

System Design and Development of Financial Product Sales Forecasting with exponentially weighted moving average and exponential smoothing method

Dianing Sandya Arisoma¹, Supangat², Luvia Friska Narulita³

¹Magister Management, Universitas Airlangga
dianing.sandya.arisoma-2018@feb.unair.ac.id

^{2,3}Faculty of Technique, Universitas 17 Agustus 1945 Surabaya
supangat@untag-sby.ac.id, luvia@untag-sby.ac.id

Abstract

There are many financial products that are offered to the customers, such as bancassurance, mutual fund or customer loan. In financial industry, the revenue of each product is calculated and summarized into one-month revenue. We can create some estimation or forecast the upcoming revenue for the upcoming month using some forecasting methods, such as moving average or exponential smoothing. In this study, we use exponential weighted moving average method and exponential smoothing. To calculate the error, Moving Average Percentage Error is used in this study. The result of this study shows that the moving average method and exponential smoothing have a pretty high error rate after calculated with Mean Average Percentage Error method.

Keywords: forecasting, moving average, exponential smoothing, MAPE

Introduction

Forecasting can be defined as an action to estimate or predict the future. Forecasting can help the planning process in an industry because the result of forecasting itself can be used as the input for planning process. From the forecasting process, we can arrange plans for the upcoming activity. Financial industries have some products or services, they are mutual fund, bancassurance and lending or loan. Each bank has their own records of their product selling and accumulates it into monthly report. From the previous and present selling data, we can estimate the upcoming income through forecasting. Forecasting process can be done by various methods, including simple moving average and simple exponential smoothing methods. The simple moving average method can be used for data that is unstable or has no trends and is not affected by the season. The simple exponential smoothing method can also be used for unstable data.

Literature Review

Financial Services

Financial services are various economic services provided by financial institutions, whether banks, credit card companies or insurance companies. The services provided by financial institutions include the following:

1. Mutual Funds/Reksa Dana

Mutual Funds or also known as reksa dana is a financial product that is used for investment. Mutual fund investment is a collective investment collected by Investment Managers from institutions or individual investors to be managed professionally (Mandiri, 2019). Mutual Funds are regulated based on the Capital Market Law 1995.

2. Bancassurance

Bancassurance is an investment and insurance product that is expended by insurance companies to meet customer needs for financial protection.

3. Loans

Commercial loans are debt-based funding between a business/individual and financial institutions such as banks. Usually used to fund large capital expenditures or cover operational costs.

In addition to the three financial products above, other financial products are forex, premier banking and deposit promos.

Forecasting

Forecasting is a process to predict future conditions based on past and current data. Forecasting uses statistical methods using time series or longitudinal data models. According to (Nasution & Prasetyawan, 2008), forecasting is a process for estimating several needs in the future which include needs in terms of quality, quantity, time and location needed in order to meet the demand for goods or services.

Moving Average

The moving data average in the last few periods is used in the Moving Average (MA) method as the forecast data for the next period. According to (Subagyo, 2008), moving average is a method of forecasting which is done by taking a group of observational values, looking for the average value as a forecast for the coming period. Moving average is done by calculating the average value of real data from a number of specific periods in the period before the forecasting period. Each new prediction calculation is done by calculating the demand for the next period; therefore this method is called Moving Average. According to (Wisner, Tan, & Leong, 2019), moving averages use historical data to produce predictive values and can work well when their values are not stable. Calculation of forecasting with moving averages can be illustrated by the following equation:

$$F_{t+1} = \frac{1}{n} \sum_{i=t-n+1}^t A_i$$

And the description of the formula is as followed:

F_{t+1} = prediction for period $t + 1$

n = the number of periods used for forecasting calculations

A_i = real value in periode i

Weighted Moving Average (WMA) is slightly different from Moving Average, using the latest data in one period, the WMA method does forecasting by adding different weights. WMA can be applied if the effect of newer data is greater when compared to old data on future conditions.

Exponential Smoothing

Exponential Smoothing is also a simple forecasting technique, but uses a weighing value between 0 and 1. If the weighting value w approaches 1, then the forecasting result approaches the observation value. The exponential smoothing model is made with the theory that trends from time series have characteristics and stability. The formula used in the exponential smoothing method for forecasting is as follows:

$$S_t = \alpha Y_{t-1} + (1-\alpha)S_{t-1}$$

The explanation of the formula above is as followed:

S_t = smoothing result on period t

Y_{t-1} = the real value of period $t - 1$

S_{t-1} = Smoothing result of time period of $t - 1$

α = Smoothing constant, between 0 – 1

Mean Absolute Percentage Error (MAPE)

After forecasting, calculation of the error rate is required. One method that can be used is Mean Absolute Percentage Error (MAPE). The error calculation method is used to measure the level of error that occurs in the forecasting process. Mean Absolute Percentage Error (MAPE) is calculated by subtracting forecasting results from actual results, and then the results of the subtraction are made absolute in each period divided by the real observed value for that period. The formula used for Mean Absolute Percentage Error is as follows:

$$M = \frac{100\%}{n} \sum_{t=1}^n \left| \frac{At - Ft}{At} \right|$$

With the explanation as follows:

M = value of MAPE calculation results

n = amount of data

At = true value

Ft = forecast value

Exponentially Weighted Moving Average (EWMA)

Exponentially Weighted Moving Average is used to do the forecasting of the sales data in financial products. This method is often used in a time order sequence of random variables. The weighted average of the sequence is compute by applying weights that decrease geometrically by the time of the observation. The formula used by EWMA is as follows:

$$Y_i = \alpha * X_i + (1 - \alpha) * Y_{i-1}$$

Where Y_i is the forecasted value at the sample number i , X_i is the input value, α is the weighting factor and Y_{i-1} is the forecasted value at the sample number $i - 1$.

Research Method

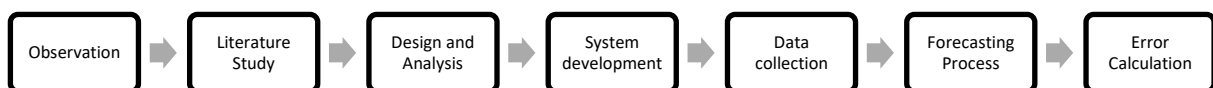
The research method used is by collecting banking product sales data, and then the data is entered into a forecasting program that uses the exponentially weighted moving average and exponential smoothing methods. Data that has been entered is then processed to determine the results of forecasting that have been done. After knowing the forecasting results, then testing is done using the Mean Absolute Percentage Error method.

Making forecasting programs using the PHP programming language and MySQL database system. The data used are 84 data from 7 types of banking products. The data used is data from July 2018 to June 2019. The amount of data used is data on banking product sales for one year in units of hundreds of millions of rupiah.

The α used in this Exponentially Weighted Moving Average method is 0.9. The α can be varied from 0.1 to 0.9, higher value of the α shows that the weighting factor gives high priority to recent changes in the input value.

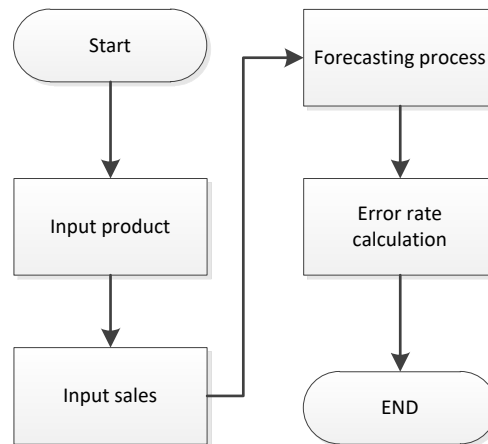
Research Flow

Based on the problems that have been outlined, the flow of research in forecasting banking product data using the exponentially moving average and exponential smoothing methods is as follows:



Result and Discussion

System Flowchart



The above flowchart shows the process of the forecasting system. Started from inserting product data and sales data, the system will do the forecasting with selected forecasting method. After the result is obtained, the system calculates the error rate.

The forecasting system that is made has the following user interface:

Login page

The login page features a title 'Login' at the top. Below the title are two input fields: 'Username' with a person icon and 'Password' with a lock icon. At the bottom of the form are two buttons: 'Login' and 'Register'.

The login page is used for entering the system which has two kinds of users, they are administrator and operator. The administrator is responsible for entering the master data of banking product, whereas the operator user has the responsibility for doing the forecasting process. User Interface for master data of banking product is as follows:

The 'Data Produk' page shows a table with columns for 'Kode Produk', 'Nama Produk', and 'Action'. There is a '+ Tambah Produk' button at the top right and a search bar. The table contains the following data:

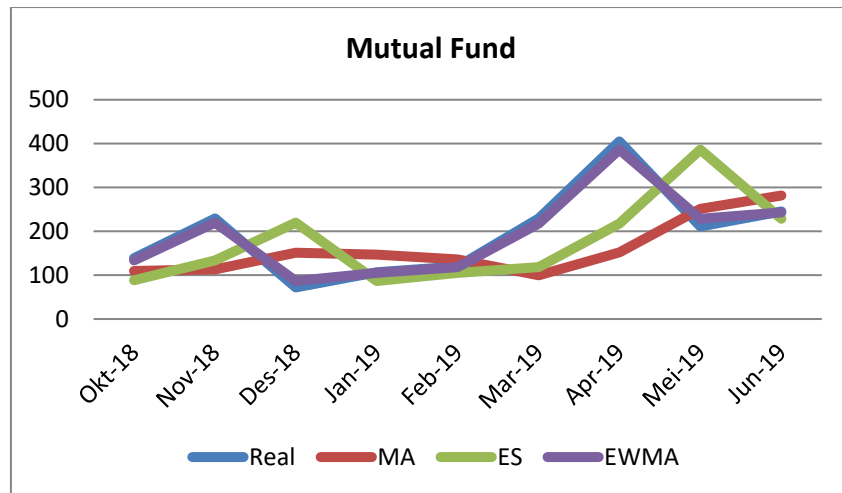
Kode Produk	Nama Produk	Action
SD	Deposito Promo	[Update] [Delete]
New FX	Pemain Baru Forex	[Update] [Delete]
MF	Mutual Fund	[Update] [Delete]
Lending	SME dan KPR	[Update] [Delete]
FX	Forex	[Update] [Delete]
CPB	Premiere Banking	[Update] [Delete]

At the bottom of the table, there are pagination controls: 'Previous', '1', '2', and 'Next'.

The Add Product button is used for displaying add financial product form. The other page that is available in this system is the selling page that is used for entering the selling data.

Forecasting Result

From the data of banking product sales for one year, the forecast results obtained using exponentially weighted moving averages and exponential smoothing 9 months selected is as follows:



The graphic shows that the EWMA method gives the best results which approach the real values. From the table shown by the forecasting system it can be seen if there is a difference between the actual sales amount and the forecast results. Error level calculation is done using MAPE (Mean Absolute Percentage Error) theory. The results of MAPE calculations for forecasting by the forecasting system that have been made are presented in the table 2.

Table 1. Forecasting Result

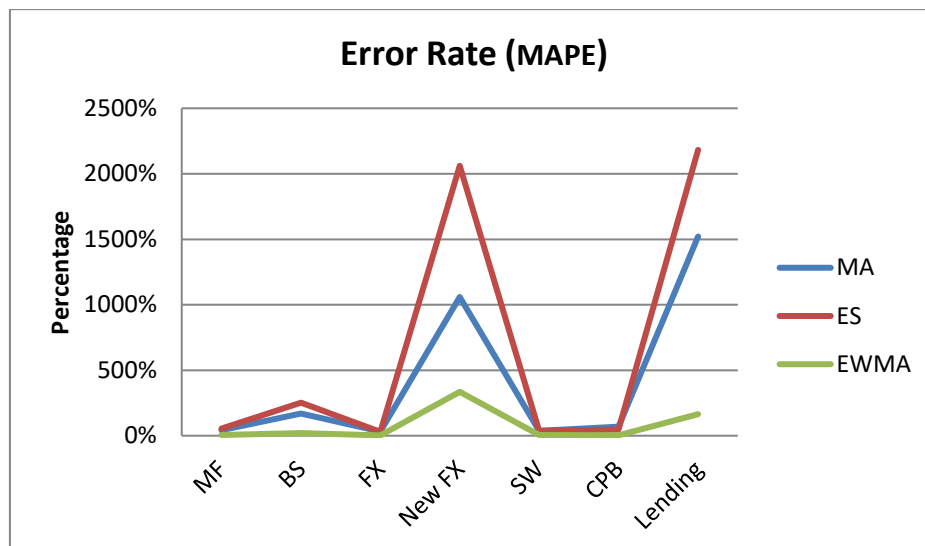
No	Month	Product	Sales	Moving Average	Exponential Smoothing	Exponentially Weighted Moving Average
1	Jul-18	MF	128			128,00
2	Agust-18	MF	115		128	116,30000000
3	Sep-18	MF	85		116	88,13000000
4	Okt-18	MF	139	109	88	133,91300000
5	Nop-18	MF	229	113	134	219,49130000
6	Des-18	MF	72	151	219	86,74913000
7	Jan-19	MF	107	147	87	104,97491300
8	Feb-19	MF	120	136	105	118,49749130
9	Mar-19	MF	229	100	118	217,94974913
10	Apr-19	MF	405	152	218	386,29497491
11	Mei-19	MF	211	251	386	228,52949749
12	Jun-19	MF	245	282	229	243,35294975

Table 2. MAPE Calculation Result

No	Month	Product	Sales	Moving Average	Exponential Smoothing	Error MA	Error ES	Error EWMA
1	Jul-18	MF	128	N/A	N/A	N/A	N/A	0%
2	Agust-18	MF	115	N/A	128	N/A	N/A	1%
3	Sep-18	MF	85	N/A	116	N/A	N/A	4%
4	Okt-18	MF	139	109	88	21%	37%	4%
5	Nop-18	MF	229	113	134	51%	42%	4%
6	Des-18	MF	72	151	219	110%	205%	20%
7	Jan-19	MF	107	147	87	37%	19%	2%
8	Feb-19	MF	120	136	105	13%	13%	1%
9	Mar-19	MF	229	100	118	56%	48%	5%
10	Apr-19	MF	405	152	218	62%	46%	5%
11	Mei-19	MF	211	251	386	19%	83%	8%
12	Jun-19	MF	245	282	229	15%	7%	1%
Mean Absolute Percentage Error						43%	55%	5%

From table 2 it can be seen that the error rate using the moving average method for one Mutual Fund product is lower than using the Exponential Smoothing method. The error rate using the Exponentially Weighted Moving Average method is the lowest among the three methods. For other products, the error value varies depending on the value of the forecast results that have been made.

The comparison of MAPE result between each product and each method used is shown in graphic below. The graphic shows that EWMA method give the smallest error rate compared to the other methods.



Conclusion

From the data entered into the system, it can be concluded that the forecasting process using the exponentially weighted moving average is better than using moving average and exponential smoothing methods. Using the moving average and exponential smoothing method shows higher error rate than using exponentially weighted moving average method.

References

- Booranawong, T., & Booranawong, A. (2017). An Exponentially Weighted Moving Average Method With Designed Input Data Assignments For Forecasting Lime Prices in Thailand. *Jurnal Teknologi*, 53-60.
- Mandiri. (2019). mandiri-investasi.co.id/en/investment-learning/information-centre/what-is-mutual-fund/. Retrieved August 2019, from mandiri-investasi.co.id.
- Nasution, A. H., & Prasetyawan, Y. (2008). *Perencanaan dan Pengendalian Produksi*. Yogyakarta: Graha Ilmu.
- Subagyo. (2008). *Forecasting Konsep dan Aplikasi*. Yogyakarta: BPFE.
- Wisner, J. D., Tan, K.-C., & Leong, G. K. (2019). *Principles of Supply Chain Management: A Balanced Approach*. Cengage.