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Proposed Improvement of Demand Forecast Accuracy using Six Sigma DMAIC in PT XYZ

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Abstract

This research aimed to optimizing strategies for PT XYZ, specifically focusing on bridging the gaps between demand forecasts and actual market demand of lubricants product, with a strong emphasis on the Business-to-Business (B2B) segment. B2B introduces unique challenges, necessitating a specialized approach. Employing the Six Sigma DMAIC methodology, a comprehensive analysis is conducted to uncover deficiencies in current sales forecasting methods. The Holt-Winter method is then applied to offer robust remedies, effectively minimizing complexities such as seasonal patterns and market trends. Drawing on historical data from the B2B lubricants segment served by PT XYZ, the analysis establishes a solid empirical foundation. This comprehensive forecasting approach positions PT XYZ as a market leader, equipped to anticipate and preempt market fluctuations. The application of the Holt-Winter time series method not only significantly enhances forecasting accuracy but also mitigates substantial risks linked to inventory imbalances concerning demand. The implementation of such a robust forecasting framework stands to elevate the operational efficiency of PT XYZ, with a paramount commitment to maintaining customer satisfaction in the dynamic business landscape.

Kata Kunci:
Perkiraan permintaan; produk pelumas; six sigma DMAIC, time series forecasting

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Abstraks

Penelitian ini bertujuan untuk mengoptimalkan strategi PT XYZ, khususnya berfokus pada menjembatani kesenjangan antara perkiraan permintaan dan permintaan pasar aktual pada produk pelumas, dengan penekanan kuat pada segmen Business-to-Business (B2B). B2B menghadirkan tantangan unik sehingga memerlukan pendekatan khusus. Dengan menggunakan metodologi Six Sigma DMAIC, analisis komprehensif dilakukan untuk mengungkap kekurangan dalam metode perkiraan penjualan saat ini. Metode Holt-Winter kemudian diterapkan untuk menawarkan solusi yang ampuh, yang secara efektif meminimalkan kompleksitas seperti pola musiman dan tren pasar. Berdasarkan data historis dari segmen pelumas B2B yang dilayani oleh PT XYZ, analisis ini memberikan landasan empiris yang kuat. Pendekatan peramalan yang komprehensif ini menempatkan PT XYZ sebagai pemimpin pasar yang mampu mengantisipasi dan mencegah fluktuasi pasar. Penerapan metode deret waktu Holt-Winter tidak hanya meningkatkan akurasi perkiraan secara signifikan namun juga memitigasi risiko besar yang terkait dengan ketidakseimbangan inventaris terkait permintaan. Penerapan kerangka peramalan yang

kuat akan meningkatkan efisiensi operasional PT XYZ, dengan komitmen utama untuk menjaga kepuasan pelanggan dalam lanskap bisnis yang dinamis.

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INTRODUCTION

Indonesia's lubricant market stands as one of the top ten largest lubricant markets globally, with an impressive demand of approximately 995.7 Kilotones in 2021. Looking ahead to the future, the estimated demand for 2026 is projected to reach a remarkable 1,138 Kilotones, exhibiting a promising compound annual growth rate (CAGR) of 2.7% (Kline, 2022). The accurate forecasting of lubricants demand is crucial for manufacturer, distributors, and customer. The manufacturing site generally tends to order sales. If the output is lower than the demand, the buyer chooses the manufacturer to meet the demand of their order, which means the chance of losing an order (Dou et al., 2021). The choice of forecasting method makes a significant difference to both the customer service and cost tradeoffs available to management (Acar & Gardner, 2012).

Thus, ability to fulfil market demand by ensuring availability of products in the market, will enable a company to win the market competition and avoid loss of opportunities. Demand forecasting is a crucial component of demand management, directly impacting manufacturing companies planning, revenues, and actors through the supply chain (Rožanec et al., 2021). Accurate demand forecasting can help lubricant manufacturers in Indonesia to optimize their production process, reduce overstocking, and stays competitive in the market.

The need for this research arises from the challenge that PT. XYZ is facing, which significant gap inventory availability and actual demand. One of the effects of inventory excess is the well-known whip effect that distorts the flow of materials along the supply chain channel (Salais-Fierro et al., 2020). This excess of inventory ties up its financial resources and results in wastage of resources, such as raw materials, warehouse space, and labour. This situation can lead to increased costs, reduced profitability, and cash flow problems.

The objective of this research is to finding the best solution that can reduce gap between inventory availability and actual demand of B2B lubricants product in PT.XYZ by implementing a robust solution in the implementation plan. This study's focus solely on how to improve demand forecast accuracy of PT XYZ. The historical data used for this study is from January 2021 to June 2023 and focused to the most contributed sector which is B2B sector.

Six Sigma term popularized by Motorola in the mid-1980s as a metric for measuring defects and improving quality. Six Sigma has evolved into a robust continuous and business process improvement initiative over the past thirty years (Byrne et al., 2021). The objective of Six Sigma is to identify and remove errors in business processes and, thereby, the causes of variability in processes (Graafmans et al., 2021). It encompasses a comprehensive philosophy and a wide array of methods designed to identify and eliminate defects. In the context of Six Sigma, a defect refers to any component or aspect of a product or process that falls outside the defined specification limits set by customers. These defects can manifest at any stage or activity within a company's operations. Consequently, the Six Sigma program aims to minimize and control the variation that can lead to these defects. For reducing variations in business processes, Six Sigma often employs statistical methods to quantify changes in process performance (Graafmans et al., 2021).

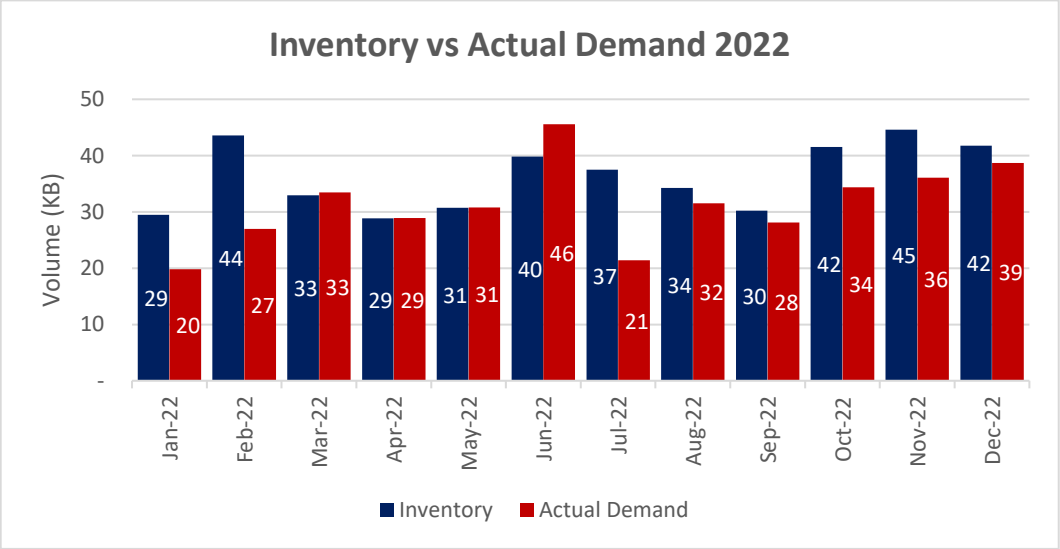
DMAIC (Define, Measure, Analyze, Improve, Control) a systematic approach used to guide the scheduling and execution of Six Sigma projects (Rifqi et al., 2021). The DMAIC cycle begins by defining the problem or opportunity for improvement. Once the problem is defined, the process is measured to understand its current performance. The data collected during the measurement phase is then analysed to identify the root causes of the problem. The improve phase of the DMAIC cycle focuses on developing and implementing solutions to the root causes of the problem. Once the solutions are implemented, the process is controlled to ensure that the improvements are sustained.

Demand forecasting is a critical activity for companies in various industries, as it helps them optimize inventory management and supply chain operations. In the lubricants industry, demand forecasting is particularly important because the

products have a limited shelf life and require specific storage conditions. Overstock can be a significant problem, leading to product waste, increased inventory carrying costs, and reduced profitability. Hence, this research aims to explore the theoretical foundation for improving demand forecast accuracy to reduce overstock in a lubricants company. Demand forecasting in the lubricants industry requires the consideration of specific factors such as the type of lubricants, customer segments, and geographical locations. Forecasting procedures are best when they relate to a problem to be solved in practice. The theory can then be developed by understanding the essential features of the problem. In turn, the theoretical results can lead to improved practice (Petropoulos et al., 2022).

The study started with the business issue, which is the low accuracy between forecast and actual demand. This disparity gives rise to various challenges related to product availability and sales performance. To enhance the optimization of sales for lubricant products, especially within the B2B sector, companies require more accurate forecasting methods. To improve their strategic planning, companies must possess the capability to anticipate lubricant demand based on available data and the appropriate methodology. To identify potential factor, this research employing Six Sigma DMAIC methodology. Six Sigma offers a set of tools for identifying the contributing factors to these challenges and proposing alternative solutions. Additionally, incorporating a time series analysis model, a statistical technique for processing historical data to predict future trends, will be beneficial.

The proposed strategy will be formulated by employing various forecasting techniques, including moving averages, single exponential smoothing, double exponential smoothing, and the Holt-Winters method. The forecast outcomes generated by each of these models will be evaluated for accuracy using the mean absolute percentage error (MAPE) model. The model that yields the lowest MAPE value will be recommended for forecasting purposes. This approach aims to deliver more accurate forecasting results that closely align with the actual demand.



Picture 1. Inventory vs Actual Demand 2022
Source: company sources (2023)

Picture 1 shown the data of available inventory and actual demand of PT XYZ on 2022. The data depicted in the picture 1 reveals that for approximately eight months in 2022, product supplies exceeded the demand. However, during the remaining four months, the demand effectively absorbed the supplies. Consequently, this pattern of supply surpassing demand has led to a situation of inventory overstocks, as supplies consistently outpace the level of demand.

METHOD

The primary data source will be the historical sales data, which included information on product demand and sales volume. The quantitative data analysis is performed using statistical software Minitab to generate statistical findings. The results obtained from the quantitative analysis were then interpreted and compared with the qualitative data

to provide a comprehensive understanding of the research problem and to support the overall research objectives. By employing rigorous data collection methods and conducting quantitative analysis, this study aimed to provide empirical evidence and statistical support for the improvement of forecast accuracy. The data analysis method employed in this study conducted on demand forecasting method. The analysis of demand forecasts will employ the Minitab system to assess the methods are, single exponential smoothing, double exponential smoothing, holt-winter and ARIMA method. For error calculation methods, such as Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE), will be utilized. The method yielding the lowest error across all the calculations will be deemed the most favorable and optimal to use for demand forecasting. This approach ensures that the chosen method provides the highest level of accuracy in predicting future demand patterns

RESULTS

DMAIC Six Sigma

Define phase resulting that during 2021-2023 there is a significant challenge emerged concerning the accuracy of demand forecasts within their B2B sectors. This challenge had a direct impact on the company's inventory management, resulting in inefficient storage costs. Currently, PT XYZ relies on historical data from the previous quarter to predict demand within the B2B sector. However, this approach has proven ineffective due to the dynamic nature of demand within this sector, which varies from month to month. Recognizing the necessity for a more comprehensive and adaptable forecasting method tailored to their specific business needs, PT XYZ is actively seeking to enhance its forecasting processes.

Measure phase explaining there is a fluctuation in Demand Forecast Accuracy (DFA) for PT XYZ on 2022. The fluctuation resulted overstock finished goods inventory accumulation of 47 KB. The overstocked primarily attributed to the low accuracy of demand forecasting. Consequently, it becomes imperative for PT. XYZ to prioritize the improvement of demand forecast accuracy. After measuring the issue, the analysis conducted using Current Reliality Tree (CRT). PT XYZ has identified three primary underlying factors: Company Competitiveness, Government Policy, and Ineffective Forecasting Method. Company Competitiveness and Government Policy will not be included in the research scope as the data seems to be qualitative and it really depends on current political condition which will be very dynamic. This research will be focus on minimized the ineffective forecast method. These factors have contributed to various issues, ultimately resulting in a notable disparity between forecasts and actual demand for lubricants. For the purpose of this research, the selected root cause for in-depth analysis is the forecasting method.

Demand forecasting will be used as the Improve phase on six sigma where method of forecast will be calculated to find the best method that can improve demand forecast accuracy. The method that will be used are simple moving average, exponential smoothing, holt-winter, and ARIMA.

Table 1. Summary of Forecast Error

No.	Forecast Method	MAD	MSD	MAPE
1	Existing Forecast	3.492	19.752	40.734
2	MA 3	4.259	28.473	49.433
3	MA 6	3.986	25.389	44.129
4	Single Exponential Smoothing	3.843	22.576	42.482
5	Double Exponential Smoothing	4.230	28.430	47.803
6	Holt-Winters Method	3.278	18.994	30.652
7	ARIMA		23.563	

Source: Author's Analysis (2023)

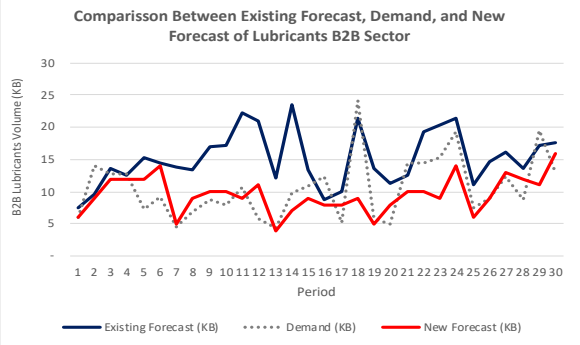
Based on table 1 results, it shows that Holt-Winters method has the lowest MAD (3.278), indicating the smallest average absolute errors. Holt-Winters method also has the lowest MSD (18.994), suggesting smaller squared errors compared to other methods. MAPE results of Holt-Winters Method also resulting the smallest error with 30.6 %. Based on the results of MAD MSD, and MAPE, Holt-Winters method is performing better rather than existing forecast. This method particularly suitable for analysing demand forecasts with historical data since this method perform relatively accurate forecast. By the error result, it is recommended to employ

the Holt-Winters method as a business solution when examining the demand data of PT XYZ to effectively incorporate seasonality and obtain precise forecasts.

DISCUSSION

Holt-Winter Method exhibits the smallest MAPE (Mean Absolute Percentage Error) in comparison to alternative methods. The holt-winter method dissects the time series data into its constituent elements, such as trend, seasonality, and residual components. Through the analysis and individual forecasting of each of these components, this approach can more precisely recognize and accommodate the underlying patterns and dynamics inherent in the data. Specifically, the holt-winter method explicitly takes into consideration the time series' trend and seasonality components. This proves particularly advantageous when the data showcases evident trends and recurrent patterns over time. By separately predicting these components, the method enhances its ability to capture and anticipate future values, thereby reducing forecasting errors

The Holt-Winters method, in a similar vein, accommodates the residual component, which represents the stochastic or unexplained variations present in the data. By integrating the residual component into the forecasting process, this method can capture any remaining unpredictable fluctuations, ultimately enhancing the accuracy of the forecasts. What sets the Holt-Winters approach apart is its adaptability when selecting suitable models and techniques for each component of the time series. For instance, distinct models can be employed to forecast the baseline level, trend, and seasonality components, allowing for a tailored approach to each aspect and the potential for overall improved accuracy. It's worth emphasizing that the Holt-Winters method often shines when applied to time series data characterized by noticeable trends, recurring seasonality, and consistent patterns. When these features are evident in the dataset, the Holt-Winters method excels at effectively capturing and modelling them, resulting in more precise and reliable forecasts.



Picture 2. Comparisson of Forecast
Source: data analysis (2023)

Picture 2 visually represents the projected demand for lubricants B2B products. Period 1-30 represents historical data from January 2021-June 2023. The graph illustrates the disparities between the existing forecast, the updated forecast, and the real demand for the lubricant products. When comparing the existing forecast to the updated one, it becomes apparent that there are variations in the forecasted values for each corresponding month. In general, the existing forecast tends to overstate the demand for B2B lubricants product, consistently producing values higher than the actual demand. In contrast, the updated forecast seems to offer a closer approximation to the actual demand, with values that are generally lower and more closely aligned with the actual demand figures. This indicates that the new forecasting method employed yields improved accuracy in predicting demand compared to the existing method. The graph underscores the significance of adopting more precise forecasting techniques, such as the new approach, to enhance decision-making, optimize resource allocation, and effectively meet the genuine market demand.

When contrasting the combined totals of Gap between new forecast and existing forecast, which amount to 7.42 KB or roughly USD 1,985,290, it underscores the substantial financial impact of this comparison. When assessing the accuracy of forecast methods, it becomes evident that the new forecast method (NF) surpasses the performance of the existing forecast method (EF). The Mean Absolute Percentage Error (MAPE) is a key metric that provides insights into the precision of these forecasts. In the case of the new forecast method, the MAPE is recorded at 30.65%, while the existing forecast method yields a notably higher MAPE of 40.73%. This discrepancy is indicative of the substantial improvement achieved by the new forecast method, resulting in a decrease in forecast error of approximately 10%. The impact of this improved forecast method is noteworthy. With a lower MAPE, it means that the new forecast method is more accurate in its predictions. This enhanced accuracy can lead to various benefits such as better resource allocation, improved decision-making, and cost savings for organizations. By reducing forecast error, the new forecast method not only provides a more reliable basis for planning and operations but also enhances the overall

efficiency of the processes relying on these forecasts.

CONCLUSIONS

This study embarked on a journey to enhance demand forecasting of PT XYZ by utilizing Sig Sigma Framework. The study has shed light on several key insights that contribute to the understanding of effective strategies in improving operational efficiency by following DMAIC (Define, Measure, Analyse, Improve, Control). Through the application of several forecasting technique, accurate demand predictions are achievable. The findings emphasize the importance of enhancing the precision of demand forecasts. Referring to table 1 which Holt-Winters method is method that resulted the smallest error amongst other forecasting method which are moving average and exponential smoothing. This means that based on historical data, the demand forecasting for lubricants product affected by seasonality. Seasonality in lubricants product caused by standard on new lubricants application is based on frequency of usage.

Through the adoption of the new forecasting method, the company can reduce the forecast error by 10% and prevent the retention of unsold lubricant products inventory, totalling **7.42 KB**, with an approximate value of **USD 1,985,290.** To execute the selected solution with efficiency, the study outlines a comprehensive plan that includes the subsequent stages which are deployment of appropriate forecasting method and monitoring evaluation. Through the diligent execution of this comprehensive plan, PT XYZ can effectively tackle the identified challenges, elevate the precision of demand forecasting, and diminish the substantial disparities between forecasts and real demand. As a result, this will lead to enhanced operational efficiency, optimized resource utilization, and more informed decision-making throughout the organization.

Six Sigma can lead to substantial improvements in forecasting accuracy, it is not without its trade-offs. Organizations should carefully assess their readiness, resource availability, and the suitability of Six Sigma for their specific forecasting challenges before embarking on improvement initiatives. Additionally, they should weigh the long-term benefits against the initial investments and potential complexities involved. Implementing Six Sigma method with DMAIC framework make a structured problem solving method. Starting from defining the main issue, collecting and analysing data, and finally come with implementation stage where the new forecast will be tested to find the method with the smallest error. For future research, it is recommended to applied advanced analytics tools and performing scenario analysis to assess the impact of different business scenarios on demand and adjust the forecasts accordingly.

Holt-Winters method offers benefits in terms of capturing trends and seasonality in time series data, but it also comes with trade-offs such as complexity, data requirements, and the need for parameter tuning. Organizations should carefully evaluate these trade-offs in the context of their specific data and forecasting needs before implementing the method.. For the future study, the researcher can observe the newly advanced technology such as machine learning algorithms and predictive analytics, to harness the power of historical data and external factors for more precise demand predictions. Regular refinement of these models ensures adaptability to changing market dynamics.

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