Selecting an Accurate Cacao Price Forecasting Model

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Abstract: This study aims to analyze and select an accurate forecasting method for predicting cocoa prices. Monthly data of cacao prices at world and domestic markets from 2008:1 – 2016:12 are used in this research. Three univariate forecasting models are applied, i.e., ARIMA, Exponential Smoothing, and Decomposition. Selection of an accurate forecasting model use three accuracy indicators, namely, MAD, MAPE and MSD. The best cocoa price forecasting method is the ARIMA method. ARIMA is the most appropriate method used at both world and domestic prices.

1. Introduction

Fluctuations in export commodity prices are crucial for importer countries. Price is frequently used as a basis for decision making in international trade. For some countries including Indonesia, agricultural commodity exports become the main source of foreign exchange, in fact, agriricultural prices tend to experience price fluctuations. The crucial issue is how to manage price fluctuations and establish strategies to cope with price fluctuation problem. For this reason, price forecasting is important to provide price information as a basis for decision making.

Forecasting method is one of the earliest techniques to examine how price fluctuations. Accurate forecasting methods can be detailed describing price movements. With appropriate forecasting methods can help to make export decisions as well as policies to be made [1]. Price fluctuations are closely related to historical data that have occurred in the past. Accordingly, selecting the most appropriate forecasting method is highly dependent on historical data from export commodities.

Time series method has an excellent performance to forecast the price of agricultural commodities. Among forecasting methods, ARIMA method is very suitable to use forecasting agricultural commodities. The ARIMA model is very accurate in predicting results that can be used for decision-making processes [2]-[6]. In addition to ARIMA, the additive and multiplicative decomposition method as well as an exponential smoothing model are frequently used to forecast the price of agricultural commodities.

Indonesia also relies on exports of agricultural commodities for its economic development, one of which is cocoa. Cocoa has the third largest export value after palm oil, and rubber in 2017 with export
value of US $ 1,120,764,743.00. Indonesian cocoa has better-fermented taste characteristics than its Ghanaian competitors [7]. The issue of fluctuations in cocoa price is very important for Indonesia in taking export commodity superior policy. Consequently, it is crucial to perform cocoa price forecasting. The problem is what is an accurate model for cacao price forecasting. Therefore, this study aims to analyze the most appropriate forecasting method for predicting cocoa prices.

2. Methodology
This study uses monthly data of cacao prices both at world and domestic markets from 2008:1 – 2016:12 or total of 96 observations. Three univariate forecasting models apply in this research, namely, ARIMA, Exponential smoothing, and decomposition. ARIMA (Autoregressive Integrated Moving Average (ARIMA) models describe stationary time series and have been widely applied to forecast commodity prices [8], such as oil [9]. Exponential Smoothing is another univariate forecasting model and assigns exponentially decreasing weights for newest to oldest observations. This model has also been applied, including pulse in Pakistan [10]. In addition, decomposition model involving additive and multiplicative decomposition model [11] decompose the time series components into several factors: trend, seasonal, cyclical and error [12]. Furthermore, Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD) and Mean Absolute Percentage Error (MAPE), as suggested by Karim, Awala & Akhter [13], are calculated in measuring the accuracy of forecasting results.

3. Result and Discussion
3.1. Statistic Descriptive of Cacao Prices
The domestic price of cacao ranges from Rp 19,679.85 in average during 2008 to 2016 (Table 1). The highest domestic price is Rp 25,805.68 in September 2016. The lowest world price reached Rp 12,676.12 in January 2008. World cocoa price reached an average of US $ 2.83 / ton. The highest price of cocoa in the world market is the US $ 3.53 / ton, which is in May 2008 and March 2011. While the lowest price in the world market reached the US $ 2.05 / ton in March 2010.

| Table 1. Descriptive data of cocoa price 2008-2016 |
|-----------------------------------------------|
| Domestic price (Rp./kg) | Mean  | Standard deviation | Maximum | Minimum |
|------------------------|-------|---------------------|---------|---------|
|                        | 19,679.85 | 3,413.83  | 25,805.68 | 12,676.12 |
| World price (US$/ton)  | 2.83  | 0.37     | 3.53     | 2.05     |

3.2. Estimated model forecasting
3.2.1. ARIMA. Looking at ACF and PACF world and domestic cocoa price results, the domestic cocoa price data have not been stationary to the average resulting in conducting first differencing, while world price data have been stationary (Fig.1). After cocoa price data both world and domestic price data has been stationary, estimating ARIMA model for price forecasting is processed.
Fig 1. Autocorrelation Function and Partial Autocorrelation Function

Note:
- Figure 1 after Differencing (1)
(a) Autocorrelation Function world cocoa prices
(b) Autocorrelation Function domestic cocoa prices
(c) Partial Autocorrelation Function world cocoa prices
(d) Partial Autocorrelation Function domestic cocoa prices

Estimation results of ARIMA model for world and domestic price forecasting are presented in Table 2. Comparing all results, it is found the best ARIMA model for world price is ARIMA (1,0,1) in which all parameter is significance at AR (1) and MA (1). For Domestic Indonesia Cocoa Price, the best ARIMA model is ARIMA model with orders of (1,1,0) or simply AR(1) model.

Table 2. Model Estimation of Domestic Price and Cocoa Prices.

|                | Data       | Coefficient | SE  | t-statistic | Probability |
|----------------|------------|-------------|-----|-------------|-------------|
| World price (1,0,1) |            |             |     |             |             |
| AR (1)         | 0.8925     | 0.0506      | 17.63 | 0.000       |
| MA (1)         | -0.3578    | 0.0957      | -3.74 | 0.000       |
| Domestic price (1,1,0) |          |             |     |             |             |
| AR (1)         | 0.4347     | 0.0898      | 4.84  | 0.000       |

3.2.2. Decomposition. Forecasting world and domestic Cocoa Prices using decomposition model is presented in Figure 3. Examining this figure, an additive and multiplicative decomposition have the same pattern, indicating that both models have nearly equal accuracy if these models are used to forecast world cacao prices. Similarly, both types of decomposition methods show the same pattern when these models are used as forecasting model for domestic prices. By looking at figure 3, it can be concluded that both models can be chosen as an accurate forecasting method.
The level of accuracy of forecasting on world cocoa prices was found that MAPE additive decomposition was 10.85% smaller than MAPE multiplicative decomposition which had a value of 10.86%. The value of MAD decomposition of the world cocoa price additive was 0.2936 lower than the multiplicative MAD decomposition value of 0.2939. In contrast to MSD decomposition value of cocoa additives higher than MSD multiplicative decomposition is worth 0.1288 and 0.1282 respectively. Based on that, then the best decomposition method for MAPE and MAD is additive. While the model of choice for MSD is multiplicative (Table 3).

The accuracy of forecasting on world coffee prices is found that MAPE additive decomposition and MAPE multiplicative decomposition have the same value of 5%. The value of MAD decomposition of the world cocoa price additive reaches 1,021 greater than the multiplicative decomposition MAD value of 1,010. In contrast to MSD decomposition value of cocoa additives lower than MSD multiplicative decomposition that is worth consecutive 1,473,016 and 1,452,363. Based on that, then the best decomposition method for MAPE is inconclusive because the same value cannot be defined. The value of MAD and MSD is multiplicative.

**Table 3. Level of Forecasting Accuracy on Cacao Prices**

| Data        | Decomposition Type | Accuracy Measure |
|-------------|--------------------|-----------------|
|             |                    | MAPE (%)        | MAD      | MSD      |
| World price | Additive           | 10.85           | 0.2936   | 0.1288   |
|             | Multiplicative     | 10.86           | 0.2939   | 0.1282   |

| Best model  | Additive | Additive | Multiplicative |
|-------------|----------|----------|----------------|
| World price | Additive | 5        | 1012           |
|             | Multiplicative | 5      | 1473016        |

| Selection    | Inconclusive | Multiplicative | Multiplicative |
|--------------|--------------|----------------|----------------|
| Domestic     |              | 1010           | 1452363        |

3.2.3. *Exponential Smoothing*. Selection of the best double exponential model also implies the choice of $\alpha$, the smoothing parameter. The choice of $\alpha$ has considerable impact on the forecast. High value of $\alpha$ results in less smoothing in forecasting, *vice versa*. In this research, the selection of $\alpha$ is from a list value of $\alpha$ and the precise $\alpha$ will be indicated the smallest value of MAPE, MAD, and or MSD.
Table 4 presents estimated double exponential smoothing model with various values of $\alpha$. The best double exponential smoothing model is the model with smoothing parameter ($\alpha$) of 0.9. This conclusion is based on the lowest value of accuracy measures used in this research, namely, MAPE, MAD, and MSD. This model has the magnitude of MAPE, MAD, MSD at the world cocoa price of 4.541; 0.124; 0.024 respectively. For the domestic price, the accuracy measure of MAPE, MAD, MSD has a value of 2; 345; and 215023 respectively (Table 4).

| Data          | Alpha ($\alpha$) | Accuracy Measures        |
|---------------|------------------|--------------------------|
|               |                  | MAPE (%) | MAD | MSD |
| World price   | 0.1              | 8.887     | 0.244 | 0.095  |
|               | 0.2              | 7.286     | 0.200 | 0.064  |
|               | 0.3              | 6.391     | 0.175 | 0.050  |
|               | 0.4              | 5.835     | 0.160 | 0.041  |
|               | 0.5              | 5.437     | 0.149 | 0.035  |
|               | 0.6              | 5.145     | 0.141 | 0.031  |
|               | 0.7              | 4.898     | 0.134 | 0.028  |
|               | 0.8              | 4.695     | 0.128 | 0.026  |
|               | 0.9              | 4.541*    | 0.124* | 0.024*  |
| Domestic price| 0.1              | 6         | 1180 | 2120473 |
|               | 0.2              | 4         | 794  | 993150  |
|               | 0.3              | 3         | 642  | 658045  |
|               | 0.4              | 3         | 551  | 494308  |
|               | 0.5              | 3         | 485  | 394467  |
|               | 0.6              | 2         | 435  | 326508  |
|               | 0.7              | 2         | 396  | 277668  |
|               | 0.8              | 2         | 367  | 241696  |
|               | 0.9              | 2         | 345* | 215023* |

4. Model selection

Based on the results of the analysis in Table 5, it was found that the best cocoa price forecasting method is the ARIMA method. ARIMA is the most appropriate method used both world and domestic prices. For world cocoa price, ARIMA has the lowest value of MAPE, MAD, and MSD, that is, 4.23; 0.11; and 0.019 respectively. Similarly, for domestic cocoa price, ARIMA has the smallest value of MAPE, MAD, and MSD, i.e., 1.5; 291.5; 1,475,762 correspondingly.

ARIMA is considered the best method to forecast cacao price both at world and domestic markets. This finding is reasonable due to many forecasting study having similar result when dealing with selecting the best forecasting model (see Michinaka[14], for example). ARIMA is also an essential and fundamental analytical tool for development of ideas in time series analysis. The ARIMA model application will generate high predictive value and interpret rapidly changing data [4].

| Forecasting model | Accuracy Measure | An Accurate Model |
|-------------------|------------------|-------------------|
|                   | MAPE (%) | MAD | MSD |       |
| World Price       |          |     |     |       |
| Exponential Smoothing | 4,541   | 0,124 | 0,024 |       |
| ARIMA             | 4,23     | 0,11  | 0,019 |       |
| Decomposition     |          |     |     |       |
| Additive          | 10,85    | 0,2936 | 0,1288 | ARIMA |
| Multiplicative    | 10,86    | 0,2939 | 0,1282 |       |
Domestic Price

|                      |       |       |       |
|----------------------|-------|-------|-------|
| Exponential Smoothing| 2     | 345   | 215023|
| ARIMA                | 1,5   | 291,5 | 147562|
| Decomposition        | ARIMA |       |       |
| Additive             | 5     | 1012  | 1473016|
| Multiplicative       | 5     | 1010  | 1452363|

5. Conclusion

Three statistical forecasting models for cacao prices have been analysed and discussed. This paper has resulted that the most accurate cocoa price forecasting method is the ARIMA method. ARIMA is the most appropriate method used at both world and domestic prices.

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