling machines. The second approach would be volume renegotiating. The approach assumes that the company is capable of renegotiating ordering quantities of Class-B inventory. On average, such an approach results in 30.0% reduction of lead times. It is important to reduce lead time for class B inventory, especially Bag category as 30+ days ordering lead time could lead to stock out. The application of both approaches could help the case study company to better synchronize the replenishment cycle and the production cycle.



Finally, the last part of this thesis would be to ensure that the suggested recommendation aids the researched company to lower its inventory cost. The new reorder points and the economic order quantity (EOQ) is proven with monte Carlo simulation of the new data set and it is found that 28.36% cost were saved with the suggested policies. This will definitely increase service level and customer satisfaction.

## 7.2 KEY RECOMMENDATIONS

Developing from the analysis and simulation in this research, a total of three implications are suggested as follows:

- Highlighting the issue of ROP for several Class-A and Class-B items, it was required for the firm to engage in reducing the overall ROP. The first strategic recommendation is established to reduce the time-period required through the vendor selection for Class-A items and Class-B items. The suggestion is to establish a legally binding contract with the suppliers to recuperate with losses that were established by issues of late deliveries. Similarly, for the majority of the Class-A items, it is recommended to source the products from Thailand. Sourcing from Thailand can also further reduce the costs of logistics and operations, especially holding cost and stock out cost, for the firm.
- The second insight included the priority of inventory goods. The firm had prioritized several of the Class-B and Class-C items as if they were the class-A items. This increased the holding cost of inventory for the firm, which led towards the increased operational costs. In order to prevent this, it is imperative for the firm to develop ABC analysis and the right cycle count for each group. For instance, monthly cycle count for Class A item, quarterly for Class B and biannual for Class C item. This can further reduce the cost of holding in inventory size and lessen inventory discrepancy in the company inventory.
- The third issue is the high volume of purchase for several units, which increases the costs of holding, with low sales volume. Considering such, the EOQ was analyzed, and it was found that, an average purchase of 24,900 units per SKU of the top 16-inventories is optimum to reduce the holding costs.



## 7.3 FUTURE RESEARCH

Underpinning the above analysis, there are several potential future research that can be explored to further this thesis. Some of the recommended approaches are suggested as follows:

Firstly, this research was performed using objective assessment. It specifically focuses on statistical and numerical judgements towards developing an ideal inventory management practice. However, a subjective approach by using means of interviews, or comparing the data with others data in article journal, could allow a

much in-depth knowledge on the practice and implementation of inventory management policies within the firm.

Secondly, this research was limited towards addressing the annual inventory data of a single year, it is very limited historical data. Herein, it would be important to gather more data from different years, aiming to address a multi-year panel data analysis that could yield effective inventory management results for the firm.

Thirdly, the further research can reassess the ABC model into a product-grading ERP system. In this fast-changing business environment, the inventory management policies must be dynamic and adaptive. Categorization of stock inventory items under A, B, C, can be too few of the classification. Based on the percentage of stock items, the categories of items can be adapted differently, with very different annual usage rates.

The ERP system (Enterprise Resource Planning) system should be further researched and integrated with ABC classification. This will be designed to enhance the rates of inventory turnover. Choudhary and Gupta (Choudhary, 2014) recommend the use of product grading systems. A product grading system is linked with studying the popularity of each individual product category. For instance, a product grading system can be divided amongst Tier 1, 2, and 3 products, with Tier 1 having the highest number of unique customer count, followed by Tier 2 and 3. Instead of adopting only ABC analysis, this form assessment can be further looked into to allow an appropriate inventory tracking and management.



Lastly, this research sensitivity analysis is limited to only performing on adjusting two parameters, ordering cost and holding cost. The future research can assess sensitivity analysis with robust analysis in order to deal with the design of the model considering all necessary assumptions / parameters that can influence the outputs and stability of the results.

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