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Forecasting Export Volume of Indonesian and Colombian Coffee in the World Market using ARIMA Model

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Abstract

Colombian coffee exports influence Indonesian coffee exports in the short term, so this study aims to forecast the export volume of Indonesian and Colombian coffee in the future. The study used time-series data from 2001 to 2021, further analyzed using the ARIMA model. Based on the projection, Indonesian coffee export is projected to increase with an average value of 1.14 percent and a potential increase of 1.79 percent. However, this result still needed to reach the desired value since the projected coffee export of Indonesia in 2025 only reached 429 172 tons, or lower than the export quantity of Colombian coffee in 2011. This finding indicated that Indonesian coffee export tended to increase stagnantly and was considered low compared to the increasing export of Colombian coffee.

Keywords:
ARIMA; coffee; export volume; forecasting

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INTRODUCTION

Coffee is a commodity that is consumed in almost every country. It has a bitter but unique taste and is usually served either cold or hot, increasing public interest in consuming coffee daily. Therefore, there was surplus demand in 2016 caused by a coffee supply of 147.94 million bags which was lower than its demand of 151.30 million bags (Rosiana et al., 2017). Currently, world coffee is supplied by several major coffee exporting countries, including Indonesia and Colombia, where coffee has become the leading export commodity (Lizano, 2017; Torok et al., 2018). In 2019, the export volume of Indonesian coffee amounted to 359 053 tons, while Colombia successfully exported a value of 769 050 tons. According to the data, the export difference between Indonesian and Colombian coffee reached 409 997 tons, indicating quite a large gap where the export value of Colombian coffee was twice that of Indonesian coffee export.

The trade potential of the coffee commodity is still widely open since coffee producing countries do not yet fulfill coffee demand. Indonesia and Colombia should maximize the situation to increase their coffee export volume globally. However, Indonesia experienced a fluctuating coffee export volume over the last five years. In 2014, the export of Indonesian coffee was 384 827 tons and further increased in 2015 to reach 502 020 tons, but drastically decreased in 2018 to a value of 279 960 tons. On the other hand, Colombia has had a stable coffee export for the last five years. In 2014, the export volume of Colombian coffee was 623 367 tons, which later increased to 717 944 tons in 2015, and 722 540 tons in 2018.

Despite the fluctuating export volume, it is predicted that the Indonesian coffee export value will increase (Erlina & Azhar, 2020). The export volume of Robusta coffee, one of the types of coffee exported by Indonesia, is also forecast to experience an annual 1.6 percent increase, even though Robusta is considered the second-class coffee with quality that is less able to compete in the international market (Chandra et al., 2013; Sahat et al., 2018). An increase in export volume might occur in trade among importing countries in the ASEAN region, showing an increasing coffee export in Malaysia, Thailand, and Vietnam (Ginting & Kartiasih, 2019). Research conducted by Deina et al. (2021) predicted the price of Brazilian coffee using several analytical methods, including ARIMA but the resulting model was only significant for Arabica coffee. Gopinath et al. (2019) predicted that coffee production in India would continue to decline.

Previous research only forecast Indonesian coffee exports in the international market (Chandra et al., 2013; Erlina & Azhar, 2020; Hamzah et al., 2020). Their research shows that Indonesia's coffee exports are predicted to increase. However, research that compares Indonesia's coffee export forecast with other coffee-producing countries has not been widely studied. So, this study was conducted to compare the forecasted volume of Indonesian coffee exports and Colombian coffee exports with a long data range, from 2001 to 2021 using ARIMA model. This is done because it is based on (Zuhdi et al., 2021), Indonesian coffee exports in the short term are influenced by Colombian coffee exports. Therefore, Colombian export forecasting will be needed to determine Colombia's potential in the international coffee trade, which

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disrupts Indonesia's export volume. This information can be used by the government to determine the policy for developing the Indonesian coffee industry to face coffee marketing competition in the international market taking into account domestic coffee production. Thus, this study aims to determine the potential changes in the export volume of Indonesian and Colombian coffee for the next five years.

METHODS

This study used *time series* data of 21 years (2001-2021) collected from the COMTRADE. The data were further analyzed using the *Autoregressive Integrated Moving Average* (ARIMA) model to obtain the short-term forecast related to coffee export in Indonesia and Colombia with the help of Minitab 19. The ARIMA method is the development of the Autoregressive Moving Average (ARMA) model, which consists of Autoregressive (AR) and Moving Average (MA) models (Jia et al., 2015; Siami-Namini et al., 2019). Zhang et al. (2017) reported a difference between ARIMA and ARMA models concerning the differencing process in ARIMA. The primary data obtained were replaced by the difference between the current and previous data; thus, the ARIMA model could minimize the non-stationarity of time series data that often leads to inaccurate forecasts.

ARIMA is a model frequently used in forecasting based on the behavior of variables and completely ignores the independent variable in the model (Qonita et al., 2017). Mathematically, the ARIMA model is written as follows:

$$(1 - \emptyset_1\beta)X_t = \mu' + (1 - \theta_1\beta)\varepsilon_t \qquad (1)$$

Where X_t is data in period-t, $\emptyset_1$ is the autoregressive parameter-1, and ε_t is an error in time-t.

There are three stages in ARIMA modeling, namely: identification of model structure, estimation of parameter, also calibration, testing, and validation of model (Sena & Nagwani, 2015). According to Riyanto & Mulyono (2019), the stages for forecasting using the ARIMA model are as follows:

Identification of Model Structure

Identification of the structure of the model is the stage to test the stationarity. Data are considered stationary if the data statistically show a constant pattern over time, either the *mean* or *variance*. However, differencing is required if data are not yet stationary. If Xt is stationary at level, which means d = 0, the model specification is ARIMA (p,0, q). If Xt is not stationary at level but is stationary after first order *differencing*, the model specification is ARIMA (p,1,q). If the process is not yet stationary after first-order differencing but is finally stationary after second-order *differencing*, the model specification is ARIMA (p,2,q). The following identification stage is determining the order of AR (p) and MA (q). In this stage, the autocorrelation function and partial autocorrelation function will determine the value of p and q. The *Autocorrelation Function* (ACF) and *Partial Autocorrelations Function* (PACF) are explained as follows:

- For AR (1), all partial autocorrelation coefficients are equal to zero for k > 1, where k is lag-k. For AR (p), general conditions apply where all coefficients of partial autocorrelation are equal to zero for k > p
- For MA (q), the autocorrelation coefficient will be zero for k > q.

The specified ARIMA (p,d,q) model is selected through the identification stage.

Estimation of Parameter

Estimating parameter in an ARIMA model is necessary to obtain the model's parameter. The Moving Average (MA) model is one of the time series models possibly selected. Moreover, if the order q from the Moving Average process is known, there are three methods possibly applied in estimating the parameter: the Moment method, the Ordinary Least Square (OLS) method, and the Maximum Likelihood method (Nirwana et al., 2018). Due to the complexity of MA (q) parameter estimation, estimating ARIMA (p,d,q) parameter becomes very complex; hence estimation of the ARIMA parameter is done using the Maximum Likelihood method.

Calibration, Testing, and Validation of Model

There are two essential things to consider in the testing stage. First, ARIMA (p,d,q) model adopts the principle of *parsimony* (simple); thus, only significant lags should be included in the model. To say, if the process of model identification and specification results in ARIMA (1,1,2) as the suggested model, but after estimation and testing, it turns out the coefficient of MA (2) is not significant, the model to be used is ARIMA (1,1,1). Second, the ARIMA (p,d,q) model is considered to meet the criteria of *goodness of fit* if an error or residual is *random*. In other words, the model estimated can capture the data pattern, resulting in non-patterned *error*. Moreover, random *error* is determined by testing the autocorrelation coefficient and partial autocorrelation of *error*. *Error* or residual is considered *random* if all coefficients of autocorrelation and partial autocorrelation of *error* are equal to zero.

RESULT AND DISCUSSION

Overview of Indonesian and Colombian Coffee Export in the Global Market

Indonesia and Colombia are included in the world's five largest coffee exporting countries. In 2018, Indonesia placed fourth, and Colombia ranked third. The export volume of Indonesian coffee during 2001 – 2019 fluctuated highly; the highest export volume of 534 025 tons was observed in 2013, while the lowest was found in 2001 at around 250 817 tons. Several reasons were responsible for the fluctuated export volume of Indonesian coffee, such as the coffee production land was still traditionally cultivated; of a total of 1,615 million hectares of coffee plantations in Indonesia in 2018, about 1,194 million hectares were smallholder (community) plantations, and the private sector or the government managed the rest, coffee plants were no longer in productive age, farmers were not yet using high-quality beans, and poor processing of coffee bean (Martauli,

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2018). The export value of Colombian coffee produced from a total area of 940 thousand Ha also found to be similarly fluctuated to Indonesia but caused by different reasons. The main factor responsible for the fluctuated export volume of Colombian coffee was the relocation of coffee production areas from Caldas, Quindío, and Risaralda to Huila, Antioquia, and Tolima due to cheaper labor costs and climate change (Gomez, 2018). The export volume of Colombian coffee in 2019 was the largest, amounting to 769 050 tons, while the lowest occurred in 2012 at approximately 400 650 tons (Table 1).

Table 1. The export volume of Indonesia and Colombia in 2001 - 2021

Year	Indonesia (ton)	Colombia (ton)
2001	250 817	560 246
2002	325 009	579 081
2003	323 903	579 223
2004	344 076	575 669
2005	445 929	617 316
2006	414 105	603 378
2007	321 404	638 304
2008	468 749	604 628
2009	510 898	460 865
2010	433 594	413 444
2011	346 492	437 140
2012	448 590	400 650
2013	534 025	547 569
2014	384 827	623 367
2015	502 020	717 944
2016	414 651	739 529
2017	467 797	720 911
2018	279 960	722 540
2019	359 053	769 050
2020	379 353	706 241
2021	382 930	700 641

Source: Secondary data processed (2022)

Analysis of *Autoregressive Integrated Moving Average* (ARIMA)

Identification of the model structure

Identification of the model is applied to test the stationarity of data since data stationarity is highly required in ARIMA analysis (Fattah et al., 2018). The time-series data will be tested for stationarity using plot analysis, and the differencing process is carried out if the data is not stationary until the data is stationary. The stationary data are then used for ACF and PACF testing (Harris, 2012). The two test results estimate the best ARIMA model for forecasting Indonesian and Colombian coffee exports.

Results of ACF and PACF tests for Indonesian coffee export data showed that the data obtained were likely in the moving average model, indicating that ARIMA (0,1,1) or ARIMA (0,1,2) was the best model to choose. Furthermore, the results of ACF and PACF tests on Colombian coffee export indicated that the data obtained were likely in the moving average model; hence the ARIMA model possibly built were ARIMA (0,2,1) and ARIMA (0,2,2).

Parameter estimation and model calibration

The next stage was the estimation of parameters and calibration of the model. This stage was applied to verify which ARIMA model is most suitable for the analysis. Estimation and calibration of the model is by comparing the p-value of each parameter coefficient with the tolerance level of 5 percent. Based on the test result of each ARIMA model, it was concluded that the best ARIMA models to forecast Indonesian is (0,1,1) because the p-value is smaller than 0.05, which is 0.001 (see Table 2). It was due to a better significant value obtained by the model than by other models.

Table 2. Estimation forecasting on Indonesian coffee export

Model/Parameter	Variable	Coef	SE Coef	t-Value	p-Value	MS
ARIMA (0,1,1)	MA (1)	0.682	0.180	3.79	0.001	6214.88
	Constant	3.71	5.96	0.62	0.542	
ARIMA (0,1,2)	MA (1)	0.724	0.238	3.04	0.007	
	MA (2)	-0.080	0.253	-0.32	0.755	6617.53
	Constant	3.83	6.68	0.57	0.574	

Source: Secondary data processed (2022)

Then, Colombian coffee export to the Global Market was ARIMA (0,2,1) because the p-value is smaller than 0.05, which is 0.000 (see Table 3). Although the p-value of ARIMA (0,2,2) is smaller than 0.05, that is 0.018, the value is greater than 0.000 in the ARIMA model (0,2,1).

Table 3. Estimation forecasting on Colombian coffee export

Model/Parameter	Variable	Coef	SE Coef	t-Value	p-Value	MS
ARIMA (0,2,1)	MA (1)	0.913	0.168	5.43	0.000	4514.13
	Constant	0.50	2.57	0.19	0.849	
ARIMA (0,2,2)	MA (1)	0.713	0.271	2.63	0.018	
	MA (2)	0.230	0.272	0.84	0.411	4491.46
	Constant	1.20	2.48	0.49	0.634	

Source: Secondary data processed (2022)

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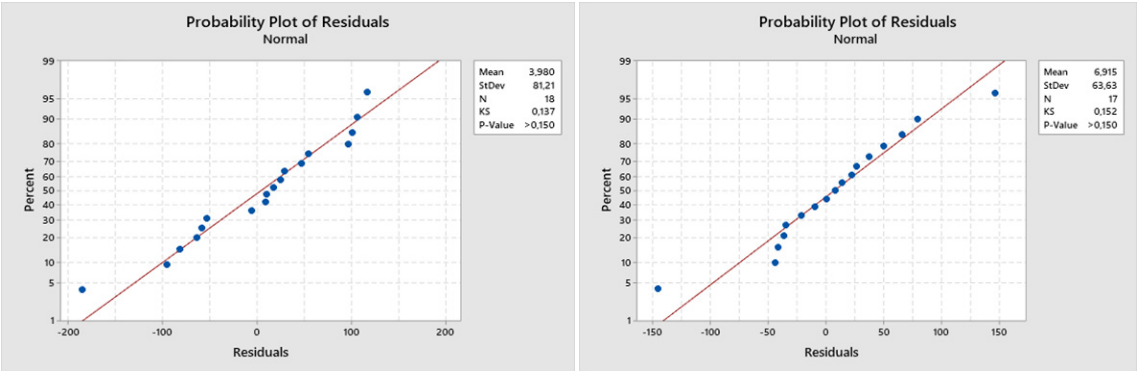
Model Testing and Validation

The ARIMA (0,1,1) and ARIMA (0,2,1) models were determined as the best ARIMA model used in this study to forecast the Indonesian and Colombian coffee export in the global market. The next stage required to verify the ARIMA model was performing a test for normality and independence in residuals (white noise). The Kolmogorov-Smirnov test for normality was done by comparing the test result with a known tolerance (0.05). If the p-value is greater than 0.05, the residual is normally ditributed and vice versa. Furthermore, the Ljung-Box test for independence was also performed by comparing the p-value with the tolerance level of 5 percent (0.05). If the p-value is greater than 0.05, there is no correlation between lags in the residuals.

Figure 1. The *Kolmogorov-Smirnov* test for Indonesian and Colombian coffee export



(a) Indonesian coffee export (b) Colombian coffee export

Based on the Kolmogorov-Smirnov test, it was concluded that the residual of the ARIMA (0,1,1) model for Indonesian coffee export data and the residual of the ARIMA (0,2,1) model for Colombian coffee export data were normally distributed since the *p-value* was greater than 0,05 and lay along the normal distribution line (Figure 10). A similar method was also used by Deina et al. (2021), Harris (2012), and Yashavanth et al. (2017). They argue that the model testing and validation stages are essential stages in determining the best model.

Table 4. The *Ljung-Box* test of Indonesian and Colombian coffee export

Residual	Lag	*Chi-Square*	*P-Value*	Description
Indonesian Coffee Export	12	11.57	0.315	White Noise
Colombian Coffee Export	12	16.45	0.087	White Noise

Source: Secondary data processed (2022)

Moreover, residual independence was examined through the Ljung-Box test. The result of the Ljung-Box test showed that the data processed were already homogenous or did not have a correlation between lags in the residuals. It was reflected by the result of the Ljung-Box test showing a p-value greater than 0.05; thus, H_0 was accepted (Table 4).

Projection of Indonesian and Colombian coffee export in the Global Market

Export value of Indonesian and Colombian coffee to the Global Market was further projected using ARIMA (0,1,1) and ARIMA (0,2,1) models to obtain the optimum, lower limit, and upper limit values of Indonesian and Colombian coffee export to the Global Market for the next five years (2021-2025). Mathematically, ARIMA (0,1,1) model was for Indonesian coffee export, and ARIMA (0,2,1) model was for Colombian coffee export, written in the following equation:

$$Zt = 4.74 + Z_{t-1} + 0.716a_{t-1} + a_t$$
$$Zt = 2.10 + Z_{t-1} + 0.951a_{t-1} + a_t$$

Based on the projection, it was found that Indonesian coffee export to the global market would experience an average increase of 0.93 percent with increased potential of 1.92 percent (Table 5). This value was still lower than a previous study which mentioned that Indonesian coffee exports, particularly the Robusta type, will have an average growth of 1.6 percent per year (Chandra et al., 2013). This increase was still considered below the expectation since projections in 2026 showed that Indonesian coffee export will only reach 409 339 tons or 4 106 tons lower than the export quantity of Colombian coffee in 2010. In contrast, Indonesian coffee export potential to the Global Market will possibly reach 592 414 tons or 44 845 tons higher than the export quantity of Colombian coffee in 2013.

This finding implied that Indonesian coffee export tended to increase stagnantly and was considered low compared to the increasing export of Colombian coffee. This result was confirmed by the projection showing that Colombian coffee export to the Global Market will experience an increase of 1.53 percent with a potential increase of approximately 6.97 percent (Table 6). Many factors caused the low export volume of Indonesian coffee, but the main reason was the low coffee production affected plantation management, harvest and post-harvest handling that was still inadequate; also, coffee plantation ownership was still dominated by smallholder plantations which resulted in low coffee production (Manalu et al., 2019). On the other hand, Colombia continued to improve the quality of the coffee product since players in the coffee industry focused on increasing coffee quality despite the declining coffee production quantity that occurred at the same time (Stringer & Roldán-Pérez, 2013).

Table 5. The forecasting value of Indonesian coffee export with the ARIMA (0,1,1) model

Year	Forecasting (ton)	Growth (%)	Lower Limit (ton)	Upper Limit (ton)	Growth Potential (%)
2022	394 511		239 965	549 058	
2023	398 218	0.94	236 068	560 369	2.06
2024	401 925	0.93	232 512	571 338	1.96
2025	405 632	0.92	229 255	582 008	1.87
2026	409 339	0.91	226 263	592 414	1.79
Average	401 925	0.93	232 813	571 037	1.92

Source: Secondary data processed (2022)

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Table 6. The forecasting value of Colombian coffee export with the ARIMA (0,2,1) model

Year	Forecasting (ton)	Growth (%)	Lower Limit (ton)	Upper Limit (ton)	Growth Potential (%)
2022	710 501		578 787	842 210	
2023	720 856	1.46	526 321	915 390	8.69
2024	731 708	1.51	483 216	980 200	7.08
2025	743 057	1.55	444 185	1 041 930	6.30
2026	754 902	1.59	407 291	1 102 510	5.81
Average	732 205	1.53	487 960	976 450	6.97

Source: Secondary data processed (2022)

The forecast results also show that Indonesia's coffee export growth will decreased every year from 0.94% in 2023 to 0.91% in 2026 (Table 5). On the other side, the Colombia's coffee export forecast shows an increase in growth every year from 1.46% in 2023 to 1.59% in 2026 (Table 6). This condition can be interpreted that if Indonesia does not make significant changes in the development of the coffee industry and continues to rely on farming that has been carried out by farmers so far, it is estimated that Indonesia will lose its competitiveness in international market. Research conducted by Narulita et al. (2014) shows that Indonesian coffee still has competitiveness in international market. However, the potential loss of competitiveness according to the forecast results could cause Indonesia's coffee market share in the international market to shrink and be taken over by other coffee producers such as Colombia.

Results of the analysis above also showed that the export volume potential of Indonesian coffee is still far behind that of Colombia. It confirms that Indonesia still faces intense competition from Colombia regarding the coffee trade in the international market (Purnamasari et al., 2014). To face this competition, Indonesia have to improve the competitiveness of its coffee by increasing the quantity and quality coffee and strengthening government coordination with the private sector (Yulia Putri & Salam, 2019). In the context of international competition, Indonesia must also be able to produce coffee that meets international standard by adapting good farming practices to qualify the sustainability certification (Wahyudi et al., 2020). In addition, efforts to increase exports can also be done with a better trade relations and entering into trade agreements (Atif et al., 2019).

If the government is serious about making coffee a leading export commodity of Indonesia, the upstream sector, particularly the on-farm aspect of the coffee plantation, should be taken into concern; as mentioned by Malaisamy et al. (2020), Indian coffee was able to be optimally produced due to the use of shade trees that was suitable to the land condition of coffee plantation. Later, Bhattarai et al. (2020) suggested that factors influencing coffee production in Nepal included the adoption of plants to intercrop with coffee and shade trees, planting distance, access to irrigation facilities, farmer experience in coffee cultivation, ownership of the vehicle, and participation in program training related to coffee production and marketing. The government of Indonesia can adopt the coffee cultivation method in both countries to increase the productivity of coffee plants; thus, the forecast will not occur.

CONCLUSION

The ARIMA (0,1,1) dan ARIMA (0,2,1) models were considered the best ARIMA model for forecasting Indonesian and Colombian coffee export in the Global Market. Based on the projection, it was found that Indonesian coffee export to the Global Market will averagely increase by 0.93 percent with a potential increase of 1.92 percent. This increase was still considered lower than the desired value since the projected result showed that Indonesian coffee export in 2026 will only reach 409 339 tons or 4 106 tons lower than the export quantity of Colombian coffee in 2010. Moreover, Indonesian coffee export potential to the Global Market will possibly reach 592 414 tons or 44 845 tons higher than the export quantity of Colombian coffee in 2013. This finding implied that Indonesian coffee export tended to increase stagnantly and was considered low compared to the increasing export of Colombian coffee. This result was confirmed by the projection showing that Colombian coffee export to the Global Market will experience an increase of 1.53 percent with a potential increase of approximately 6.97 percent.

The forecast results also show that Indonesia has the potential to lose coffee competitiveness so that the government have to improve the quantity and quality of its coffee. Indonesia must be able to produce coffee that meets international standard by adapting good farming practices to qualify the sustainability criteria. This is because the sustainability issue has become a concern for international consumers in choosing agricultural products. To fulfill this, the government must pay attention to improving the coffee cultivation process by disseminating the latest cultivation technology to farmers.

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