A Comparison of Various Forecasting Techniques for Coffee Prices

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Abstract: This study aims to analyze and compare among forecasting techniques for selecting the best to predict the volatility of coffee commodity prices. This study uses secondary data at two different markets, world and domestic markets. Three forecasting techniques apply in this research, namely, MA, ARIMA and Decomposition. The most appropriate model to forecast world and domestic coffee prices are the ARIMA model. This conclusion is based on the lowest MAPE, MAD and MSD values.

1. Introduction

Coffee is Indonesia's export commodities which have contributed significantly to Indonesia foreign exchange. This commodity is essential for the national economy and able to play an important role in regional development. Coffee commodity is the fourth agricultural export commodity with an export value of US $ 1,047,077,095. The Coffee export volume growth causes its trade balance tend to surplus with a total increase of 7.85% [1]. Currently, Indonesia has a strategic position in the trade of coffee in the international market in which Indonesia is the fifth world coffee exporters. Concerning quality, Indonesia's coffee is the fourth position in the world [1].

Relating to coffee export development, price fluctuations become a concern. Price fluctuations of coffee will effect a lot of market risk to farmers, marketing institutions, importers and the final price received by consumers. The position of the price of coffee and cocoa will significantly determine the amount and value of exports [2]. Commodity price is an important factor on the amount, cost and competitiveness of export commodity demand in the world market. The development of coffee prices in domestic market has increased by 4.98% per year [1]. High price growth does not guarantee that the price of coffee will decline in the future due to its external conditions affecting domestic production.

The problem of price fluctuation is crucial to the decision making to maintain and improve the competitiveness of coffee in the international market. Export commodity price forecasting is essential to support it. Long-term export development planning decisions require estimates that can be analyzed from past mass data. Appropriate forecasting methods will affect the accuracy of price forecasting and price policy decisions. There are three forecasting models used, namely Moving Average, Decomposition Model, ARIMA Model, and decomposition.
Forecasting technique using Moving Average is suitable for analyzing trading based on information contained in trading and formulating the trading strategy, stock price trend, stock market returns [3]-[5]. These conditions were needed in the process of analysis of the volatility of coffee prices. Decomposition method to estimate coconut oil prices for two decades [6]. Therefore this method can be used in this study to forecast the price of coffee commodities. The use of ARIMA is considered very accurate to predict the price of agricultural products, strategic planning, help maximize revenue and minimize cost price [7]-[9]. Based on the above issues it is important to analyze which forecasting method is best to predict the volatility of coffee commodity prices.

2. Methodology

2.1 Data and data sources

This study uses secondary data obtained from Index Mundi for world / international coffee price data and Central Bureau of Statistics and Ministry of Agriculture of Indonesia for domestic coffee price data. The data taken are monthly data of coffee prices from January 2008 to December 2016 or 96 observations.

2.2 Model Forecasting

2.2.1 Moving average. The Moving Average (MA) method is an often used indicator in technical analysis that shows the average value of data over a given period. The data that is tabulated is time-dependent data. Moving averages are commonly used in technical analysis of stocks/forex, prices to measure momentum and determine possible support and resistance areas. Simple Moving average (SMA) can be used to create a smooth/smooth stock price curve and filter out noise data, so it is easier to see the data trend. The SMA method can be formulated as follows:

\[ A_t = \frac{D_t + D_{t-1} + D_{t-2} + \cdots + D_{t-N+1}}{N} \]

Note: \( D_t \) = Times series data; \( N \) = Total number of periods averaged; and \( A_t \) = Prediction in period \( t+1 \)

2.2.2 ARIMA Model. ARIMA is a method that produces predictions based on the synthesis of historical data patterns [10]. ARIMA has been used extensively as in economic forecasting, budgetary analysis, controlling processes and quality (quality control & process controlling), and census analysis[11]. The ARIMA model itself uses only a variable (univariate) time series. ARIMA model is a combination of AR model (Autoregressive) is a model that explains the movement of a variable through the variable itself in the past, and the model MA (Moving Average) is a model that saw the change of its variables through residual in the past. Generally ARIMA Model (q, d, r) can be written as follows:

\[ X_t = \mu + \phi_1 X_{t-q} + \theta_1 e_{t-k} \]

Where \( t = 1, 2, 3 \ldots T \), \( \epsilon_i \) is a process that is not correlated with mean zero, \( \phi_i \) and \( \theta_i \) are coefficient values.

2.2.3 Decomposition model. In the decomposition method, there are an additive and multiplicative decomposition model. Additive and multiplicative decomposition models can be used to forecast trend, seasonality, and cycle factors. Both model can be written mathematically as follows:

\[ X = T + S + C + I \] (Additive model)
\[ X = T \times S \times C \times I \] (Multiplicative model)

Note: \( X \) : periodic series data, \( T \) : data trend period, \( S \) : seasonal factor (index), \( C \) : cyclical factor, and \( I \) : error factor
3. Result and Discussion

3.1. Estimated Model Forecasting Moving Average

The comparison result above shows that for world coffee price, MA (1) has the smallest MSD value compared to MA (2), MA (3), MA (4) and MA (5). The same with MAPE and MAS indicators. Thus, for the case of forecasting the price of world coffee Moving Average model that is appropriate MA (1). As for domestic coffee prices, MA (1) also has the smallest MSD value compared to MA (2), MA (3), MA (4) and MA (5). The same is true with MAPE and MAS indicators, so for forecasting domestic coffee prices, the moving average model is MA (1).

Based on the estimation using the Moving Average method (Table 1), the mean absolute percentage error (MAPE) of domestic coffee is 3.73953%, Mean Absolute Deviation (MAD) of 0.07794, and Mean Square deviation (MSD) of 0.01079. While world prices have MAPE 0.9%, MAD 145.3, and MSD of 48151.2.

Table 1. Estimation Result Moving Average Model

| Tipe  | World Prices (MAPE, MAD, MSD) | Domestic Prices (MAPE, MAD, MSD) |
|-------|-------------------------------|----------------------------------|
| MA1   | 3.73953* 0.07794* 0.01079*     | 0.9* 145.3* 48151.2*             |
| MA2   | 4.57509 0.09481 0.01499        | 1.1 175.4 67208.6                |
| MA3   | 5.33635 0.10946 0.01974        | 1.3 207.5 89120.8                |
| MA4   | 6.23911 0.12772 0.02605        | 2 238 106204                    |
| MA5   | 7.01979 0.14326 0.03288        | 2 269 128639                    |

3.2. Estimated Model Forecasting ARIMA

The use of time series cannot be separated from the problem of autocorrelation because autocorrelation causes the data to be not stationary. The autocorrelation and partial autocorrelation functions show tests of the world price data rates and the robusta coffee commodity domestic price (figure 2). The ACF and PACF graphs have been processed differencing 1, this indicates that the data is stationary both to the average and to the variety (Figure 1).

After differencing on world price data and domestic commodity coffee prices, ARIMA model for world price data and domestic coffee commodity prices are estimated. Comparing all output results, it is found that the best model of each data price of coffee is ARIMA model with ordo of (1,1,0). While for domestic coffee price, the best model is ARIMA(1,1,0). Estimated forecasting model of world and domestic using ARIMA is presented in Table 2.

Table 2. Model Estimate of domestic coffee prices and world prices

| Data                 | Coefficient | SE   | t-statistic | probability |
|----------------------|-------------|------|-------------|-------------|
| World price (1,1,0)  | AR (1)      | 0.2700 | 0.0932      | 2.90        | 0.005       |
| Domestic price (1,1,0)| AR (1)      | 0.2073 | 0.0949      | 2.18        | 0.031       |
Figure 1. Autocorrelation Function and Partial Autocorrelation Function coffee prices

Note: *Figure 2 after Differencing (1)
(a) Autocorrelation Function price of world coffee
(b) Autocorrelation Function domestic coffee prices
(c) Partial Autocorrelation Function coffee world
(d) Partial Autocorrelation Function of domestic coffee prices

3.3. Estimated model forecasting Decomposition

Based on the classical decomposition method, the forecasting results of the world and domestic robusta coffee prices can be seen in Figure 2. Additive decomposition and multiplicative decomposition have the same pattern, indicating that both have almost the same accuracy to be used as a method of forecasting at world prices. Similarly, the price of domestic coffee (Indonesia) for both types of methods has the same tendency. Both approaches show a trend with the same slope, so both can be chosen to be the correct forecasting methods.

The accuracy of forecasting at world coffee prices is found that MAPE additive decomposition is 12.88%, greater than MAPE multiplicative decomposition which has a value of 12.85%. The value of MAD additive decomposition for world coffee prices is 0.2534, higher than the value of MAD multiplication decomposition of 0.2528. In contrast to MSD value, additive decomposition model has a lower value compared to multiplicative decomposition, i.e., 0.0920 and 0.0922 respectively. Based on these estimations, the best decomposition method for MAPE and MAD is multiplicative. While the model of choice for MSD is additive (Table 4). With similar procedures, the best model for domestic coffee prices is multiplicative decomposition model. This conclusion is based only on MSD indicator while MAPE and MAD are inconclusive since both indicators have a similar value.
Figure 2. Additive and multiplicative decomposition of the price of coffee

Note:
(a) The additive decomposition of world coffee prices
(b) Multiplicative decomposition of world coffee prices
(c) Additive decomposition of domestic coffee prices
(d) Multiplication decomposition of domestic coffee prices

Table 3. Level of Forecasting Accuracy on Coffee Prices

| Data      | Decomposition type | MAPE (%) | MAD   | MSD   |
|-----------|--------------------|----------|-------|-------|
| World Price | Additive           | 12.88    | 0.2534| 0.0920|
| World Price | Multiplicative     | 12.85    | 0.2528| 0.0922|
| Conclusion | Multiplicative     |          |       |       |
| Domestic price | Additive        | 3        | 409   | 236890|
| Domestic price | Multiplicative   | 3        | 409   | 235944|

3.4. Model selection

Based on the results of analysis using the accuracy of MAPE, MAD, and MSD, the most appropriate model to predict the price of coffee world or domestic is the ARIMA model. This conclusion is based because ARIMA Model has the lowest values MAPE, MAD and MSD compared to other models. The lower the accuracy measurement indicator, the more reliable a model becomes an appropriate analysis tool for forecasting (Table 4). The ARIMA model is the most accurate method selected in this study. So in the analysis of price fluctuations and determine the strategy of Indonesian coffee price policy ARIMA method is the best method. Forecasting domestic and world prices of coffee commodities are
based on monthly data of 96 months in the range from January to 2016. ARIMA is the most appropriate method for predicting short-term monthly data. This is in line with the results of domestic price research and the world of coffee commodities using monthly data is very suitable forecast by the ARIMA model. This is in line with research conducted by Xin and Xin [12] who analyzed the ARIMA model that is very suitable for predicting cucumber price as an agricultural commodity with monthly data.

### Table 4. Level of Forecasting Accuracy on Coffee Prices

| Forecasting model | Accuracy Measure | Conclusion       |
|-------------------|------------------|------------------|
|                   | MAPE (%)         | MAD              | MSD              |                  |
| **World Price**   |                  |                  |                  |
| Moving average    | 3.73953          | 0.07794          | 0.01079          |                  |
| ARIMA             | 3.76             | 0.074            | 0.010            | The ARIMA model is the best Choice |
| Decomposition     |                  |                  |                  |
| Addif             | 12.88            | 0.2534           | 0.0920           |                  |
| Multiplicative    | 12.85            | 0.2528           | 0.0922           |                  |
| **Domestic price**|                  |                  |                  |
| Moving average    | 0.9              | 145.3            | 48151.2          |                  |
| ARIMA             | 0.9              | 141.2            | 43455            | The ARIMA model is the best Choice |
| Decomposition     |                  |                  |                  |
| Addif             | 3                | 409              | 236890           |                  |
| Multiplicative    | 3                | 409              | 235944           |                  |

### 4. Conclusion
The most appropriate model to forecast world and domestic coffee prices are the ARIMA model. This is based because the ARIMA model is the model that has the lowest MAPE, MAD and MSD values.

### References

[1] Kementerian Pertanian, 2016 Outlook Kopi. Pusat Data dan Sistem Informasi Pertanian. Jakarta pp.1-73

[2] Zakaria M L Musadieq M A Sulasmiyati S, 2016 Pengaruh Produksi, Harga dan Nilai Tukar terhadap Volume Ekspor (Studi pada Volume Ekspor Biji Kakao Indonesia Periode Januari 2010-Desember 2015) Jurnal Administrasi Bisnis, 40(2). pp.139-145

[3] Toms M C, 2011 The Technical Analysis Method of Moving average Trading rules That Reduce the Number of Losing Trades. Newcastle University Press Ingris

[4] Grebenkov D S Serror J, 2014 Following a Trend with An Exponential Moving Average: Analytical Result for A Gaussian Model Physica A 394. pp. 288-303

[5] Ahmar, A.S., Rahman, A., Arifin, A.N.M. & Ahmar, A.A. 2017, "Predicting movement of stock of “Y” using suit indicator", Cogent Economics and Finance, Vol. 5, no. 1.

[6] Gabrallan L A Abraham A, 2013 Computational Modeling of Crude Oil Price Forecasting, A Review of Two Decades of Research. International Journal of Computer Information Systems and Industrial Management Applications. Vol 5. pp. 729-740

[7] Nochai R Nochai T, 2010 Arima Model For Forecasting Oil Palm Price. Proceedings of the 2nd IMT-GT Regional Conference on Mathematics, Statistics and Application Penang. pp. 1-7

[8] Assis K Amran A Remali Y, 2010 Forecasting Cococa Bean Prices Using Univariate Time Series Model Journal of Arts Science & Commerce 1 (1). pp. 71-80

[9] Ankrah S Nyantakyi K A Dadey E, 2014 Modeling the Causal Effect of World Cocoa Price on Production of Cocoa in Ghana Universal Journal of Agricultural Research 2(7) pp.264-271

[10] Licolin Y S, 1995 Emerging Criteria for Quality in Qualitative and Interpretive Research. Qualitative Inquiry. 1 (3) pp. 275-289
[11] Zulkarnain Iskandar, 2011. Akurasi Peramalan Harga Saham dengan Model ARIMA dan Kombinasi Main Chart + Ichimoku Chart *Management Insight* 7 (1) pp 59-70

[12] Xin W Xan W, 2016 Empirical Study on agricultural products price Forecasting based on internet-based Timely Price Information. *International Journal of Advanced Science and Technology*, Vol 87. pp.31-36