

INVENTORY MANAGEMENT AND PRODUCT DEMAND PLANNING: CASE STUDY BAKERY PRODUCT FACTORY

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ABSTRACT

Purpose: AMZAP Group Company Limited is engaged in the agricultural product processing business, focusing on food preservation and bakery products. Among its product portfolio, the Memorize brownie has gained widespread recognition. The company recognizes the need to enhance and optimize its factory and store inventory efficiency to serve the market's demands effectively. The lack of accurate knowledge regarding the appropriate quantities and timings for deliveries has resulted in instances of raw material shortages or excessive ordering, leading to lost customers and unnecessary costs. To address these challenges, the company has embarked on a research project to improve its inventory system, including the raw material and ready-made goods inventory. The project aims to facilitate efficient inventory checks, integrating forecasting theory to anticipate demand quantities for each branch accurately.

Design/methodology/approach: This study adopts a comprehensive analytical approach, integrating the principles of Design and Plant Layout, Inventory Management, Production Planning, and Scheduling Theory. To optimize and determine the factory inventory layout, Economic Order Quantity (EOQ), and Reorder Point (ROP) for raw materials and ready-made goods within the inventory, a range of tools are employed, including ABC Classification analysis, Rectilinear, FIFO, and FEFO principles. Additionally, Microsoft Excel analyzes sales history and forecasts future plans.

Findings: The outcomes of this study comprise comprehensive delivery plans for each branch based on sales forecast data analysis. Furthermore, the study provides two inventory layout diagrams, offering practical guidance to the company's operational endeavors.

Research limitations/implications: In order to gather relevant data for analysis, this study collects information from five branches, namely AQUA, Ladprao, Ayutthaya, Central Festival Chiang Mai, and Nimmanhaemin, focusing on three key products: Brownie Shot, Original Brownie, and Chocolate Nama dark and mild.

Originality/value: In conclusion, by adopting the analytical methodologies and tools, this study presents valuable insights and actionable recommendations to enhance inventory efficiency and effectively meet market demands.

Keywords: ~~Keywords:~~ Inventory Management, Demand Forecasting and Planning, Bakery Product

Introduction

The case study company operates in the agricultural product processing sector, specializing in food preservation and bakery products. The company's objective is to effectively meet the increasing market demands by optimizing inventory efficiency across factory and store operations. However, challenges such as raw material shortages and excessive ordering have arisen due to a need for more accurate knowledge regarding appropriate quantities and delivery schedules. These challenges have resulted in customer attrition and unnecessary costs and wastes.

This study aims to enhance the inventory system by addressing two primary issues. Firstly, it employs the theory of Plant Layout Design, which focuses on designing the best arrangement of physical facilities for efficient operations, to optimize the arrangement of raw materials and finished goods. Secondly, the study emphasizes the importance of demand information and the challenges of demand unpredictability. To mitigate forecasting errors, the study proposes integrating forecasting theory into efficient inventory checks

for accurate demand anticipation. Additionally, Microsoft Excel is recommended as a simple and quick tool for TS-forecasting.

Literature Reviews

According to Thanapotivirat and Jitpakdeepornrat (2022), in the recent years, the confectionery market in Thailand have witnessed a significant influence of socio-psychological factors on consumer behaviour, leading to the notable popularity of bakery industries despite their relatively higher prices. However, the increasing demand has introduced challenges in inventory management and sales forecasting. Jurado-Muñoz, et.al. (2021) highlighted that inaccurate inventory management can result in defective products, and they advocate adopting lean method to improve inventory management, reduce defects, and enhance economic flow. Various tools, such as motion and time study, process flow analysis, and plant layout design, were suggested to effectively decrease production time by optimizing movement distances Tippayawong and Prapasirisulee (2011). Additionally, the ABC class-based storage concept can significantly reduce travel distance and picking time and improve space utilization and inventory service level (Tippayawong et.al., 2013). Efficiency-focused organizations, as discussed by Liu and Ma (2019) strive to reduce emissions from inventory and warehousing without compromising profitability, thus aligning with sustainability goals through waste and emission reduction efforts. Mehdizadeh (2020) underscored the utility of the ABC analysis in forecasting future retailer demands and suggests implementing a periodic review approach when placing orders. Combining the ABC concept with plant layout design offers two main advantages. Firstly, it simplifies product search and retrieval processes, making it easier and more efficient for employees to locate and access items within the inventory (Srisuk and Tippayawong, 2020). Secondly, it increases space utilization, allowing the facility to better accommodate potential future demand growth and optimize the use of available storage space.

Abolghasemi, et al. (2020) emphasized the impact of demand unpredictability on store inventory management. Inaccurate demand forecasting can lead to substantial errors, resulting in unnecessary costs and wastage. In contrast, accurate demand forecasting enables better inventory, supply, and transportation decision-making. Rahardja (2021) discussed the usefulness of Excel's (2019) built-in function "FORECAST.ETS" for implementing the Exponential Smoothing Methods (ESM) family of Time Series (TS) methods. This function considers the presence of level, trend, and seasonality components in the data. It requires minimal computing resources, making it a practical option for forecasting in scenarios with limited computational power. It can be effectively applied to various data series, including sales data, to generate forecasts that account for underlying trends, seasonality, and level components. Furthermore, Pamungkas et.al. (2021) concluded that the Holt Winter Exponential Smoothing method is particularly suitable for production forecasting. They emphasize the importance of accurate data for successful forecasting and advocate for effective data management practices to maintain accurate records.

Methodology

The methodology of this study consists of six steps as follows;

Studying the Current Situation of Inventory before Implementing Improvements

Data collection had been conducted several times in order to gather data in the warehouse which included all inventory information, order patterns, locations, current demand, existing management model.

Analyzing Products to Classify and Allocate Inventory Space

The inventory is evaluated and grouped based on annual demand, picking frequency and value using the ABC Classification technique. The result will be later utilized to assign storage area in for optimizing retrieval time.

Analyze Historical Sales Data to Generate Forecasts for Product Demand

Sales data for three products (A, B, C) are collected from five branches (1, 2, 3, 4, 5) over a 24-month period (January 2021 to December 2022) for the first four branches. For branch 5, the data spans 14 months

(April 2021 to December 2022). Multiple forecasting techniques such as Moving Average, Exponential Smoothing, and Linear Regression are utilized to forecast sales using historical data. The forecasting performance is evaluated using the mean absolute percentage error (MAPE), where a lower MAPE indicates better results.

Developing Individualized Delivery Plans for Each Branch

Examine the freight schedule of the central depot. Next, analyze the delivery plan based on historical daily sales data from 2022, and establish a comprehensive and efficient delivery schedule.

Results

This study integrates a range of theories and tools to enhance and optimize inventory management to maximize space utilization in raw material and finished goods. Additionally, it aims to determine the optimal delivery quantities for each branch, thereby, improving overall operational efficiencies.

Current Situation

The inventory occupies an area of 96 square meters (8 x 12 meters) with a single entry and exit point. The data reveals that the factory follows a Fixed Location System without proper records, resulting in inefficient storage and accessibility issues. Figure 1 shows the initial warehouse layout.

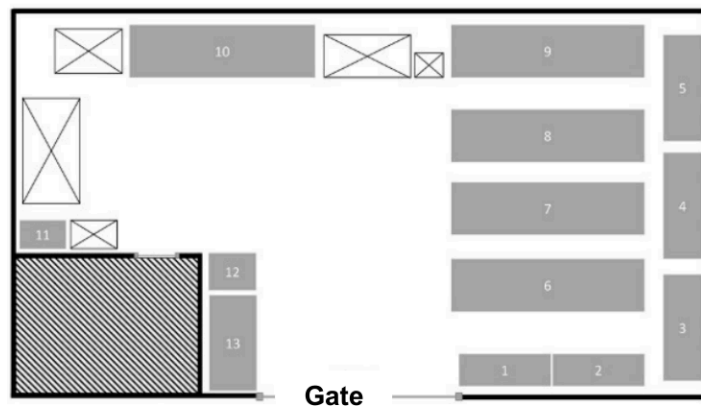


Figure 1 Warehouse Layout before Implementing Improvements

ABC Classification Analysis

The inventory is subjected to an ABC Classification Analysis based on historical data from 2022. It consists of 160 items, including 61 raw materials, 47 packaging materials, and 52 miscellaneous items. Equation 1 provides the method for calculating the product value, and Table 1 demonstrates a sample classification of five materials derived from raw materials. The classification criteria are as follows: Group A represents highly significant products, accounting for about 80% of the product value. Group B includes moderately important items, comprising approximately 15% of the product value. Group C consists of less critical products, contributing to around 5% of the product value.

The product value = the frequency of use x the price per unit. (1)

Material	Frequency of use	Product value	Percentage	Cumulative Percentage	Group
Material A	5,504	1,265,920	29.1	29.1.	A
Material B	860	828,180	19.0	48.1	A
Material C	7	128,844.80	3.00	80.00	B
Material D	79,543	91,474.45	2.10	84.70	B
Material E	83	24,900	0.6	95.1	C

Table 1 Sample of Raw Material Grouping Example

Based on the classification, the materials can be grouped as follows:

- Raw materials: Group A consists of 5 items, Group B consists of 12 items, and Group C consists of 44 items.
- Packaging materials: Group A comprises 9 items, Group B comprises 10 items, and Group C comprises 28 items.
- Miscellaneous items: Group A includes 5 items, Group B includes 9 items, and Group C includes 38 items.

The Layout of the Inventory Storage

Utilize the Rectilinear Distances, as shown in Equation 2, and strategically position products based on their value from ABC classification analysis. In this method, it is necessary to measure the distances along the x and y axes from the centroid of the door to the centroid of each shelves. The shelves closest to the door can be designated as Zone A, as illustrated in the Figure 2. Group A products, being of high importance, will be placed near the entrance for easy accessibility.

$$d_{ij} = |\Delta x| + |\Delta y| \quad (2)$$

d_{ij} = The distance between the door and shelves j (let j be the shelves number $\{j = 1,2,3,4,5,6,7,8,9,10,11,12,13\}$).

Δx = The difference in distance on the x-axis.

Δy = The difference in distance on the y-axis.

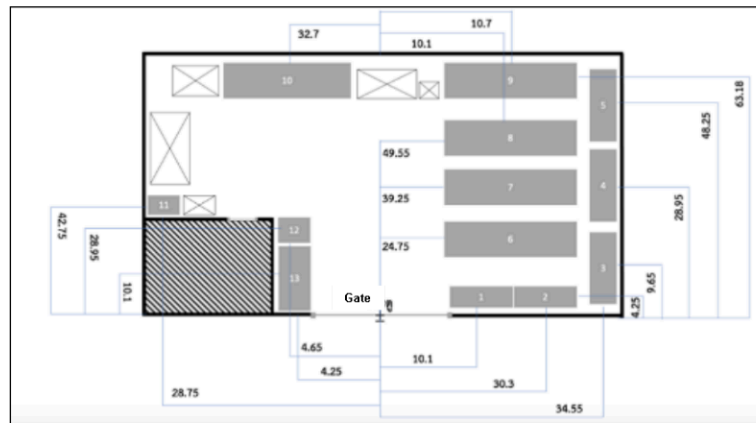


Figure 2 Distances Map for Axial Calculations in the Warehouse

By designating the centre of the door as the origin point (0,0), an illustrative calculation example is demonstrated as illustrated in the Table 2.

$d_{door,j}$	$ \Delta x + \Delta y $	Total distance (meters)	$d_{door,j}$	$ \Delta x + \Delta y $	Total distance (meters)
$d_{door,1}$	$ 10.1 + 4.25 $	14.35	$d_{door,8}$	$ 10.1 + 49.55 $	59.65
$d_{door,2}$	$ 30.3 + 4.25 $	34.55	$d_{door,9}$	$ 10.7 + 63.18 $	73.88
$d_{door,3}$	$ 34.55 + 9.65 $	44.2	$d_{door,10}$	$ -32.7 + 63.18 $	95.88
$d_{door,4}$	$ 34.55 + 28.95 $	63.5	$d_{door,11}$	$ -28.75 + 42.75 $	71.5
$d_{door,5}$	$ 34.55 + 48.25 $	82.8	$d_{door,12}$	$ -4.65 + 28.95 $	33.6
$d_{door,6}$	$ 10.1 + 24.7 $	34.8	$d_{door,13}$	$ -4.25 + 10.1 $	14.35

$d_{door,7}$	$ 10.1 + 39.25 $	49.35		
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Table 2 The distance between the door and shelves j

Shelves 1, 12, and 13, which are closest to the door, are assigned as Group A for raw materials, miscellaneous materials, and packaging materials, respectively. Shelves 2, 6, and 3 are designated for Group B materials. Group C materials will be arranged on adjacent shelves, as shown in Figure 3.

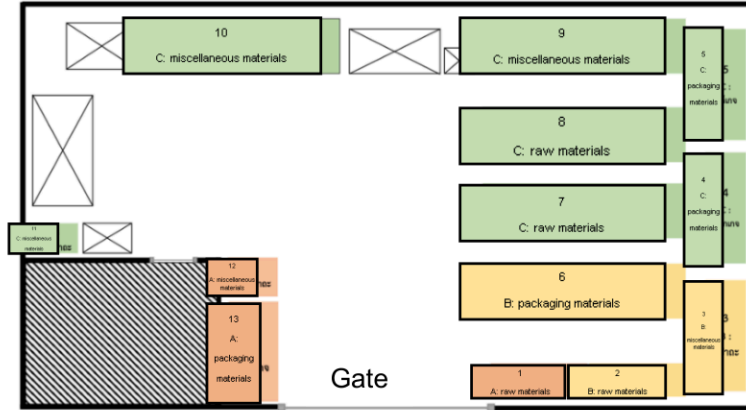


Figure 3 Inventory Layout after Implementing Improvements (1)

Furthermore, considerations are made for weather and environmental factors, ensuring that certain raw materials are protected from sunlight or heat. Implementing the FIFO and FEFO principles, products within this group are organized on the middle shelves, as depicted in Figure 4.

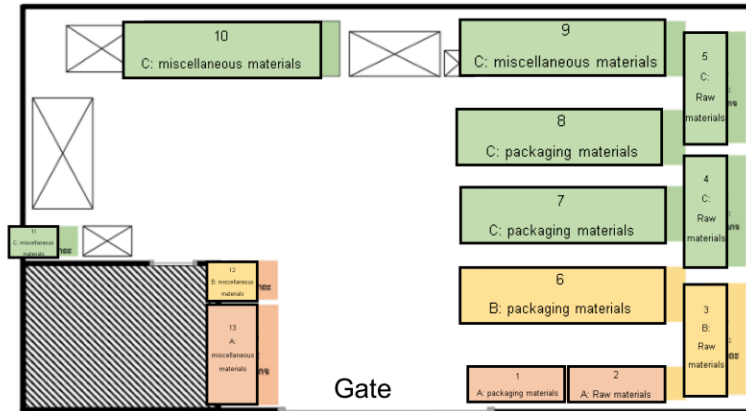


Figure 4 Inventory Layout after Implementing Improvements (2)

Forecasting Sales from Historical Data with Microsoft Excel Program

Analysing 24 months of historical sales data for four products across five branches, Excel program was used. By comparing forecasting methods with MAPE as an indicator, Exponential Smoothing showed the lowest error. A forecast graph will be generated, along with a pop-up window displaying the format for Forecast and Seasonal numbers. Adjustments can be made for desired forecasts, including quantity increases if necessary. Pressing the create button generates forecast results, as depicted in Figure 5.

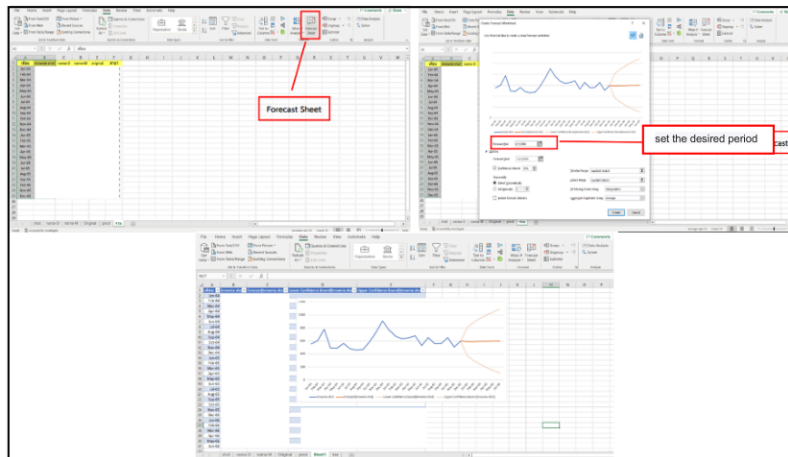


Figure 5 Sales forecasting using Forecast Sheet mode in Excel program

Once the forecast values have been obtained for all five branches, a further three-month forecast is conducted in order to develop a delivery plan for each branch. The sample of forecasted values for Brownie Shot across the branches are illustrated in Table 7.

Month	Product A	Branch	Month	Product A	Branch	Month	Product A	Branch
Jan-23	589	1	Jan-23	542	3	Jan-23	229	5
Feb-23	590	1	Feb-23	456	3	Feb-23	160	5
Mar-23	592	1	Mar-23	370	3	Mar-23	91	5
Jan-23	1,497	2	Jan-23	2,244	4			
Feb-23	1,477	2	Feb-23	2,104	4			
Mar-23	1,458	2	Mar-23	1,964	4			

Table 7 The Forecasted Values for Product A Across the Branches

After reviewing the forecast values, it was noted that some items showed a consistent decline, resulting in negative or non-positive values. These items may need to be revised for long-term delivery planning. Instead, generating forecasts at shorter intervals within a 24-month is advisable to ensure more accurate forecasts for these specific items. It is recommended to focus on sales data from the past 12 months.

Individualized Delivery Plans for Each Branch

The primary warehouse's freight schedule was examined, revealing that the Chiang Mai branches consist of Branch 1 and 2, with deliveries scheduled for Mondays, Thursdays, and Saturdays. The Bangkok branches include Branch 3, 4, and 5, with transport rounds scheduled for Wednesdays and Fridays. The delivery plan will be further analysed using historical daily sales data from 2022, considering the percentage of weekly sales and delivery cycles. Table 8 presents a sample of quantities and percentages of weekly sales for Product A in January 2022 at Branch 1.

Week	Day	Product A	Percentage	Week	Day	Product A	Percentage
Week 1	Fri-Sat	62	8.1	Week 3	Sun-Mon	50	6.5
Week 1	Sun-Mon	99	12.9	Week 3	Tue-Wed-Thu	52	6.8
Week 1	Tue-Wed-Thu	77	10.0	Week 3	Fri-Sat	51	6.6
Week 1	Fri-Sat	41	5.3	Week 4	Sun-Mon	30	3.9
Week 2	Sun-Mon	67	8.7	Week 4	Tue-Wed-Thu	37	4.8

Week 2	Tue- Wed-Thu	60	7.8	Week 4	Fri-Sat	46	6.0
Week 2	Fri-Sat	58	7.6	Week 5	Sun-Mon	37	48
Total						767	100

Table 8 The percentage of weekly sales for Product A at Branch 1 in January 2022

This analysis will enable the formulation of a comprehensive delivery plan for each store's cycle, as shown in Table 9.

				The forecasted values for Product A – Jan 2023 – Branch 1
				589
Week	Day	Product A	Percentage	The delivery quantity
Week-1	Fri-Sat	62	8.1	48
Week-1	Sun-Mon	99	12.9	31
Week-1	Tue-Wed-Thu	77	10.0	59
Week-1	Fri-Sat	41	5.3	31
Week-2	Sun-Mon	67	8.7	51
Week-2	Tue-Wed-Thu	60	7.8	46
Week-2	Fri-Sat	58	7.6	45
Week-3	Sun-Mon	50	6.5	38
Week-3	Tue-Wed-Thu	52	6.8	40
Week-3	Fri-Sat	51	6.6	39
Week-4	Sun-Mon	30	3.9	23
Week-4	Tue-Wed-Thu	37	4.8	28
Week-4	Fri-Sat	46	6.0	35
Week-5	Sun-Mon	37	48	28
Week-5	Tue			47
				589

Table 9 Delivery plans for Product A at Branch 1 in January 2023

Subsequently, a delivery plan is devised for each product at every branch.

Discussion and Conclusion

The study combined inventory improvement techniques such as ABC analysis, FIFO, FEFO principle, and plant layout design within a company case study. Additionally, delivery plans for each branch were formulated based on the analysis of sales forecast data using Microsoft Excel functions and historical sales data. The results demonstrate that the inventory layout diagrams, as depicted in Figure 4, serve as practical guidance for the company's operations, ensuring greater safety from environmental factors and facilitating ease in locating and picking items. Furthermore, the developed delivery plans for each branch are optimized and practical, aimed at reducing losses arising from shortages and excessive ordering.

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