Proposed Forecasting and Inventory Management System to Reduce Out of Stock: A Case Study of Distributor of Agricultural Product

Kiagus Muhammad Amris Amrullah(✉) and Gatot Yudoko

School of Business and Management, Bandung Institute of Technology, Jalan Gelap Nyawang No. 1, Bandung 40132, Indonesia
kiagusmuhammad_amrisamrullah@sbm-itb.ac.id

Abstract. A distributor of agricultural products sells Rockwool, which is imported from the Netherlands. The problem faced by the distributor is the product that is often out of stock resulting in a reduced customer service level. This research aims to overcome the out stock of Rockwool products by proposing a forecasting and inventory management system. The method used is by comparing 8-time series analysis methods based on the last 3 years and comparing 3 models of the inventory management system based on the last 1 year. The forecast method is determined based on the smallest forecast error, and the inventory management system is determined based on a model that applies to the company. The result showed that simple exponential smoothing with an alpha of 0.38 was chosen as the forecast method, and the fixed order quantity model was chosen as an inventory management system. Besides ensuring stock availability, this result also provides cost savings.

Keywords: Out of Stock · Demand Forecasting · Inventory Management · Warehouse

1 Introduction

One of the agricultural methods that are developing in Indonesia is the hydroponic method. Limited land and high land prices are the factors driving this method to develop rapidly, especially in densely populated urban areas, because the advantages of this method are that it can be applied to limited space and some plants are not seasonally dependent. This method does not use soil as a growing medium and water containing a nutrient solution [1, 2]. As a substitute for soil, growth media can be made from coal, sponge, cocopeat, sand, Rockwool, vermiculite, moss, wood powder, and fern stems [3].

PT AAP is one of the distributors and importers of growth media and hydroponic nutrition in Bogor, West Java. As a distributor, PT AAP must properly manage the supply chain of products for hydroponic needs so that farmers and retailers in the hydroponics sector can run well and sustainably. One of the main products marketed by PT AAP is

R. Hurriyati et al. (Eds.): GCBME 2022, AEBMR 255, pp. 382–388, 2024.
https://doi.org/10.2991/978-94-6463-234-7_38

Rockwool, which is imported from the Netherlands. Rockwool is a growing medium for a hydroponic system made of basalt rock heated at high temperatures and commonly used for growing tomatoes, cucumbers, and red pepper [4].

During 2020, there was a rapid increase in sales of Rockwool at PT AAP, increasing from 10,492 bales and 332 slabs in 2019 to 25,870 bales and 831 slabs in 2020. This increase in demand was not predicted before, so the availability of Rockwool stock in the warehouse and the amount of Rockwool imports were not balanced with market demand. This condition resulted in out-of-stock, and some customers did not get the products.

The increasing demand for Rockwool and insufficient stock availability prompted the company to place large orders in late 2020. However, the number of Rockwool orders has exceeded market demand, where customer demand has been fulfilled, but there is still much stock in the warehouse. To balance demand and stock, PT AAP tries to reduce the number of orders to 1–2 containers per month. The company also tries to keep the inventory level around 1–2 containers of Rockwool available in the warehouse.

The system for ordering 1–2 containers per month runs smoothly until September 2021, when stock availability is maintained and does not experience out-of-stock. Condition changed in October 2021 when the company again experienced out-of-stock for Rockwool. According to the company's assumption, out-of-stock in October is caused because the company should not only order 1–2 containers per month. In addition, there was a delay in the arrival of Rockwool to Indonesia in March and August 2021. The availability of Rockwool stock in the warehouse that is often out of stock makes PT AAP look for an ordering system and the amount of Rockwool stock that must be stored in the warehouse.

Literature review used is inventory management, which is part of supply chain management that is related to the planning, implementing, and controlling of goods, services, and related information between the point of origin and the point of consumption to meet customers' requirements. The goal of inventory management is to keep the inventory level balanced at all times without ever having too much or too little of each product in stock [5]. The five main process steps in inventory management were forecasting, purchase, goods receipt, storage, and goods issue [6].

Demand Forecasting

Forecasting can be classified into four basic types, which are qualitative, time series analysis, casual relationships, and simulations. Time series analysis is the most often used in supply chain planning and control. Time series analysis is a forecast in which past demand data is used to predict future demand [7].

Inventory Management

An inventory system provides the organizational structure and the operating policies for maintaining and controlling goods to be stocked. The system is divided into single-period systems and multiple-period systems. There are two general types of multiperiod inventory systems: fixed-order quantity models and fixed-time period models [7].

Fixed-order quantity models, also called the economic order quantity (EOQ) or Q-model, attempt to determine the specific point, R, at which an order will be placed and the size of that order, Q. The order point, R, is always a specified number of units. An

order of size Q is placed when the inventory available, currently in stock and on order, reaches point R [7].

In a fixed–time period system (P-model), inventory is counted only at particular times, such as every week or every month. In a fixed–time period system, reorders are placed at the time of review (T), and the safety stock must protect against stockouts during the review period and lead time [7].

Based on the background and literature review used, the objectives of this research is to overcome out-of-stock Rockwool products by proposing a forecasting and inventory management system.

2 Methods

This research aims to overcome out-of-stock from Rockwool by proposing forecasting and inventory management. The primary data was obtained from the result of depth interviews and observations. The secondary data was obtained from the company's historical data and literature review.

In determining the forecasting method, this research compares 8-time series analysis methods based on the last 3 years, namely 3-month moving average, 4-month moving average, 5-months moving average, 3-month weighted moving average, 4-months weighted moving average, 5-months weighted moving average, simple exponential smoothing, and exponential smoothing with the trend. Weight in the 3-months weighted moving average for periods 1, 2, and 3 are 20%, 30%, and 50%. Weight in 4-month weighted moving average for periods 1, 2, 3, and 4 are 10%, 20%, 30%, and 40%. Weight in 5-months weighted moving average for periods 1, 2, 3, 4, and 5 are 5%, 10%, 15%, 30%, and 40%. The value of and β in exponential smoothing is determined using a solver with intervals $0 < \alpha < 1$ and $0 < \beta < 1$ to get the lowest MAD. The initial forecast is determined based on demand in the previous period, and the initial trend is 0. The selection of the forecast method is based on the smallest forecast error, Mean Absolute Deviation (MAD).

In determining the inventory management system, this research compares 3 models of inventory management based on the last 1 year, namely current models, fixed-order quantity models, and fixed-time period models. The selection of an inventory management system is based on its ability to be applied to the company.

3 Result and Discussions

By using excel, the forecast error obtained in Table 1.

After comparing the data with the last 3 years, the forecast method that can be used is simple exponential smoothing with α of 0.38 because it has the smallest forecast error, namely Mean Absolute Deviation (MAD). MAD is the average error in the forecasts, using absolute values, and measures the dispersion of some observed value from some expected value [7]. MAD is a better measure of error than MSE if the forecast error does not have a symmetric distribution. Even when the error distribution is systemic, MAD is an appropriate choice when selecting forecasting methods if the cost of a forecast error is proportional to the size of the error [8]. The forecasting method, simple exponential

Table 1. Forecast Error

Forecasting Method	MAD
3-months moving average	2.49
4-months moving average	2.64
5-months moving average	2.68
3-month weighted moving average	2.52
4-month weighted moving average	2.60
5-months weighted moving average	2.65
Simple exponential smoothing	2.47
Exponential smoothing with trend	2.51

smoothing itself, is a forecasting method widely used in retail firms, wholesale companies, and service agencies [7]. With a forecast system, it is expected that the company will be able to project future demand to determine the quantity that needs to be ordered and prepare the funds needed for purchases.

In managing inventory, PT AAP does not yet have a special policy that provides guidelines for managing the purchase of goods and how much inventory level must be maintained. Currently, companies are still using estimates based on experience to determine the purchase of goods and the amount of inventory in the warehouse so that purchases and inventories change over time. During 2021, the company ordered 17 times with an order quantity of 1–2 containers per order. Based on the data that has occurred, the annual total cost for 2021 was 4,779,550,476 IDR, with ordering and holding costs being 64,473,021 IDR.

In compiling a fixed-order quantity model, several data are needed, including annual demand, ordering cost, and holding cost, to determine how much quantity must be ordered (EOQ). Based on the calculations, the EOQ is 6.9 containers, or about 7 containers. By knowing the EOQ, the frequency of orders in one year can be determined, which is 5 times in one year. In addition to order policies, safety stock must also be determined in the inventory management system to prevent stockouts due to varying demands or uncertain lead times. The result of the calculation of safety stock with a service level of 95% is 3.54 containers. After knowing the amount of safety stock, the reorder point (ROP) can be calculated, and the result shows 10.11 containers.

From the calculations in the fixed-order quantity model, the company orders 7 containers when the inventory level reaches 10.11 containers, of which 3.54 containers are safety stock. Assuming the company orders 5 times a year, the annual total cost for Rockwool products is 4,749,568,830 IDR, with ordering and holding costs being 64,473,021 IDR.

In preparing the fixed-time period model, the length of the review period must be determined first. In this research, 1 month was used to conduct a review because it was in accordance with the company's habit of conducting stock reviews every month. During each review period, the inventory level is calculated, and the company places an order to increase the inventory level until it reaches the base-stock level. To determine the

base-stock level, the safety stock needs to be determined first. After the safety stock is known, the base-stock level can be calculated, resulting in 12.74 containers. The result of the calculation of safety stock with a service level of 95% is 3.46 containers.

From the calculations in the fixed-time period model, the company reviews every 1 month and orders every month so that the inventory level returns to 12.74 containers. Because the company orders every month and assuming the company orders 3 containers per order, the annual total cost for Rockwool products is 4,764,434,387 IDR, with ordering and holding costs being 49,356,932 IDR.

Based on Table 2, the amount of safety stock that the company currently implements is still below the amount of safety stock in the fixed-order quantity model and fixed-time period model. This indicates that the company's assessment of safety stock is still less than its needs. This can be proven by stockouts occurring again from October to December 2021. Therefore, the company must increase the amount of safety stock stored in the warehouse to meet the demand when conditions are unusual, regardless of the inventory management system that the company will implement.

Of the 2 proposed models, the fixed-order quantity model is more suitable to be applied to companies in terms of the currently available warehouse capacity where the warehouse can store a maximum of 7 Rockwool containers. This capacity is still lower than the inventory level required for the fixed-order quantity model, which requires a capacity to accommodate up to 10.3 containers. However, this capacity requirement can be overcome by using the warehouse section for other products first when the Rockwool stock is high, and the company directly sends Rockwool to the customer because usually

Table 2. Comparison Between the Three Models

	Current Model	**Fixed-Order Quantity Model**	**Fixed-Time Period Model**
Safety stock	1–2 containers	3,54 containers	3,46 containers
Order Quantity	1–2 containers per order	7 containers per order	Adjust to reach base level 12,74 containers
Order frequency	Uncertain	Order 5 times in a year when the inventory level reaches 10,1 containers	Order 12 times a year or order every month
Capacity requirement	Unknown	Up to 10,54 containers	Up to 12,74 containers
Cashflow effect	The funds needed are small but continuous	Many funds are needed at one time	The funds needed are small but continuous
Service level	Unknown	95%	95%
Total cost	4,779,550,476 IDR	4,749,568,830 IDR	4,764,434,387 IDR
Ordering & holding cost	64,473,021 IDR	34,491,375 IDR	49,356,932 IDR

the customer has ordered and paid for it, even though the goods have not yet arrived in Indonesia or the company warehouse. When compared to the fixed-time period model, which requires a capacity to accommodate 12.74 containers, the requirement is higher than the fixed-order quantity capacity requirement, so the fixed-time period model is more difficult to apply to companies at this time.

In an aspect of the total cost, the fixed-order quantity model provides the lowest annual total cost compared to other models, although it is only 0.6% lower than the current model. However, if we do not include purchasing costs and only compare the ordering costs and holding costs of each inventory management model, then the fixed-order quantity model can save up to 46.5% of the current model. This percentage difference is due to the purchasing cost itself covering almost 99% of the total cost. Furthermore, the purchasing cost has the same value in all models, so the percentage of savings from each proposed model will not show large results because the contribution of purchasing costs is too large.

Based on the explanation above, it can be determined that the alternative solution to overcome stock outs for Rockwool products at PT AAP is to apply demand forecasting with the simple exponential smoothing method with α of 0.38 and apply a fixed-order quantity model as an inventory management system.

The problem that may be felt by the company if implementing inventory management, especially fixed-order quantity models, is that it requires more funds than usual to purchase 7 containers at a time. This situation differs from the previous condition, where purchases are made in small quantities with much frequency. This difference makes the company must be able to manage the company's finances to be able to place orders in large quantities.

4 Conclusion

This research provides forecasting and inventory management proposals to overcome the occurrence of out-of-stock. The forecasting method that is suitable for use in companies is simple exponential smoothing with α of 0.38. Meanwhile, the inventory management that can be applied by the company is a fixed-order quantity model where the company orders based on EOQ calculation when the inventory level reach reorder point. Based on historical data for 2021, the company orders 7 containers of Rockwool when the inventory level reaches 10.1 containers, where 3.54 containers of the stock are used as safety stock.

References

1. A. P. Lestari, A. Riduan, Elliyanti, and D. Martino, "Pengembangan Sistem Pertanian Hidroponik pada Lahan Sempit Komplek Perumahan," Saintifik, vol. 6, no. 2, pp. 136–142, https://doi.org/10.31605/saintifik.v6i2.259 (2020).
2. M. Subandi, S. Birnadi, S. Ginandjar, and B. Frasetya, "Identifikasi Arah Pengembangan Riset dan Tinjauan Sistem Teknik Budidaya Hidroponik di Indonesia," p. 14 (2020).
3. E. S. Putra, J. Jamaluddin, and M. D. Djatmiko, "Comparation of Hydroponic System Design for Rural Communities in Indonesia," J. Arts Humanit., vol. 7, no. 9, pp. 14–21, https://doi.org/10.18533/journal.v7i9.1490 (2018).

4. D. Dannehl, J. Suhl, C. Ulrichs, and U. Schmidt, “Evaluation of substitutes for rock wool as growing substrate for hydroponic tomato production,”J. Appl. Bot. Food Qual., vol. 88, no. March, pp. 68–77, https://doi.org/10.5073/JABFQ.2015.088.010 (2015).
5. D. Singh and A. Verma, “Inventory Management in Supply Chain,” Mater. Today Proc., vol. 5, no. 2, pp. 3867–3872, https://doi.org/10.1016/j.matpr.2017.11.641 (2018).
6. J. Varajão, M. M. Cruz-Cunha, and A. Trigo, “Organizational integration of enterprise systems and resources: Advancements and applications,” Organ. Integr. Enterp. Syst. Resour. Adv. Appl., pp. 1–463, https://doi.org/10.4018/978-1-4666-1764-3 (2012).
7. F. R. Jacobs and R. B. Chase.: Operation and Supply Chain Management, Fifteenth. McGraw-Hill Education, New York (2018).
8. S. Chopra and M. Peter.: Supply chain management: strategy, planning, and operation - third edition (2014).