Improving Inventory Management by Better Forecasting Method for Healthcare Industry Company

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Abstract

The healthcare industry is one of the most valuable industries today. Its value is expected to continue to increase along with the increase of the world's population. In line with this, the number of requests for assistive devices related to services in the healthcare industry is expected to increase. That way, companies need to do good forecasting so that production results can be maximized. Based on the research results, the weighted moving average method is the best forecasting method that can be used by manufacturing companies that focus on tools in the healthcare sector. This is due to the relatively smaller mean average percentage errors (MAPE) value compared to other forecast methods.

Keywords
Healthcare, Forecasting, Linear Forecasting, Weighted Moving Average, MAPE.

1. Introduction
In most developed countries, the healthcare sector accounts for more than 10% of GDP (WHO 2019). Healthcare is also one of the world's most important and fastest-growing industries. From global data, the healthcare industry was worth $8.7 trillion in 2017, and it is expected to increase at a 5.4 percent compound annual growth rate (CAGR) to $10.059 trillion by 2022. The demand for healthcare continues to rise as the world population ages. Countries are aggressively seeking more efficient medical solutions and policies, such as precision health and digital medicine. They hope to improve medical care efficiency by accelerating the development of advanced medical technologies in order to improve health and extend life (Harold 2013).

Medical equipment such as trolleys, wheelchairs, hospital beds, infusion stands, safety cabinets, and others are important needs in the healthcare industry. The availability of this equipment at the hospital is critical, especially if an unusual incident occurs that necessitates additional medical attention (Eric et al. 2022). Hence it is important for manufacturers in the healthcare industry to forecast the demand and plan their material requirement to be able to set business in motion and generate profits.

Forecasting and planning have an enormous role in establishing the production rate to balance the customers' orders. A good production forecasting and planning can lead to a low production cost, on time delivery system, and minimum waste. In order to maximize certain strategy and policy, a company needs to have a well designed production planning and forecasting, including well planned material stock schedule. A poor material supply and storage system will have a negative impact on production such as delays in the completion of products or even stopping the production, which can lead to a decrease in customer satisfaction level that will decrease the competitiveness of the company (Rahmat et al. 2020).

Demand forecasting has been shown to be a significant factor in supply chain improvement, resulting in an increase in the companies' responsiveness to actual customer demand (A. Ross 2004). This paper addresses the implementation of demand forecasting to optimize production planning in the medical equipment industry. The

problem faced by PT. X is how to forecast the production of a product so that PT. X can fulfill future customer's demands.

Since PT. X is a medium-sized enterprise, it uses a simple forecasting technique to determine their production for the upcoming week. Due to the ever-changing trends of the demand in the medical industry, this condition can lead to opportunity loss. Also, the raw materials order planning methods used by PT X that are either greater or lesser than the number of raw materials required for production. Too much on-hand inventory of raw materials can cause losses to a company because of the holding cost.

Meanwhile, this paper attempts to implement forecasts to improve inventory management. It is important to choose the appropriate modeling approaches as the first step for accurate demand forecasting (Chen et al. 2019). In forecasting the estimated level of demand in order to avoid excesses and not less inventory quantities based on past data (Dewi and Chamid 2019).

1.1 Objectives

The objective of this study is to give forecasting method recommendations for PT. X. capitalize the available market demand for PT. X by adjusting the number of demand with the number of production. This can be done by improving materials requirement planning methods using demand forecasting to avoid out-of-stock material. by doing so, PT X will experience an increase in sales, hence increasing the company's profit.

2. Literature Review

2.1 Make to Order

Make to Order (MTO) is a production strategy when production of an item starts until an order is received from a customer. This strategy is used to produce products to customer specifications after an order has been received, hence it is best for an intermittent operation (Reid and Sanders 2013). Examples of firms that use this strategy are custom-tailored clothing, machinery, or any product made to customer specification. This strategy allows customers to specify their offered product and they are willing to wait for an order to be made. In general, companies use make to order when products are expensive to manufacture and store also several product options are offered (Arnold et al. 2008).

Flowchart that describes the MTO production strategy of PT X are shown in figure 1.

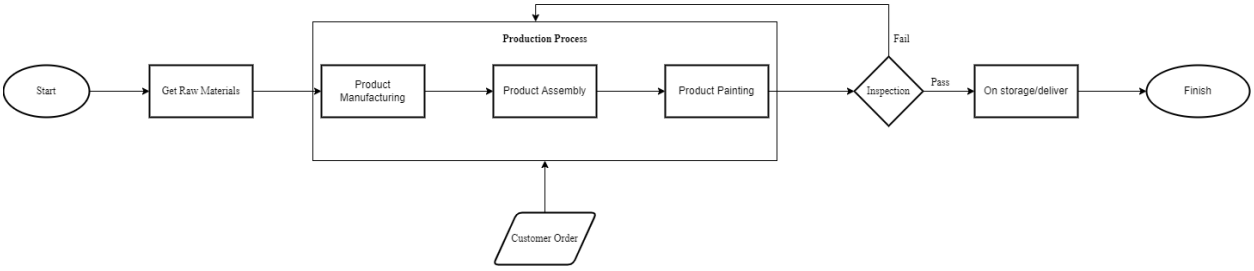

Figure 1. Flowchart describing MTO production strategy of PT X.

2.2 Demand Forecasting

Forecasting is the process of predicting what conditions will exist in the future. Forecasts are important for all decision-making tasks, from inventory management and scheduling to planning and strategic management, and it remains the foundation of all science (Makridakis and Hibon 2000). Forecasting is needed for production planning, such as budgets, labor planning, long lead time, procurement items, and overall inventory levels. Rather than single end items, forecasts are generated for groups or families of products. Identification of the best forecasting techniques for each data set, or, even, for each series separately, is still the 'end goal' in the forecasting field, and, as a result, empirical comparisons in this approach are seen as important things (Fildes and Makridakis 1995). There are two kinds of forecasting methods, quantitative and qualitative. For qualitative forecasting methods, they're using experts, intuition, surveys, or certain judgment to produce its estimation. It can also be called a subjective forecasting method. For quantitative forecasting methods, they depend on mathematical models to make forecasts. There are several examples

of quantitative models, such as regression models, moving averages, exponential smoothing, ARIMA, and also advanced methods such as Bayesian method and simulation. (Zellner et al. 2021)

Demand forecasting is the basis for a lot of managerial decisions in the supply chain such as demand planning, order fulfillment, production planning, and inventory control (Narayanan et al. 2019). Because of the volatility and variable uncertainties inherent in forecasting, it is frequently difficult to achieve the appropriate level of precision. Customers normally expect delivery in a reasonable amount of time, and manufacturers must prepare for future demand for products or services and ensure that they have the capacity and resources to meet it. Standard product manufacturers must have saleable things on hand right away, or at least to have materials and subassemblies available to shorten the delivery time. Firms that make-to-order products are unable to begin production before a consumer placed an order, but they must have sufficient staff and equipment to meet demand.

There is no one-size-fits-all solution that can solve all types of forecasting problems and outperform all other forecasting models in all scenarios and under all conditions. However, under certain circumstances, certain models may outperform others. For instance, there was a previous study that compared the forecasts generated by an artificial neural network (ANN), triple exponential smoothing, ARIMA, and multiple aggregation methods (Alon & Sadowski, 2001). They concluded that ARIMA and triple exponential smoothing outperform the other models when the macroeconomic conditions are stable, whereas ANN and multiple aggregations might work better in volatile markets. The point from these studies is that we shall construct or choose an appropriate model based on the characteristics of the demand.

3. Methods

This research follows several steps in order to reach a conclusion. First step is data collection. Data collection process is conducted by collecting recapitulation of monthly product demand, in this case monthly instrument trolley demand that has been recorded by the PPIC Department of PT. X. Factory visit is conducted in order to collect the data as well as interviewing the PPIC Department of PT. X whether there is a problem in the production process of the trolley. Then, the data will be pre-processed by filtering the data needed for calculations. The extracted data is taken from the order documentation. By processing the collected and preprocessed data, researchers compare the actual demand with the forecasted demand to decide which forecasting method is the best suit for this case by using the MAPE value.

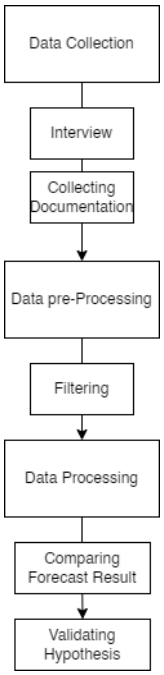

Figure 2. Research Methodology Flowchart

3.1 Weighted Moving Average

For the weighted moving average, the forecasted demand in the first period is calculated by using the average demand from the previous sixth month periods. The forecasted demand for the period after is calculated by adding the weighted demand from the previous period with weighted average of the last sixth month periods. Furthermore, exponential smoothing (α) value of 0.05 is used in the calculation of the weighted moving average due to the confidence level standard of 95% is set for the past sixth months data trend reliability.

The formula for the Double Weighted Moving Average is as follows:

$$Forecast = (\alpha \; x \; latest \; forecast \; at \; n \; period) + ((1 - \alpha) \; x \; old \; forecast \; at \; n \; period)$$

3.2 Linear Forecasting

Another method of forecasting used in this research is linear forecasting. By using the principles of linear regression, forecasts of demand can be obtained using this method. Below is the general equation for linear regression:

$$y_i = \beta_0 + \sum_{k=1}^{n} \beta_n x_{ik} + \varepsilon_i$$

Figure 3. General Equation for Linear Regression

y_i represents the dependent variable for i-th observation; x_{ik} represents the independent variable(s) for i-th observation, β_0 represents the intercept and β_n represents the coefficient for x_{ik}; and finally, ε_i represents the error team for i-th observation.

Linear forecasting in this research is conducted using Microsoft Excel. Using the syntax FORECAST(x; data_y; data_x). x is the data point which we want to predict the value, data_y is the dependent array or range of data, and data_x is the independent array or range of data.

4. Data Collection

According to interviews with PT. X company, table 1 below shows order records for trolley products in 2020 and 2021. PT. X company did not have any order for trolleys for some period of month. Mostly, the order came in the half remaining of the year period. The table also shows that the demand may fluctuate by a huge gap since it is a medium-to-long term investment product. This can be detrimental to the company which results in the company failing to meet consumer demand. Of course, the risk of errors in rearranging supplies from suppliers or selling those supplies will also increase.

Table 1. Trolley Order Data at PT. X (in unit)

Product	Year	Period											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trolley	2020	0	0	0	0	0	21	8	0	13	68	2	0
	2021	0	1	0	1	5	8	35	16	0	0	0	1

5. Results and Discussion

5.1 Numerical Results

Table 2 below shows the result of each forecasting method for 2021. Based on the calculations, the linear forecasting method has a total of forecasted demand 1.7 times higher than the weighted moving average method. This certainly makes sense because linear forecasting takes little-to-no trends or seasonality into account.

Table 2. Forecasted Demand for 2021 (in unit)

Product	Method	Period											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trolley	Linear Forecasting	22	24	26	27	29	31	33	35	39	41	43	45
	Weighted Moving Average	14	16	19	20	20	15	17	18	18	18	18	17

Table 3 below shows the comparison between the result of the linear forecast method with the actual demand. Based on the calculations, the linear forecasting method has an average of 33 demand per month while the actual has an average of only 9 demand per month. The linear forecasting method has a mean absolute percentage error (MAPE) value of 848.

Table 3. Linear Forecast and Actual Demand Comparison (in unit)

Period	Linear Forecast	Actual	Absolute Percentage Error
Jan	22	0	0
Feb	24	1	2265
Mar	26	0	0
Apr	27	1	2647
May	29	5	488
Jun	31	8	291
Jul	33	35	5
Aug	35	16	119
Sep	39	0	0
Oct	41	0	0
Nov	43	0	0
Dec	45	1	4365

Table 4 below shows the comparison between the result of the weighted moving average method with the actual demand. Based on the calculations, the weighted moving average method has an average of 18 demand per month while the actual has an average of only 9 demand per month. The weighted moving average method has a mean absolute percentage error (MAPE) value of 457.

Table 4. Weighted Moving Average and Actual Demand Comparison

Period	WMA	Actual	Absolute Percentage Error
Jan	14	0	0
Feb	16	1	1514
Mar	19	0	0
Apr	20	1	1883
May	20	5	298
Jun	15	8	89
Jul	17	35	51
Aug	18	16	11
Sep	18	0	0
Oct	18	0	0
Nov	18	0	0
Dec	17	1	1634

5.2 Graphical Results

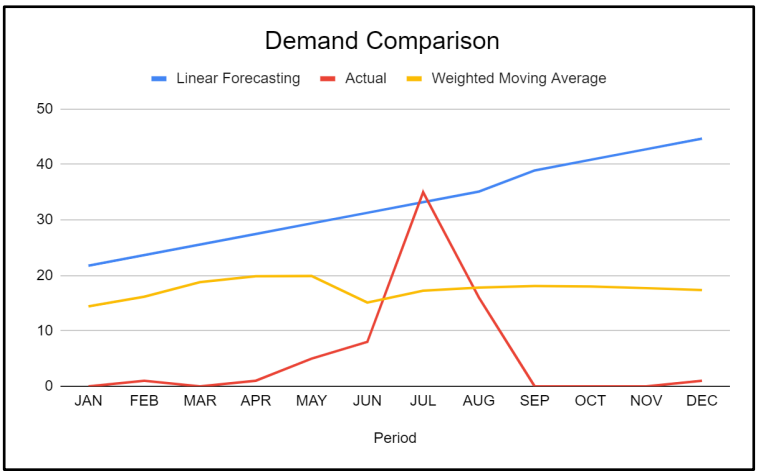

Figure 4. Actual Demand Comparison with Two Forecasting Method Result in 2021

Figure 4 above shows the result of each forecasting method for 2021. The figure shows that the linear forecasting method results in a continuous increase of demand. On the other hand, the weighted moving average has a relatively stagnant trend. This is one of the impacts resulting from using the exponential smoothing technique.

5.3 Proposed Improvements

Based on the MAPE value, the weighted moving average method is considered much more feasible to use in forecasting the trolley product demand. Hence, it is reasonable for PT. X company to use weighted moving average method for forecasting the product demand in the future. Table 5 below are the forecasted demand for the trolley product in 2022 that used the weighted moving average method. This forecast can help PT.X to better prepare the Material Requirement Planning for the next production period. The average number of demand per month is 4 in 2022. In addition, since there is no constraint from lead time and with the presence of demand fluctuation, PT.X can use the chase production strategy.

Table 5. Forecasted Demand for 2022 (in number of unit)

Period	Forecasted Demand
Jan	8
Feb	4
Mar	2
Apr	3
May	3
Jun	4
Jul	4
Aug	3
Sep	3
Oct	3
Nov	3
Dec	3

5.4 Validation

The result of comparison of Absolute Percentage Error value between linear forecast method and weighted moving average method is validated using a statistical test.

Table 6. Absolute Percentage Error Value (percent)

Linear Forecast	Weighted Moving Average
0	0
2265	1514
0	0

2647	1883
488	298
291	896
5	51
119	11
0	0
0	0
0	0
4365	1635

The Absolute Percentage Error Value of both method model are depicted on the following graph:

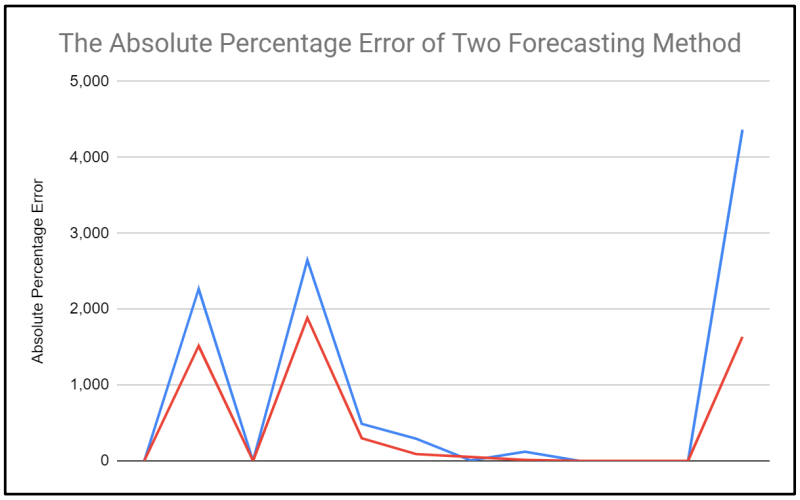

Figure 5. Graphic of Absolute Percentage Error of Two Forecasting Method

From the chart on figure 5, it is concluded that the data does not follow a normal distribution. Each of the sample points also has autocorrelation with each other as it is a time series. Therefore, parametric statistical tests cannot be used. To compensate for the data quality, a non-parametric test is used for the statistical test. The test is conducted to investigate whether there is any significant evidence, at the 5% level, that the absolute percentage error value of Linear Forecast is bigger than Weighted Moving average. Wilcoxon Rank Sum Test is used to validate null hypothesis and alternative:

$$H0: \quad \mu 1 \geqslant \mu 2; \; H1: \; \mu 1 < \mu 2$$

The Wilcoxon Rank Sum Test is then done using the Google Spreadsheet. The resulting output from the software is shown on the table 7 below.

Table 7. Wilcoxon Rank Sum Test

α	0.5
tail	2
W	78
W-crit	115
significance	yes

Since W-crit > W we can't reject the null hypothesis. So, it is concluded that the absolute percentage error value of Linear Forecast is bigger than the Weighted Moving average.

6. Conclusion

The forecast results in 2022 show a decline which is not in line with the addition of the value of the healthcare industry. However, PT.X needs to enhance forecasting in its production activities. Through forecasting, the risk of the emergence of unmet demand can be reduced. As a company that offers goods that are medium-to-long term investment, PT.X needs to choose the right forecasting method. Some of the best known forecasting methods include linear forecasting and weighted moving average. Between the two, the better forecast method to use is the weighted moving average based on the mean absolute percentage error. This can happen because the method has taken into account the trend of the data provided.

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Biography

Arif Furqan Wantuah is an undergraduate Industrial Engineering student at Universitas Indonesia. He is currently in the fourth semester of his study. He's also currently active in student communities and organizations. His research interests are mainly in project management, business development and analysis, data analytics, and system information.

Atsalabi Dimas Fadillah is an industrial engineering Universitas Indonesia sophomore. He was a project officer at a social program that has a goal to increase awareness about the importance of higher education and successfully reach thousands of students from more than 20 schools. He is currently a Chief Marketing Officer at Engineering Corporation FT UI. Atsalabi also already has international work experience as he is currently a Business Analyst at MZZ Asia. Atsalabi also has a rich experience in case competitions. In 2021, he was the champion of a national case competition that revised a company CSR (corporate social responsibility) program. His research interests are mainly in supply chain and inventory management.

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