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INVENTORY COST EFFICIENCY IN 2019 BY APPLYING PERISHABLE INVENTORY POLICY AND DEMAND FORECAST IN AGRICULTURE WHOLESALER: STUDY CASE PT BIMANDIRI AGRO SEDAYA

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Abstract

Low efficiency in spending inventory cost could be harmful for every company. In agriculture industry, there is bigger risk of having higher inventory cost because inventory could turn into wastages. This research aims to help PT. Bimandiri Agro Sedaya, as one of the biggest agriculture wholesalers in Indonesia, to reduce their inventory cost by applying new inventory review policy.

From the analysis, researcher proposes Holt-Winter exponential smoothing with multiplicative model as new forecast method to improve their demand forecast. The method is chosen since it has the smallest forecast error among others. By using this model, the measure accuracy is as follows: MAPE = 30%, MAD = 903, MSE = 1,009,481. The firm are also suggested to use periodic inventory review policy for the next period because it has the lowest inventory cost, which is Rp 2,031,107,223, after being simulated for 2019. By applying this policy, the firm can reduce their inventory cost until 65%.

Keywords: demand forecast, inventory review policy, agriculture wholesalers, inventory cost

1. Introduction

1.1. Background

People around the world are struggled to consume fruit and vegetable as required by World Health Organization (WHO). The organization suggest people to consume around 400 grams of fruit and vegetable every day, depends on the age of respective people. Until present, 45 percent people globally are failed to consume fruit and vegetable sufficiently. While in Indonesia, people only consume around 180 grams of fruit and vegetable in average (Asian Journal of Agriculture and Development, 2013). In the other hand, Indonesia has produced various fruit and vegetable across thirty-four provinces. One of the most productive provinces is West Java, with tomato has the highest contribution to annual national production. (Kementerian Pertanian Indonesia, 2018).

Agriculture products have various shelf life. Some products, which have already passed their shelf life, become wastages and cannot be sold to customers. Agriculture waste has become global issue, with annual global wastages reach 28 percent of agriculture areas. All players in agriculture industries have wastages in their warehouse, including wholesalers. As intermediaries between suppliers and retailers, they have tough job to maintain the quality of agriculture products and deal with short shelf life.

Wastages always exist in agriculture industry, no matter what the condition looks like. But wastages can be reduced through proper inventory management. Non-optimal inventory management of quickly perishable goods is one of the most frequent cases of the waste problem in grocery retail (Kranert et.al., 2012). Inventory management answers two questions, which are when an order should be placed and what quantities should be ordered. Inventory replenishment policies will fall between two categories: continuous and periodic review policy. The special consideration of the lifetime of an item is the significant factor leading to the high complexity of inventory systems. One reason of the difficulties is that when one period of time goes by, the age of each unit in stock must calculated once again (Chiu, H. N., 1995).

Agriculture products are seasonal commodities. The supply chain of these commodity categories is composed of growers, wholesalers and retailers. Wholesaler purchases agriculture products from farmers and store them immediately in special storages. Those products could be sold to retailers periodically until products' shelf life is expired. Agriculture products are perishable inventories. Strong relation exists between key performance indicators and parameters of perishable inventory system. The decrease of mean stock level can reduce waste quantity in grocery stores. It can be achieved through shortened order cycle and more frequent delivery of quickly perishable goods. (Van Donselaar and Broekmeulen, 2012).

Like others, wholesalers in Indonesia also have similar problem in managing their perishable inventory. One of the wholesalers is PT. Bimandiri Agro Sedaya. As one of the biggest wholesalers in Java, they suffered annual financial loss. From operational perspective, wastages amount strongly affect their high expense in the year. Unlike manufacture goods, excess stocks in agriculture commodities could result into wastages. The firm do not have any clues to manage their inventory since their demand forecast is not accurate enough. In 2019, they produced average of more than 500 kilograms wastages for each day. Wastages are rejected products from their primary customers. Thus, the firm should find other customers with lower quality requirement. To reduce wastages, the firm should also reduce their inventory on hand by improving their ordering policy. In the end, they will be able to reduce their inventory cost.

1.2. Research Questions

1. What is the most critical inventory of all commodities for the firm?
2. How do the firm reduce inventory cost for the most critical inventory?
3. How do the firm improve their demand forecast for the most critical inventory?
4. How do the firm manage their most critical inventory for the upcoming period?

1.3. Literature Review

1. Time Series Forecasting

According to Silaparasetti (2017), demand forecasting is the key driving factor in planning and decision making in supply chain management. Forecasting is a prediction or estimation of an actual value in a future time period. Accurate forecasting of food demand has significant economic and environmental consequences, while unreliable forecasts can result in a multitude of problems that ripple across the food supply chain, ranging from frequent changes to production schedules, expedited shipments and high inventory carrying costs to poor customer service levels, stock outs and significant waste.

Data from the time series represent the interaction between both predictable and unpredictable trends. Prediction techniques based on time series data are conducted on the assumption that future series values can be estimated from past values. Several patterns may appear, such as trends, seasonal variations, cycles, and variations around an average. In some cases, time series may also contain irregular and random variations. In this research, researcher follows time series forecast method, which are used in previous study by Petropoulos and Carver (2016). Those methods are naïve approach, simple moving average, simple exponential smoothing, Holt exponential smoothing and Holt-Winter exponential smoothing.

Naïve forecast uses a single previous value of a time series as the basis of a forecast. Advantages of native methods are free of charge, quick and easy to prepare because data analysis is nonexistent, and it is easily understandable. On the other side, this method does not provide high accuracy forecast. The accuracy of naïve forecast can serve as a standard of comparison against which to judge the cost and accuracy of other techniques.

Simple moving average is used to exclude irregularities in history pattern. All actual values of period have same weight. It makes moving averages turns slow in response to changes into latest data point. Decreasing number of values in the average increases the weight of more recent value, but it does so at the expense of losing potential information from less recent values. In selecting the number of periods to include, the decision maker must take into account that the number of data points in the average determines its sensitivity to each data point. The fewer the data points in an average, average tends to be more responsive, even to random variations.

Equation 1 Simple Moving Average for Period t

$$F_t = MA_k = \frac{\sum_{i=1}^{k} A_i}{k}$$

Simple exponential smoothing is based on the level of previous period. The level is calculated from previous forecast plus a percentage of the difference between that forecast and the actual value of the series at that point. Simple exponential smoothing method will give more weight to the more recent historical data. In fact, weights of combination are controlled by smoothing constant. The smoothing constant represents a percentage of forecast error. The quickness of forecast adjustment to error is determined by the smoothing constant. The closer its value to zero, the slower the forecast will be to adjust to forecast error and the greater the smoothing.

Equation 2 Forecast for Next Period using Simple Exponential Smoothing

$$F_{t+1} = (1-\alpha)F_t + \alpha A_t$$

Forecasting trended data is known as Holt exponential smoothing. It uses the same technique as simple exponential smoothing, but it also applies trend. An alpha factor determines the weight regarding how quickly forecast reacts to a change in recent history, while a beta factor determines how quickly the forecast picks up trend in history. If the data exhibit trends (change of the level over time), either upwards or downwards, then simple exponential smoothing will produce biased forecasts.

Equation 3 Initial Level (Holt's Exponential Smoothing - Linear)

$$l_t = \alpha A_t + (1-\alpha)(l_{t-1} + b_{t-1})$$

Equation 4 Initial Trend (Holt's Exponential Smoothing - Linear)

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1}$$

In the most complex form, exponential smoothing methods have three separate components: level, trend and seasonality. Such methods are widely known as Holt-Winters (HW) exponential smoothing methods. Each component is smoothed separately using a different smoothing parameter. The estimation of the level is a linear combination of the seasonally adjusted actual and the seasonally adjusted forecast.

- Additive

Equation 5 Initial Level (HW Exponential Smoothing - Additive)

$$l_t = \alpha(A_t - s_{t-m}) + (1-\alpha)(l_{t-1} + b_{t-1})$$

Equation 6 Initial Trend (HW Exponential Smoothing – Additive)

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1}$$

Equation 7 Seasonal Component (HW Exponential Smoothing - Additive)

$$s_t = \gamma(A_t - l_t) + (1-\gamma)s_{t-m}$$

- Multiplicative

Equation 8 Initial Level (HW Exponential Smoothing - Multiplicative)

$$l_t = \alpha\left(\frac{A_t}{s_{t-m}}\right) + (1-\alpha)(l_{t-1} + b_{t-1})$$

Equation 9 Initial Trend (HW Exponential Smoothing - Multiplicative)

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1}$$

Equation 10 Seasonal Component (HW Exponential Smoothing - Multiplicative)

$$s_t = \gamma\left(\frac{A_t}{l_t}\right) + (1-\gamma)s_{t-m}$$

Every instance of demand has a random component. The random component manifests itself in the form of a forecast error. Forecast errors contain valuable information and must be analyzed carefully. Firm use forecast error to determine whether the current forecasting method is predicting the systematic of demand accurately. The error for period t comes from the difference between forecast result for period t and actual demand for period t. Forecast errors influence decisions in two different ways. One is in making a choice between various forecasting techniques, and the other is in evaluating the success or failure of a technique in use.

To evaluate the result of forecast error, researcher uses three kind of parameters from previous study by Chopra and Meindl (2016). Those parameters are mean squared error, mean absolute deviation and mean absolute percentage error. Mean squared error can be related to the variance of forecast error. In effect, random component of demand has a mean of 0 and variance of mean squared error. Mean absolute deviation is the average of absolute value of the error over all periods. This measurement can be used to estimate the standard deviation of the random component, assuming it is normally distributed. In this case, standard deviation of random component is 1.25 of mean absolute deviation. Similar with mean squared error, mean of random component is assumed to be 0. Mean absolute percentage error is the average absolute error as a percentage of demand.

Equation 11 Mean Squared Error

$$MSE_n = \frac{\sum_{t=1}^{n} E_t^2}{n}$$

Equation 12 Mean Absolute Deviation

$$MAD_n = \frac{\sum_{t=1}^{n} A_t}{n}$$

Equation 13 Absolute Error

$$A_t = |E_t|$$

Equation 14 Mean Absolute Percentage Error

$$MAPE_n = \frac{\sum_{t=1}^{n} \left|\frac{E_t}{D_t}\right| 100}{n}$$

1. Inventory Management

Inventory system is a set of policies applied to maintain and control inventory levels. A good inventory management will maximize business profits, and vice versa. Critical decisions are about the balance of ordering and transportation costs. Thus, a balance between transportation costs, order costs and inventory costs are necessary

Company should not monitor inexpensive items with the same intensity as very expensive items. ABC analysis helps company to divide on-hand inventory into three classifications on the basis of annual dollar volume. ABC analysis is an inventory application of what is known as the Pareto principle. Class A represents 75 percent of dollar usage. Class B represents 20 percent of dollar usage, while class C has the other 5 percent of dollar usage. (Chopra and Meindl, 2016).

2. Inventory Policies

An inventory management deals with two questions: when an order should be placed and what quantities should be ordered. Inventory replenishment falls into one of two categories: a periodic or continuous inventory control. These two policies are derived from the Economic Order Quantity (EOQ) model, which is the classic model of inventory management. EOQ model is one of the timing decision models answering questions of when and how much to order (Ma & Kremer, 2013).

Continuous review policy is the policy where inventory is monitored real time and orders are placed when inventory level reaches the reorder point. The advantages of this policy is could handle the situation when demand is high, but the loss of order quantity is variant. The supplier has a great possibility to make amount of orders variation. This situation is contrary to periodic review policy. For periodic review policy, the inventory position is checked at fixed intervals only and orders are placed based on the current position. Reorder point is made to raise inventory level to a predetermined point (Ma, J. & Kremer, G., 2013).

3. Performance Metrics

The performance of the policies will be compared on the basis of number of lost sales, number of outdates, service level, fill rates, and total cost of operation. (Madduri, 2009). Number of lost sales represents sales that are lost in each cycle due to lack of inventory on hand. Number of outdated items refers to the fraction of products that do not get sold at the end of their useful life and have to be disposed. Cycle service level measures the fraction of time during an order cycle when the customer demand is satisfied. It is also the probability of not having a stockout in a replenishment cycle. Fill rate is defined as the fraction of customer orders that are satisfied from inventory. The total cost of operation is the sum of the fixed ordering cost, the cost of ordering the individual products, the inventory holding cost, the penalty cost for not meeting the demand, and the disposal cost for a product that has perished.

- Number of Lost Sales
- Continuous review policy

Equation 15 Number of Lost Sales - Continuous Review Policy

$$\int_{R}^{\infty} (x - R) f(x, LT)\, dx$$

- Period review policy

Equation 16 Number of Lost Sales - Period Review Policy

$$\int_{S}^{\infty} (x - S) f(x, RP + LT)\, dx$$

Where:

$f(x, LT)$ is the distribution of lead time demand for continuous review

$f(x, RP + LT)$ is the distribution of demand during the review period plus lead time

- Cycle Service Level
- Continuous review policy

Equation 17 Cycle Service Level - Continuous Review Policy

$$CSL = Prob\ (Demand\ during\ lead\ time\ LT \leq R)$$

- Periodic review policy

Equation 18 Cycle Service Level - Periodic Review Policy

$$CSL = Prob\ (Demand\ during\ LT + RP \leq S)$$

- Fill Rate

Equation 19 Fill Rate

$$fr = 1 - \frac{Expected\ shortage\ in\ a\ cycle}{Expected\ demand\ in\ a\ cycle}$$

- Inventory Cost
- Continuous review policy

Equation 20 Total Inventory Cost - Continuous Review Policy

$$A + c * Q + h * (IH) + p * \int_{R}^{\infty} (x - R) f(x, LT)\, dx + O * (EO)$$

- Periodic review policy

Equation 21 Total Inventory Cost - Periodic Review Policy

$$A + c * Q_p + h * (IH) + p * \int_{S}^{\infty} (x - S) f(x, RP + LT)\, dx + O * (EO)$$

Where:

A = ordering cost

c = material cost

h = holding cost

IH = inventory on hand

p = penalty cost

O = outdated cost

EO = expected outdated items

2. Method

2.1. Research Design

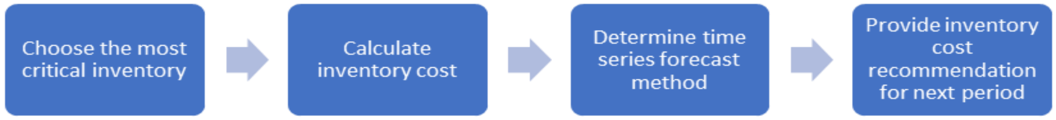
Researcher states that the firm face critical problem, which is high wastage amount. To solve the problem, this research uses quantitative approach. The approach is used to find the most critical commodity. Then, researcher tries to find the most suitable inventory review policy and forecast method as well. All calculations of quantitative approach are gained from equations in literature review.

2.2. Data Gathering

Researcher uses both primary and secondary data to complete this research. For primary data, researcher conducted interview and observation in company warehouse. The warehouse is located in Lembang, West Java, Indonesia. Primary data includes root cause identification, variable costs for calculating inventory review policy, company profile and business process. Secondary data includes company annual wastages, inventories on hand and historical demand throughout 2019 and some literature review from previous studies.

2.3. Data Analysis

To answer research questions, researcher should analyze data after executing data gathering. At first, researcher should determine which commodity is the most critical by applying ABC analysis. After that, the chosen commodity is analyzed further through inventory review policy. There are two kind of inventory review policies. But researcher only chooses the policy with lowest inventory cost, out of two policies. After that, researcher wants to predict future demand of commodity. In this case, time series forecasting methods are used. Like inventory review policy, only one forecasting method is chosen as demand prediction data to calculate inventory cost for next period. Inventory review policy follows the previous year chosen policy.



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3. Result and Discussion

Instead of analyzing all commodity, researcher decides to analyze deeply on the most critical commodity. The firm have an aim to reduce their inventory cost and maintain their annual service level above 90 percent. To solve the whole problem, researcher should start from the most impactful inventory. Based on ABC analysis, Cilembu sweet potato is chosen since it has high contribution to firm annual revenue in 2019. It is worth to be analyzed further to solve research problem efficiently.

Researcher uses two kind of inventory review policies, which are periodic and continuous. The output is annual inventory cost from Cilembu sweet potato in 2019. These policies should have lower inventory cost than current condition since the firm do not use any policies. Continuous review policy is differed by lead time, while periodic review policy is differed by both lead time and review period. Since this research analyzes perishable inventories, the result involves many uncertainty and possibilities. In the table below, researcher only includes the lowest inventory cost of all possibilities in periodic and continuous inventory review policy, respectively. Besides annual inventory cost, there are also other performance metrics, such as number of lost sales, number of perished inventories, cycle service level and fill rate. Other performance metrics follow the used possibility option after deciding the lowest inventory cost. These metrics are used to show regarding how many customers they will be able to serve in 2019, if they used either periodic or continuous inventory review policy.

Table 1 Result Comparison between Periodic and Continuous Inventory Review Policy in 2019

	Periodic	Continuous
Inventory Cost	Rp 2,031,107,223	Rp 2,331,004,201
Number of Lost Sales	8,294 kg	3,283 kg
Number of Perished Inventories	153 kg	55 kg
Cycle Service Level	90.5%	94.9 %
Fill Rate	98.3%	98.1%

Annual inventory cost is the total cost, which are summed up from penalty cost, disposal cost, holding cost and material cost. Penalty cost and disposal cost are calculated from number of lost sales and perished inventories, while holding cost is Rp 2,375 and material cost is Rp 9,500 for every kilogram. Current annual inventory cost is Rp 5,680,890,375. From the table above, periodic inventory policy is the most suitable policy to be applied by the firm for Cilembu sweet potato. Although it has higher number of lost sales and perished inventories, periodic inventory policy offers less inventory on hand in a year. It happens because inventories are reviewed regularly each day. The firm will only place an order if current inventory level is below their minimum level, which have already been calculated before calculating inventory cost.

To predict future demand, researcher applies several methods of time series forecast. These methods include moving average, single exponential smoothing, Holt exponential smoothing and Holt-Winter exponential smoothing. Each of forecast method is compared to others, based on forecast accuracy. Forecast is computed through weekly basis, forming 52 weeks in total.

Table 2 Forecast Accuracy of Time Series Method

Forecast Method	MSE	MAD	MAPE
Moving average	1,928,101	1,043	39
Single exponential	1,854,966	1,034	41
Holt exponential	2,271,294	1,193	46
Holt Winter exponential (Additive)	1,232,012	958	30
Holt Winter exponential (Multiplicative)	1,009,481	903	30

Based on three metrics of forecast accuracy, Holt Winter exponential method with multiplicative model offers the best result. It includes level, trend and seasonal factors. Thus, forecast method can control the random variation better than other forecast methods. The result is used to predict future demand of Cilembu sweet potato in the first quarter of 2020. Due to global pandemic, researcher decides to predict only from January until March 2020. Time series forecast could contain significant bias to predict demand in global pandemic since it does not consider external factors and just focus on analyzing historical demand.

Using periodic inventory review policy, researcher provides prediction for the firm on how much expense they probably spend in the first quarter of 2020. The method is repetitive to previous question, which calculating possible lowest inventory cost in 2019.

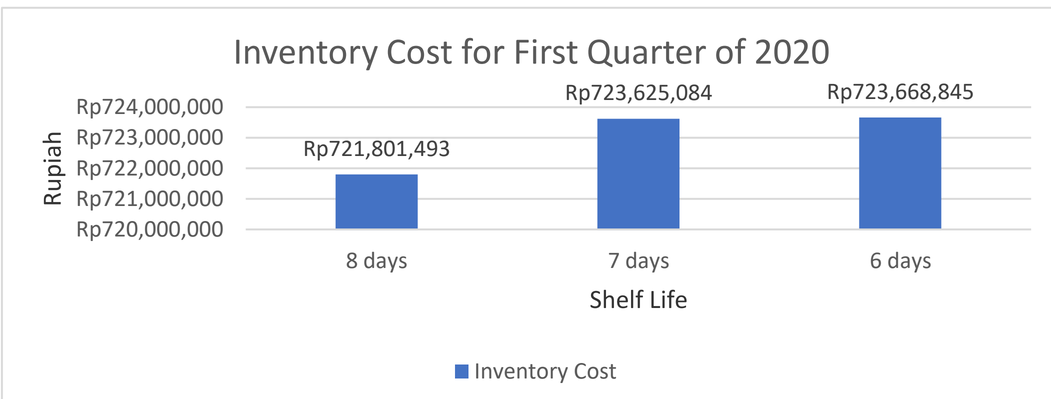

Figure.1 Prediction Inventory Cost for the First Quarter in 2020 Using Periodic Inventory Review Policy

Out of three alternatives of shelf life, eight-days shelf life is the most effective to reduce inventory cost. Inventory level should be reviewed every day after the firm completes order shipping. After passing eight days in shelf, inventories should be disposed from the warehouse. The firm could have lost sales items until 2,823 kilograms and perished inventories only reach 21 kilograms. They are predicted to have decent rate in serving their customers, with cycle service level reaches 90.4 percent and fill rate achieves 98.4 percent. The rates have surpassed the firm's minimum requirement. In the end, this method has categorized as successful in solving firm's problem.

The firm can reduce inventory cost if only they apply right ordering decision to support their current inventory review policy. They should place an order every day until inventory level reaches 2,213 kilograms unless their current inventory level equals or exceeds the maximum inventory level. It has already included safety stock, which is about 1,284 kilograms. Safety stock level is more than half of total inventory level because weekly demand is fluctuated. Safety stock can help the firm to reduce risk of having stockouts and reach desired service level at the same time.

4. Conclusion and Recommendation

Based on the research, Cilembu sweet potato is chosen as the most critical commodity since it had the highest annual revenue in 2019. Since the firm do not have any inventory review policy, researcher chooses periodic review policy after being compared to continuous review policy. The chosen policy can reduce current inventory cost significantly until 65 percent. For predicting future demand, Holt-Winter exponential smoothing has the lowest forecast method. The method is chosen as the new forecast method since it has significant improvement toward existing forecast method. Forecast is launched for the next three months, before global pandemic affects Indonesia, to minimize bias result. Forecast result is used to predict inventory cost for the first quarter of 2020. After identifying estimated inventory cost, the firm can measure other performance metrics as well. Besides that, they can get clear instruction on how much and when they should place an order.

Researcher provides several recommendations for the firm to be applied in the future. The firm, which is PT. Bimandiri Agro Sedaya, are suggested to apply periodic inventory review policy to control their inventory of Cilembu sweet potato and make decisions regarding how many and when they should place an order. The firm should check their inventory position regularly and ensure their product quality to maximize shelf life. Then, researcher also suggests the firm to apply this research to other commodities, which are critical to their annual revenue. For readers, they can use this research to reduce wastages in their factory, especially if they are struggled to manage perishable inventories.

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