α-Sutte Indicator: a new method for time series forecasting

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Abstract. α-Sutte Indicator (α-Sutte) was originally from the development of Sutte Indicator. Sutte Indicator can be used to predict the movement of stocks. As the development of science, Sutte Indicator is developed to predict not only the movement of stocks but also able to forecast the data on finance, insurance, and time series data. This method is called α-Sutte Indicator (α-Sutte). α-Sutte was developed by using the principle of the forecasting method of using the previous data. α-Sutte choose because it have best accuracy in forecasting. To implementation and check the accuracy of this method, the Consumer Price Index and Indices by Regions (Turkey) data used in this research. Data taken from January 2003 to June 2017. This data used because CPI data unstable and sometimes difficult to predict using other method. The data is divided into two parts, namely data training and testing. Data training starts from January 2003 to October 2016, and data testing starts from November 2016 to June 2017. To see the accuracy of α-Sutte, benchmark will be conducted from the results of forecasting with other forecasting methods e.g. Multiplicative Holt-Winters, Additive Holt-Winters, and Automatic Time Series Forecasting: The forecast Package for R (AutoARIMA) developed by Hyndman-Khandakar (2008) for the ARIMA/SARIMA model. The comparison of this accuracy is to compare the value of MSE, RMSE, and MAPE of forecasting the result on data training by using the data as reference data. The results are obtained that MSE value of Indicator of α-Sutte is smaller than other methods that is Multiplicative Holt-Winters, Holt-Winters Additive, and ARIMA (1,2,2)(0,0,2)¹². Thereby the case for MAPE accuracy value Indicator of α-Sutte better than others method: Multiplicative Holt-Winters, Holt-Winters Additive, and ARIMA (1,2,2)(0,0,2)¹².

1. Introduction

Based on data from the World Bank, Indonesia is categorized as a low-middle income country together with other developing countries, such as India and Myanmar. To see the main economic indicator performance of a country, it is important to consider consumer price index (CPI). CPI is an index that is used for measuring the level of price change of any goods and services from time to time [1]. Furthermore, according to International Labor Organization, CPI is the main statistics that are used as Policy takers in social, economic, and have wide and substantial effect for governments, businesses, and household [1]. This CPI is related to the inflation of certain area. The higher inflation rate, the higher CPI rate. The lower of certain CPI, the better for them towards a country because a low CPI indicates that life costs is increasingly cheaper. Therefore, Inflation and CPI are one of the indicators to see the economic condition of a country.

CPI and Inflation experience a change from time to time and a stagnant CPI / Inflation sometimes it suddenly changes. To look the change of this from time to time, forecasting data needs to be done.
Forecasting data about CPI has been done by various experts, i.e. modeling and forecasting consumer price index which is done by Norbert, Wanjoya, & Waititu in 2016, a case study in Rwanda, it results that ARIMA (3.1.4) is a suitable model to be used in forecasting the CPI historical data in Rwanda [2]. The other research is done by Alvares-Diaz and Gupta in 2016, they conducted a research about forecasting CPI in US economy using Random Walk (RW) [3], seasonal integrative moving average (SARIMA)[4], autoregressive (AR), genetic programming (GP) [5], [6] and non linear (artificial neural network (ANN) [7], [8]. The result that is obtained from this research is that SARIMA model is more superior if it is compared with other methods. The purpose of this research is to implement new forecasting method (α-Sutte) to predict CPI Turkey data.

2. Literature

2.1. ARIMA and SARIMA
A process $Z_t$ is stated as following a mixed-autoregressive-moving average or ARMA (p,q) model, if it meets [9], [10]:

$$\phi_p(B)Z_t = \theta_q(B)a_t,$$

where $\phi_p(B) = (1-\phi_1B-\phi_2B^2-\cdots-\phi_pB^p)$ (for AR(p))

and $\theta_q(B) = (1-\theta_1B-\theta_2B^2-\cdots-\theta_qB^q)$ (for MA(q))

If there is a non-seasonal difference, so that it becomes ARIMA(p,d,q) model as follows [4]:

$$\phi_p(B)(1-B)^dZ_t = \theta_q(B)a_t,$$

where $\phi_p(B) = (1-\phi_1B-\phi_2B^2-\cdots-\phi_pB^p)$ (for AR(p)), $(1-B)^d$ (for differencing non seasonal) and $\theta_q(B) = (1-\theta_1B-\theta_2B^2-\cdots-\theta_qB^q)$ (for MA(q)).

Seasonal ARIMA model (SARIMA) is the same as non-seasonal ARIMA model. A process $Z_t$ is stated as following a mixed autoregressive-moving average model that is expanded for handling seasonal aspect or ARMA (p,d,q)(P,D)s if it satisfies [4]:

$$\Phi_p\left(B^s\right)\phi_p(B)Z_t = \theta_q(B)\Theta_q\left(B^s\right)a_t,$$

If there is a seasonal difference on Seasonal ARIMA model, so the model becomes as follows:

$$\Phi_p\left(B^s\right)\phi_p(B)(1-B)^d\left(1-B^s\right)^D\tilde{Z}_t = \theta_q(B)\Theta_q\left(B^s\right)a_t,$$

where

$$\tilde{Z}_t = \begin{cases} Z_t - \mu, & \text{if } d = D = 0 \\ Z_t, & \text{otherwise.} \end{cases}$$

$$\Phi_p(B^s) = 1-\Phi_1B^s-\Phi_2B^{2s}-\cdots-\Phi_pB^{ps}$$

and $$\Theta_q(B^s) = 1-\Theta_1B^s-\Theta_2B^{2s}-\cdots-\Theta_qB^{qs}$$

2.2. Holt-Winters
There are 2 types of Holt-Winters methods applied on this research namely Multiplicative Holt-Winters (MHW) and Additive Holt-Winters (AHW). The formula of Multiplicative Holt-Winters (MHW) is elaborated in the following equation [11]:

...
\[ L_t = \alpha \left( \frac{Y_t}{S_{t-s}} \right) + (1 - \alpha)(L_{t-1} + b_{t-1}) \]  
(4)

\[ b_t = \beta (L_t - L_{t-1}) + (1 - \beta)b_{t-1} \]  
(5)

\[ S_t = \gamma \left( \frac{Y_t}{L_t} \right) + (1 - \gamma)S_{t-t} \]  
(6)

\[ F_{t+m} = (L_t + b_t m)S_{t-s+m} \]  
(7)

and Additive Holt-Winters:

\[ L_t = \alpha (Y_t - S_{t-s}) + (1 - \alpha)(L_{t-1} + b_{t-1}) \]  
(8)

\[ b_t = \beta (L_t - L_{t-1}) + (1 - \beta)b_{t-1} \]  
(9)

\[ S_t = \gamma (Y_t - L_t) + (1 - \gamma)S_{t-s} \]  
(10)

\[ F_{t+m} = L_t + b_t m + S_{t-s+m} \]  
(11)

where:

- \( Y_t \) = data on \( t \) time,
- \( s \) = the seasonal length in a certain time,
- \( m \) = the amount of data to be predicted.

2.3. \( \alpha \)-Sutte Indicator

\( \alpha \)-Sutte Indicator is the development of Sutte Indicator that was developed in 2015 by Ahmar [12]. Sutte Indicator initially developed for predicting the movement of stock [12]. Along with its time development and needs, Sutte Indicator is developed to be \( \alpha \)-Sutte Indicator [13]–[17]. The development is expected to provide a better accuracy level and not only limited to the prediction of stock movement but also predict the time series of data. The development of this \( \alpha \)-Sutte Indicator considers the trend of certain data. Moreover, the formula of \( \alpha \)-Sutte Indicator is as follows.

\[
\alpha_t = \frac{\alpha \left( \frac{\Delta x}{\alpha + \delta} \right) + \beta \left( \frac{\Delta y}{\beta + \alpha} \right) + \gamma \left( \frac{\Delta z}{\gamma + \beta} \right)}{3}
\]  
(12)

Where:

- \( \delta = a_{t-4} \)
- \( \alpha = a_{t-3} \)
- \( \beta = a_{t-2} \)
- \( \gamma = a_{t-1} \)
\[ \Delta x = \alpha - \delta = a_{t-3} - a_{t-4} \]
\[ \Delta y = \beta - \alpha = a_{t-2} - a_{t-3} \]
\[ \Delta z = \gamma - \beta = a_{t-1} - a_{t-2} \]
\[ a_t = \text{series observations at } t \text{ time} \]
\[ a_{t-k} = \text{series observations at } (t-k) \text{ time} \]

3. Method
The data of the research is obtained from TURKSTAT (http://www.turkstat.gov.tr). The data used on the research is divided into two parts namely data training and testing. Data training used 166 data (month) and testing data will be tested by 8 data in the following (month). From this data testing, the results will be obtained from data training. This forecasting result is then compared with the actual data. In the process of forecasting data, this research uses the R package for \( \alpha \)-Sutte Indicator namely: suttleForecastR package [17] and RcmdrPlugin.sutteForecastR [17] and R package for automatic time series forecasting [18].

The forecasting method that is used in this research i.e. ARIMA, Holt-Winters, SARIMA, and \( \alpha \)-Sutte Indicator. To evaluate the accuracy level of forecasting result measurement from the applied method, so that the accuracy measurement method that is used i.e. MSE (Mean Squared Error), MAPE (Mean Absolute Percentage Error), and RMSE (Root Mean Squared Error).

The accuracy level of forecasting measurement that is often used is MSE [10].

\[
\text{MSE} = \frac{1}{N} \sum_{t=1}^{N} (Y_t - F_t)^2, \quad t = 1, 2, 3, \ldots, N
\]  

\( Y \) is the actual value, \( F_t \) is the forecasting value, and \( N \) is the number of samples.

MAPE is relative error size of a forecasting and it is defined as:

\[
\text{MAPE} = \frac{1}{N} \sum_{t=1}^{N} \left| \frac{Y_t - F_t}{Y_t} \right| \times 100\%, \quad t = 1, 2, 3, \ldots, N
\]  

RMSE is alternative method for evaluating the result of a forecasting by rooting the value of MSE. The smaller MSE, MAPE and RMSE value, the better forecasting result is obtained or in other words, the better the accuracy level.

\[
\text{RMSE} = \sqrt{\text{MSE}}
\]

4. Result and Discussion
In this research, data training starts from January 2003 to October 2016, and data are tested from November 2016 to June 2017. The first stage in forecasting is that perform plotting data to data training. Plotting Data is conducted to see the trend of certain data. Moreover, the plotting of CPI Turkey data is as follows.
Figure 1. The plot of the consumer price index in Turkey (January 2003 - October 2016)

Based on Figure 1, CPI Turkey experiences an upward trend from year to year so it needs to be considered about the influence of trend in forecasting data. The next stage is forecasting data by using ARIMA/SARIMA method, Holt-Winters and α-Sutte Indicator. This data forecasting uses the R software.

Moreover, the forecasting results of R software from this research by using ARIMA/SARIMA, Holt-Winters and α-Sutte Indicator are as follows.

Holt-Winters exponential smoothing with trend and multiplicative seasonal component.

```r
Call:
HoltWinters(x = data.ts, seasonal = "mult")

Smoothing parameters:
alpha: 0.9044907
beta : 0.03339319
gamma: 1
```

Holt-Winters exponential smoothing with trend and additive seasonal component.

```r
Call:
HoltWinters(x = data.ts, seasonal = "additive")

Smoothing parameters:
alpha: 0.8594444
beta : 0.03480424
gamma: 1
```

Series: data.ts
ARIMA(1,2,2)(0,0,2)[12]

Coefficients:
From the output of R Software for Multiplicative Holt-Winters method (MHW or HW-Mul), it is obtained $\alpha = 0.9044907$, $\beta = 0.03339319$, and $\gamma = 1$ parameter, while for Additive Holt-Winters method (AHW or HW-Add), it is obtained $\alpha = 0.8594444$, $\beta = 0.03480424$, and $\gamma = 1$ parameter. For ARIMA forecasting, it is obtained model namely ARIMA (1,2,2) (0,0,2)$^{12}$. If it is modeled in mathematical form, it will be as follows:

Multiplicative Holt-Winters:

$$L_t = 0.9044907 \left( \frac{Y_t}{S_{t-s}} \right) + (0.095509)(L_{t-1} + b_{t-1})$$

$$b_t = 0.0333939 (L_t - L_{t-1}) + (0.966607)b_{t-1}$$

$$S_t = \frac{Y_t}{L_t}$$

$$F_{t+m} = (L_t + b_t)mS_{t-s+m}$$

Additive Holt-Winters:

$$L_t = 0.8594444(Y_t - S_{t-s}) + (0.140556)(L_{t-1} + b_{t-1})$$

$$b_t = 0.03480424(L_t - L_{t-1}) + (0.965196)b_{t-1}$$

$$S_t = Y_t - L_t$$

$$F_{t+m} = L_t + b_t m + S_{t-s+m}$$

SARIMA:

$$\phi(B)(1-B)^2Z_t = \theta_2(B)\theta_1(B^{12})a_t$$

$$(1-\phi B)(1-B)^2Z_t = (1-\theta_2 B - \theta_1 B^2)(1-\theta_1 B^{12} - \theta_2 B^{24})$$

$$Z_t - (\phi + 2)Z_{t-1} + (1+2\phi)Z_{t-2} - \phi Z_{t-3} =$$

$$a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \theta_1 \theta_2 a_{t-3} + \Theta_1 a_{t-14} + \Theta_2 a_{t-24} + \Theta_1 \Theta_2 a_{t-25} + \Theta_1 \Theta_1 a_{t-26} + \Theta_2 a_{t-26}$$

Moreover, the forecasting results to 8 months later by using ARIMA/SARIMA, Holt-Winters and $\alpha$-Sutte Indicator method are displayed in Table 1 and Figure 2.
Table 1. The data of forecasting result for 8 months later

| Date   | Data | α-Sutte | Auto ARIMA | MHW (HW-Mul) | AHW (HW-Add) |
|--------|------|---------|------------|--------------|--------------|
| 11-2016| 286,33| 286,33  | 286,33     | 286,33       | 286,33       |
| 12-2016| 287,81| 287,59  | 280,66     | 288,04       | 287,44       |
| 01-2017| 292,54| 289,84  | 282,16     | 288,58       | 287,90       |
| 02-2017| 299,74| 295,99  | 283,57     | 291,81       | 290,84       |
| 03-2017| 302,17| 304,25  | 285,01     | 292,34       | 291,35       |
| 04-2017| 305,24| 307,00  | 286,44     | 293,90       | 292,84       |
| 05-2017| 309,23| 309,51  | 287,88     | 296,11       | 295,04       |
| 06-2017| 310,61| 312,41  | 289,31     | 296,77       | 295,90       |

Figure 2. The graph of the comparison from the forecasting result by α-Sutte Indicator and other methods in Consumer Price Index in Turkey (November 2016 - June 2017)

In table 1 and figure 2, it is shown that forecasting result from α-Sutte Indicator is more accurate if it is compared with other forecasting methods (ARIMA/SARIMA and Holt-Winters). The comparison of accuracy level from each forecasting method is displayed in Table 2.

Table 2. The Accuracy Comparison of α-Sutte Forecasting Result with Other Methods

| Type            | MSE   | RMSE | MAPE (%) |
|-----------------|-------|------|----------|
| MHW (HW-Mul)    | 109,48| 10,46| 3,05     |
| AHW (HW-Add)    | 123,29| 11,10| 3,27     |
| α-Sutte Indicator| 5,70 | 2,39 | 0,67     |
| ARIMA(1,2,2)(0,0,2)12 | 292,51| 17,10| 5,40     |

From table 2 and figure 3, it can be seen that the forecasting result of α-Sutte Indicator is far different if it is compared with other methods (ARIMA/SARIMA and Holt-Winters) either from accuracy level of MSE, RMSE, or MAPE.
Figure 3. The graph of the accuracy comparison of α-Sutte forecasting result with other methods

5. Conclusion

Based on the analysis about forecasting result to Consumer Price Index data in Turkey, α-Sutte Indicator forecasting method is more suitable if it is compared to other methods i.e. Multiplicative Holt-Winters, Additive Holt-Winters and ARIMA method \((1,2,2)(0,0,2)\). This can be seen from the data result of forecasting for 8 months later (November 2016 - June 2017) and from this result, it is obtained MSE value for every forecasting method namely: α-Sutte Indicator at 5.70, Multiplicative Holt-Winters at 109.48, Additive Holt-Winters at 123.29, and ARIMA \((1,2,2)(0,0,2)\) at 292.51. For MAPE value, it is obtained the accuracy as follows: α-Sutte Indicator at 0.67, Multiplicative Holt-Winters at 3.05, Additive Holt-Winters at 3.27, and ARIMA \((1,2,2)(0,0,2)\) at 5.40.

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