Drug Sales Forecasting Using Single Exponential Smoothing (Case Study: NDM Pharmacy)

Muhammad 'Ariful Furqon [1], Erik Razasyah Fahlefi [1], Nelly Oktavia Adiwijaya [1,a)],

[1] *Jl. Kalimantan Tegalboto No.37, 68121, Jember Indonesia*

[a)] *nelly.oa@unej.ac.id*

Abstract. NDM Pharmacy is a pharmaceutical retail establishment. A production production plan is vital to operational management, especially concerning inventory availability. Presently, NDM Pharmacy needs help accurately forecasting future inventory levels, particularly for three distinct categories of pharmaceuticals. This study utilizes the Single Exponential Smoothing approach to predict pharmaceutical sales in the drugstore. The analysis utilizes drug sales data from January 2022 to December 2022, which reveals a consistent average with oscillations in a horizontal pattern. The research findings demonstrate that the single exponential smoothing method uses several alpha values for optimal weight values. The assessment of forecasting accuracy is determined by the value of the Mean Absolute Percentage Error (MAPE), with a smaller MAPE indicating a higher level of accuracy in forecasting. The forecasting findings indicate that the single exponential smoothing yields the lowest MAPE for three medications, with alpha values of 0.1, 0.4, and 0.3, respectively. The MAPE for the three categories of medications is 11.96843%, 14.55955%, and 13.9353%, respectively. This study offers valuable insights for NDM Pharmacy in strategizing the future supply of pharmaceutical stock and improving the accuracy of sales predictions.

Keywords: Inventory forecasting, single exponential smoothing, pharmaceutical sales analysis

INTRODUCTION

NDM Pharmacy Store is a pharmaceutical retail business in the Wuluhan District of Jember. Pharmaceutical retailers need help managing medicine inventory to fulfill future demands. Regrettably, the operational administration of NDM stores, particularly regarding medicine supply management, lacks a well-defined structure due to its reliance on unreliable sales data. Narcotic drug market (NDM) outlets employ uncomplicated strategies, such as recurring procurement of identical drug provisions as the preceding month. Consequently, pharmacy store proprietors encounter challenges in guaranteeing sufficient accessibility of medications. In addition, the business continues to manually document sales data using books and Microsoft Excel, leading to less effective administration of sales data and drug orders.

To address the issues above, it is necessary to employ a methodology to forecast the required inventory quantity for the upcoming month and guarantee the optimal stock level for that period [1,2]. Forecasting is a technique that can be employed to address this issue by accurately predicting the appropriate inventory quantity. Forecasting is a systematic procedure used to predict future requirements, encompassing factors such as amount, quality, timing, and location necessary to fulfill the demand for products or services [3]. Hence, there is a requirement for a forecasting system that can accurately anticipate future sales at the NDM medicine Store and an efficient system to handle sales and medicine inventory information.

Forecasting predicts future events by analyzing and evaluating historical data [4]. The prediction method choice relies on the evaluated data's specific attributes. If the chosen methodology is considered suitable for forecasting, the effectiveness of the forecasting approach can be determined by measuring the prediction error. Various statistical techniques are employed to estimate time series data, such as smoothing, Box-Jenkins, econometrics, regression, and transfer function methods [5]. A time series is a collection of data points representing measurements of variables taken at regular intervals over time [6]. The time utilized may range from hours to years. Previous data patterns are crucial for comprehending time series behavior [7]. Anderson, Sweeney, Williams, Camm, and Cochran have found several data patterns, including horizontal, trend, seasonal, and cyclical [8].

I. H. Agustin (ed.), *Proceedings of the 2nd International Conference on Neural Networks and Machine Learning 2023 (ICNNML 2023)*, Advances in Intelligent Systems Research 183,
https://doi.org/10.2991/978-94-6463-445-7_4

The Single Exponential Smoothing approach is highly efficient in predicting time series data and delivering precise outcomes [9]. The selection of Single Exponential Smoothing as the forecasting method for NDM Pharmacy Store is grounded in its suitability for the business's specific challenges. Its simplicity and ease of implementation make it an attractive choice [10], particularly for a retail environment like a pharmaceutical store. The method's inherent adaptability to time series data aligns well with the nature of sales records, which are typically collected at regular intervals [11]. Moreover, single-exponential smoothing can capture specific seasonal patterns, which is crucial in the pharmaceutical industry, where demand might vary based on seasonal factors. Hence, the methodology employed in this study is Single Exponential Smoothing.

METHODS

This study is a form of quantitative research that depends on numerical data and historical patterns. Quantitative planning (forecasting) can be categorized into two distinct methodologies. The initial methodology is a time series encompassing the design phase to provide precise planning outcomes as a cohesive entity that necessitates no additional processing [12]. The investigation was conducted at the NDM Drug Store in the Wuluhan District, Jember Regency, East Java, with the postal number 68162. The investigation was conducted from October 2022 to January 2023. This research comprises multiple steps, specifically data gathering, system analysis and design, implementation of SFS, and model testing and evaluation. The research stages conducted in this study are illustrated in Fig. 1 below.

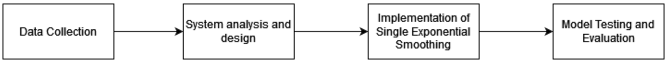

FIGURE 1. Flowchart of research stages

This study entails gathering data by comprehensively examining existing literature and conducting interviews. Literary studies entail acquiring information from several sources, such as periodicals, books, and prior references. An interview was performed with the proprietor of the NDM Drug Store to acquire drug sales data documented in the bookkeeping ledger. The planning stage is conducted to strategize the system's functioning, encompassing data processing and determining parameters for the forecasting approach. Additionally, the system incorporates planned features and provides estimations for system time. In the data processing stage, a time series plot is generated to visualize and analyze data patterns. The research employs Single Exponential Smoothing as the forecasting approach and evaluates its accuracy using Mean Absolute Percentage Error (MAPE) [13]. The forecasting data suggest the optimal amount of pharmaceutical inventory for the upcoming month.

RESULTS AND DISCUSSION

The sales data collected spans from January 2022 to December 2022 and encompasses sales data for three specific categories of drugs: Acetaminophen, Amoxicillin, and Hydrochlorothiazide. Fig. 2 displays the sales data for three different types of medicine at the NDM Drug Store.

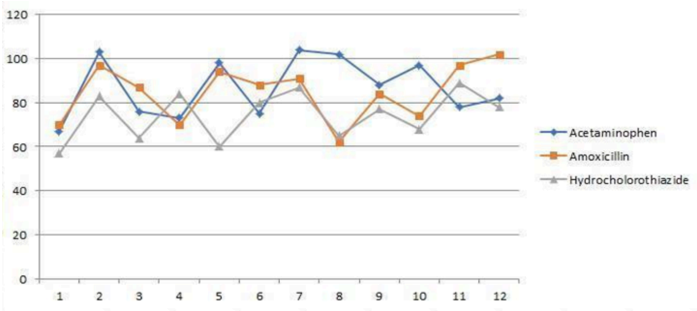

FIGURE 2. Time series data plot of drug sales data

Upon analyzing the plotted data on sales of the three categories of medications, it is evident that the data exhibits a horizontal pattern characterized by consistent fluctuations around a steady average. There is no discernible trend or seasonal variation in the data. The acquired data will be computed manually via the Single Exponential Smoothing technique. In this forecast's Single Exponential Smoothing computations, the Alpha (α) value is randomly determined as a weight value [14]. The possible values for α are 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. Equation 1 below outlines the computation of the Single Exponential Smoothing technique.

$$oneFt + 1 = \alpha * X_t + (1 - \alpha) * F_t - 1 \quad (1)$$

The Single Exponential Smoothing method cannot currently calculate using the alpha value as a weight and the expected value in the first period. As a temporary solution, the predicted value in the first period is set to match the actual data in the first period. Table 1 displays one of the manual computations for the Single Exponential Smoothing approach, utilizing alpha values of 0.1 and 0.2.

TABLE 1. Single exponential smoothing calculation using alpha values of 0.1 and 0.2

Month	**Actual**	**Single Exponential Smoothing Calculation**	
		α = 0.1	**α = 0.2**
January	67	The forecast value for the January period is 67, as it remains un-forecast.	The forecast value for the January period is 67, as it remains un-forecast.
February	103	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 67 + (1 - 0{,}1) \text{ x } 67$ $Ft + 1 = 67$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 67 + (1 - 0{,}2) \text{ x } 67$ $Ft + 1 = 67$
March	76	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 103 + (1 - 0{,}1) \text{ x } 67$ $Ft + 1 = 70{,}6$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 103 + (1 - 0{,}2) \text{ x } 67$ $Ft + 1 = 74{,}200$
April	73	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 76 + (1 - 0{,}1) \text{ x } 70{,}6$ $Ft + 1 = 71{,}14$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 76 + (1 - 0{,}2) \text{ x } 74{,}200$ $Ft + 1 = 74{,}560$
May	98	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 73 + (1 - 0{,}1) \text{ x } 71{,}14$ $Ft + 1 = 71{,}32$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 73 + (1 - 0{,}2) \text{ x } 74{,}560$ $Ft + 1 = 74{,}248$
June	75	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 98 + (1 - 0{,}1) \text{ x } 71{,}32$ $Ft + 1 = 73{,}993$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 98 + (1 - 0{,}2) \text{ x } 74{,}248$ $Ft + 1 = 78{,}998$
July	104	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}1 \text{ x } 75 + (1 - 0{,}1) \text{ x } 73{,}993$ $Ft + 1 = 74{,}09$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1 = 0{,}2 \text{ x } 75 + (1 - 0{,}2) \text{ x } 78{,}998$ $Ft + 1 = 78{,}199$
August	102	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$

Month	Actual	Single Exponential Smoothing Calculation	
		α = 0.1	α = 0.2
		$Ft + 1$= 0,1 x 102 + (1 – 0,1) x 74,09 Ft +1 = 77,085	$Ft + 1$= 0,2 x 104 + (1 – 0,2) x 78,199 Ft +1 = 83,359
September	88	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,1 x 102 + (1 – 0,1) x 77,085 Ft +1 = 79,576	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,2 x 102 + (1 – 0,2) x 83,359 Ft +1 = 87,087
October	97	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,1 x 88 + (1 – 0,1) x 79,576 Ft +1 = 80,419	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,2 x 88 + (1 – 0,2) x 87,087 Ft +1 = 87,270
November	78	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,1 x 97 + (1 – 0,1) x 80,419 Ft +1 = 82,077	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,2 x 97 + (1 – 0,2) x 87,270 Ft +1 = 89,216
December	82	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,1 x 78 + (1 – 0,1) x 82,077 Ft +1 = 81,669	$Ft + 1 = \alpha * Xt + (1 - \alpha) * Ft - 1$ $Ft + 1$= 0,2 x 78 + (1 – 0,2) x 89,216 Ft +1 = 86,973

The Single Exponential Smoothing approach utilizes MAPE evaluation to evaluates its error rate (11). Table 2 contains an instance of manual MAPE calculation using the Single Exponential Smoothing method with alpha values of 0.1 and 0.2. The Xt value represents the current sales data, whereas the Ft value corresponds to the forecasted figure.

TABLE 2. MAPE calculation for the acetaminophen uses alpha values of 0.1 and 0.2

Month	Xt	Ft		$PE = \left\lvert\frac{X_t - F_t}{X_t}\right\rvert x\,100$	
		α = 0,1	α = 0,2	α = 0,1	α = 0,2
January	67	-	-	-	-
February	103	67,00	67,00	$= \left\lvert\frac{103-67}{103}\right\rvert x\,100$ $= 34,95145631$	$= \left\lvert\frac{103-67}{103}\right\rvert x\,100$ $= 34,95145631$
March	76	70,60	74,20	$= \left\lvert\frac{76-70,60}{76}\right\rvert x\,100$ $= 7,105263158$	$= \left\lvert\frac{76-74,20}{76}\right\rvert x\,100$ $= 2,368421053$
April	73	71,14	74,56	$= \left\lvert\frac{73-71,14}{73}\right\rvert x\,100$ $= 2,547945205$	$= \left\lvert\frac{73-74,56}{73}\right\rvert x\,100$ $= 2,136986301$
May	98	71,32	74,25	$= \left\lvert\frac{98-71,32}{98}\right\rvert x\,100$ $= 27,21836735$	$= \left\lvert\frac{98-74,25}{98}\right\rvert x\,100$ $= 24,23673469$
June	75	73,99	79,00	$= \left\lvert\frac{75-73,99}{75}\right\rvert x\,100$ $= 1,342133333$	$= \left\lvert\frac{75-79,00}{75}\right\rvert x\,100$ $= 5,3312$
July	104	74,09	78,20	$= \left\lvert\frac{104-74,09}{104}\right\rvert x\,100$ $= 28,75571154$	$= \left\lvert\frac{104-78,20}{104}\right\rvert x\,100$ $= 24,80892308$
August	102	77,80	83,36	$= \left\lvert\frac{102-77,80}{102}\right\rvert x\,100$ $= 24,4268098$	$= \left\lvert\frac{102-83,36}{102}\right\rvert x\,100$ $= 18,27551373$
September	88	79,58	87,09	$= \left\lvert\frac{88-79,58}{88}\right\rvert x\,100$ $= 9,572512955$	$= \left\lvert\frac{88-87,09}{88}\right\rvert x\,100$ $= 1,037294545$

October	97	80,42	87,27	$= \left\|\frac{97-80,42}{97}\right\| x\ 100$ $= 17,094258$	$= \left\|\frac{97-87,27}{97}\right\| x\ 100$ $= 10,03119109$
November	78	82,08	89,22	$= \left\|\frac{78-82,08}{78}\right\| x\ 100$ $= 5,226554828$	$= \left\|\frac{78-89,22}{78}\right\| x\ 100$ $= 14,37922527$
December	82	81,67	86,97	$= \left\|\frac{82-81,67}{82}\right\| x\ 100$ $= 0,40360794$	$= \left\|\frac{82-86,97}{82}\right\| x\ 100$ $= 6,064190939$
	MAPE			13,22038503	11,96842808

The MAPE value for the first period was not calculated due to the absence of a forecasting value. Manual calculations were performed using two alpha values, 0.1 and 0.2, as shown in Table 2. The MAPE values have varying outcomes. The error value calculations reveal notable discrepancies, particularly in the 3rd period and subsequent periods. The accuracy of the MAPE value is significantly impacted by errors in determining the alpha value during the calculation process. The MAPE value obtained from forecasting calculations using an alpha value of 0.2 is superior to that obtained using an alpha value of 0.1. This is because the alpha value of 0.2 yields a smaller error value, resulting in a lower final MAPE value. The projected value for the medication Acetaminophen is 11.96842808. The calculation result for the medications Acetaminophen, Amoxicillin, and Hydrochlorothiazide with alpha values ranging from 0.1 to 0.9 is presented in Table 3 below.

TABLE 3. Comparison of MAPE values with alpha values of 0.1 to 0.9

Drug	**Alpha Value**								
	0,1	**0,2**	**0,3**	**0,4**	**0,5**	**0,6**	**0,7**	**0,8**	**0,9**
Acetaminophen	13,22	11,96	12,49	13,32	14,03	14,68	15,29	15,95	16,81
Amoxicillin	15,31	14,78	14,60	14,56	14,58	14,62	15,10	15,95	16,87
Hydrocholorothiazide	14,33	13,31	13,19	13,93	14,93	16,02	17,22	18,52	19,95

Upon comparing the outcomes data from system calculations and manual calculations, it is evident that the produced results from both methods are identical. The MAPE value calculation yields three alpha values, namely 0.2, 0.4, and 0.3, which represent the differences between system calculations and manual calculations. The least alpha value among the three is 0.2. The corresponding values for this alpha are 11.96843, 14.55955, and 13.19353.

Conclusion

The study introduces a methodology for predicting drug sales at NDM Drug Stores. It employs the Single Exponential Smoothing method for sales forecasting. The analysis is based on sales data from a 12-month period, specifically spanning from January 2022 to December 2022. The Single Exponential Smoothing method involves the use of various alpha values to determine the optimal weight values. These alpha values play a crucial role in the accuracy of the forecasting process. The study evaluates the accuracy of the forecasts by using MAPE. A lower MAPE value indicates a higher level of accuracy in forecasting. The results of the study show that the Single Exponential Smoothing method produced the lowest MAPE for three different types of medications, with alpha values of 0.1, 0.4, and 0.3. The specific MAPE values for these three categories of medications are 11.96843%, 14.55955%, and 13.9353%, respectively.

Acknowledgment

This research is financially supported by the Faculty of Computer Science, Universitas Jember.

References

1. Nangi J, Hartinah Indrianti S, Pramono B. (2018). Peramalan Persediaan Obat Menggunakan Metode Triple Exponential Smoothing (Tes) (Studi Kasus : Instalasi Farmasi Rsud Kab. Muna). 4(1):135–42.
2. Fachrurrazi S. (2019). Peramalan Penjualan Obat Menggunakan Metode Single Exponential Smoothing Pada Toko Obat Bintang Geurugok. Techsi - Jurnal Teknik Informatika [Internet]. 2019 Mar 21 [cited 2023 Jun 25];7(1):19–30. Available from: https://ojs.unimal.ac.id/techsi/article/view/178
3. Irawan HS, Adiwijaya NO, Furqon M ‘Ariful. (2024). Implementasi Metode Holt-Winters Multiplicative pada Sistem Peramalan Pengunjung Objek Wisata Kawah Ijen Kabupaten Bondowoso. Simetris: Jurnal Teknik Mesin, Elektro dan Ilmu Komputer [Internet]. 2023 Nov 30 [cited 2024 Jan 5];14(2):209–16. Available from: https://jurnal.umk.ac.id/index.php/simet/article/view/9549
4. Pranata AS, Adiwijaya NO, Furqon M. (2023). Screen Printing T-shirt Stock Forecasting System with Weight Moving Average. Jurnal Komputer Terapan [Internet]. 2023 Jun;9(1):50–7. Available from: https://jurnal.pcr.ac.id/index.php/jkt/article/view/5834
5. Nurhamidah N, Nusyirwan N, Faisol A. (2020). Forecasting Seasonal Time Series Data using The Holt-Winters Exponential Smoothing Method of Additive Models. Jurnal Matematika Integratif [Internet]. 2020 Dec 5 [cited 2023 Jun 25];16(2):151. Available from: http://jurnal.unpad.ac.id/jmi/article/view/29293
6. Komaria V, Maidah N El, Furqon MA. (2023). Prediksi Harga Cabai Rawit di Provinsi Jawa Timur Menggunakan Metode Fuzzy Time Series Model Lee. Komputika : Jurnal Sistem Komputer [Internet]. 2023 Sep 8 [cited 2024 Jan 5];12(2):37–47. Available from: https://ojs.unikom.ac.id/index.php/komputika/article/view/10644
7. Sintiya ES, Kusumawardana A, Furqon MA, Najwa NF, Puspitaningrum AC, Afrah AS. SARIMA and Holt-Winters. (2020). Seasonal Methods for Time Series Forecasting in Tuberculosis Case. In: 2020 4th International Conference on Vocational Education and Training (ICOVET). 2020. p. 1–5.
8. Anderson DR, Sweeney DJ, Williams TA, Camm JD, Cochran JJ. Statistics for business & economics. Cengage Learning; 2016.
9. Barrow D, Kourentzes N, Sandberg R, Niklewski J. (2020). Automatic robust estimation for exponential smoothing: Perspectives from statistics and machine learning. Expert Syst Appl. 2020 Dec 1;160:113637.
10. Seong B. (2020). Smoothing and forecasting mixed-frequency time series with vector exponential smoothing models. Econ Model. 2020 Sep 1;91:463–8.
11. Rabbani MBA, Musarat MA, Alaloul WS, Rabbani MS, Maqsoom A, Ayub S, et al. (2021). A Comparison Between Seasonal Autoregressive Integrated Moving Average (SARIMA) and Exponential Smoothing (ES) Based on Time Series Model for Forecasting Road Accidents. Arab J Sci Eng [Internet]. 2021 Nov 1 [cited 2024 Jan 5];46(11):11113–38. Available from: https://link.springer.com/article/10.1007/s13369-021-05650-3
12. Risqiati R. (2023). Penerapan Metode Single Exponential Smoothing dalam Peramalan Penjualan Benang. Smart Comp :Jurnalnya Orang Pintar Komputer [Internet]. 2021 Oct 20 [cited 2023 Jun 25];10(3):154–9. Available from: http://ejournal.poltektegal.ac.id/index.php/smartcomp/article/view/2887
13. Restyana A, Savitri L, Laili NF, Probosiwi N. (2024). Analysis of Drug Forecasting with Single Moving Average and Single Exponential Smoothing Approach (Case Study in Jombang Regency 2017-2019). J Phys Conf Ser [Internet]. 2021 May 1 [cited 2024 Jan 5];1899(1):012100. Available from: https://iopscience.iop.org/article/10.1088/1742-6596/1899/1/012100
14. Sesario R, Duha T, Alfiah A, Pramono SA, Cakranegara PA, Pontianak PN. (2022). Single Exponential Smoothing In Forecasting Tools And Medicine Stocks. INFOKUM [Internet]. 2022 Oct 13 [cited 2024 Jan 5];10(4):27–32. Available from: http://infor.seaninstitute.org/index.php/infokum/article/view/667