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Analysis of The Profitability of Islamic Banking Using Arimax Model and Regression with Arima Errors Model

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ABSTRACT

Profitability of Islamic banking is a benchmark for the performance of Islamic bank. Indicators for measuring the profitability of Islamic banking is ROA. There are several predictor variables involved that affect the profitability of Islamic banking, namely interest rates, exchange rates and inflation. This research was aimed to predict the effect of predictor variables on Islamic bank profitability using two approaches namely ARIMAX and ARIMA errors. Both model approaches are conceptually the combination between the regression model and ARIMA model. The best model of the two approaches will be compared by considering the MAPE value. The best model is reflected by the smallest SBC value, significant parameter estimator, and the smallest MAPE value. As a result, the approach model of ARIMA (1, 1, 1) error with variable of exchange rate was found to be the best model with MAPE value of 32.013%, while the model of ARIMAX (0, 1, 2) with exchange rate variable obtained MAPE value of 375.78%. Thus, the best model to predict the effect of predictor factor on Islamic banking profitability was ARIMAX model (0,1,2) with exchange rate variable.

Keywords : ARIMAX, ARIMA errors, Predictor, Profitability, ROA

I. INTRODUCTION

Building a model to predict the effect of correlation between independent variables and dependent variable can be done using time series model approach. Time series is a series of variables influenced by the time and at the same interval[1]. Time series can also be defined as the collection of data from an event in sequence based on the timeline of occurrences[2].

Banking profitability is one of studies conducted in the field of socio-economics that mainly applies the approach of linear regression method. This regression method approach is aimed to correlate the effect of dependent variable (Z) and independent variable (X), namely the effect of independent variable on profitability variable. Some previous researches that applied regression method approach include the study conducted by Abduh and Idress [3] which showed that inflation was found to have positive and significant impact on the profitability of Islamic Banks in Malaysia. Research of Swadayani and Kusumaningtias [4] showed that the variables of inflation, interest rates, exchange rates and money supply together resulted in a significant effect on the ROA of Islamic banking in Indonesia. A recent study conducted by Hidayati [5] indicated that inflation and exchange rates significantly affected the profitability of Islamic banks in Indonesia.

Models that combine the correlation between the observed variables by considering observation time are rarely found; therefore, it is required to perform research on such approach which is able to measure the effect of correlation between the observed variables by taking observation time into consideration. Model approach which conceptually combines the regression model approach and ARIMA model is the Autoregressive Integrated Moving Average with Exogenous Input (ARIMAX). ARIMAX can be interpreted as an extension of ARIMA model that considers exogenous factors.

Another approach that can predict the correlation of exogenous factors towards independent variables is the approach of regression model with ARIMA errors (ARIMA error). This approach is started by examining the assumptions for residual autocorrelation. Regression model with autocorrelation in its residual is modelled using ARIMA. The best model is selected from both approaches and further compared to obtain a model that can predict the effect of exogenous variables on Islamic banking profitability.

II. METHODS AND MATERIALS

Monthly data for the independent variables and ROA interest rates, inflation and exchange rates used in this study were obtained from the website of Indonesia Central Bank from January 2010 until December 2017. All the data were divided into two, i.e. data from January 2010-December 2016 as training data and data from January 2017 - December 2017 as testing data.

The stages of data analysis conducted in this study are listed as follows:

1. Data exploration
2. Divide the data into two: training data and testing data
3. Build ARIMAX model
   a. Build ARIMA model with ROA variables
   b. Build 3 ARIMA models by including predictor variables (interest rates, exchange rates, inflation)
4. Build Regression models with ARIMA errors
   a. Build 3 linear regression model
   b. Perform assumption test for autocorrelation on the residuals of regression model
   c. Build ARIMA model for error model that has autocorrelation
5. Build ARIMA model
   a. Identify ROA variables for ARIMAX and the residual of regression models which has autocorrelation with ARIMA errors. Data identification can be done by examining the data plot or ACF and PACF plots as well as applying KPSS test for ARIMAX and ADF test for ARIMA errors
   b. Predict the parameters for both models by performing prediction of parameters using maximum likelihood method by considering the lowest value of Schwart's Bayesian criterion (SBC) to select the best model
6. Perform diagnostic model by conducting assumption test for autocorrelation using Ljung-Box test (Q*) and assumption that the residuals are normally distributed (Gaussian assumption) by Jarque Bera (JB).
7. Compare the MAPE value of the best model selected from ARIMAX and ARIMA errors
8. Complete

III. RESULTS AND DISCUSSION

A. ARIMA Model for ROA Variables

ARIMAX modelling is started by building ARIMA models for ROA variables. Exploratory examination for stationarity can be observed through data plot or plots of ACF and PACF. In addition, the test for data stationarity is done through KPSS test. The KPSS test is performed to assure the conclusion of ACF and PACF plots whether the data are stationary or not. If

the data are not stationary, differencing should be applied.

Figure 1 shows that ROA data tended to be not stationary. Result of KPSS test showed that the p-value was smaller than α = 0.05 or rejection of H_0, reflected that ROA data were not stationary. Hence, it is necessary to perform differencing to solve the problem of data stationarity in ROA.

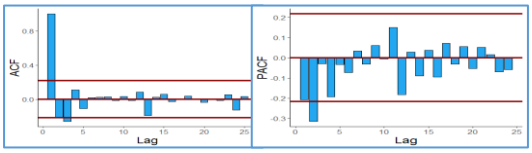

Figure 2. ACF and PACF plots of ROA variables after first differencing

Based on the plot of ACF and PACF in Figure 2, ROA data were already stationary at first differencing. The result of KPSS test showed that p-value was greater than α = 0.05, which indicated that there was sufficient evidence to prove that ROA data were stationary. Parameter estimation is done after testing the stationarity of ROA data. The candidate of ARIMA model can be built by observing ACF and PACF plots. Selection of the best model is done by considering the smallest SBC value. Moreover, tentative models of ARIMA are shown in Table 1 below:

Table 1. Tentative models of ARIMA for ROA variables

Model	SBC
ARIMA (0,1,0)	49.54714
ARIMA (0,1,1)	46.12539
ARIMA (0,1,2)	**45.30919**
ARIMA (0,1,3)	48.39329
ARIMA (1,1,0)	50.43735
ARIMA (1,1,1)	47.51204
ARIMA (1,1,2)	Inf
ARIMA (1,1,3)	Inf
ARIMA (2,1,0)	46.43814
ARIMA (2,1,1)	50.20309
ARIMA (2,1,2)	Inf
ARIMA (2,1,3)	Inf

The best model based on the smallest SBC value was found in ARIMA model (0,1,2). Building ARIMAX model with variables of interest rate, exchange rate and inflation rate resulted in 3 ARIMAX models. The parameter estimators formed are shown in Table 2.

B. ARIMAX Model with interest rate, exchange rate and inflation

Table 2. ARIMAX Parameter Estimates for Predictor

No	Model	Variables	estimate	p-value
1.	ARIMAX (interest rate) (0,1,2)	MA(1)	-0.2624	0.0284
		MA(2)	-0.3210	0.0138
		Interest rates	-0.0827	0.3295
2.	ARIMAX (exchange rates) (0,1,2)	MA(1)	-0.3450	0.0037
		MA(2)	-0.3213	0.0103
		change rates	-0.0003	0.0036
3.	ARIMAX (Inflation) (0,1,2)	MA(1)	-0.2610	0.0307
		MA(2)	-0.2870	0.0194
		Inflation	-0.0234	0.5798

The parameter estimator of 3 ARIMAX models in Table 3 shows that ARIMA model with the addition of exchange rate variable was significant at α = 5%. However, ARIMA model with the addition of interest rate and inflation variables was not significant. Thus, ARIMAX model (0,1,2) with exchange rate variable was selected as the best model.

C. *Model of ARIMA Errors*

The regression model with ARIMA error is started by building the regression model of ROA with interest rate, exchange rate and inflation into 3 regression models. The regression assumption requires that the residual model is not correlated. Figure 1 shows that correlation between residuals occurred since the residual plots produced had pattern and were identical to the original data plot. Solution for violation of assumption between independent residuals is done by performing ARIMA modelling towards the residuals.

Model 1 Model 2 Model 3

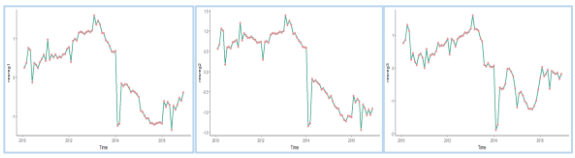

Figure 3. Residual Plot of Regression Model

Residual model which has autocorrelation is further modelled with regression approach with ARIMA error. The stage of regression with ARIMA error is started by performing test for data stationarity, followed by the determination of tentative model of regression with ARIMA error by observing ACP and PACF plots, determination of the best model based on the smallest SBC value, and finally determination of parameter estimator from the selected model. Table 3 shows the candidate of regression model with ARIMA error as follows:

Table 3. Tentative Models of ARIMA errors with the addition of one predictor

Model 1	SBC
ARIMA(2,1,1)	54.11596
ARIMA(0,1,0)	53.94888
ARIMA(1,1,0)	54.84407
ARIMA(0,1,1)	**50.45654**
ARIMA(1,1,1)	51.35002
Model 2	**SBC**
ARIMA(2,1,2)	48.05273
ARIMA(0,1,0)	50.53547
ARIMA(1,1,0)	50.62844
ARIMA(0,1,1)	44.8974
ARIMA(1,1,1)	**44.19366**
ARIMA(1,1,0)	50.62844
ARIMA(1,1,2)	45.12336
ARIMA(0,1,1)	44.8974
ARIMA(2,1,1)	48.01803
Model 3	**SBC**
ARIMA(2,1,1)(1,0,1)[12]	Inf
ARIMA (0,1,0)	53.86577
ARIMA	56.07754
(1,1,0)(1,0,0)[12]	51.70949
ARIMA	56.11418
(0,1,1)(0,0,1)[12]	**50.40603**
ARIMA	51.67818
(0,1,1)(1,0,1)[12]	51.85441
ARIMA(0,1,1)	
ARIMA (1,1,1)	
ARIMA	
(0,1,1)(1,0,0)[12]	

Based on Table 4 of regression model with the tentative ARIMA error, the smallest SBC value was found in the regression model with ARIMA (0,1,1) error for the variable of interest rate and inflation, while the smallest SBC for exchange rate variable was found in the regression model with ARIMA (1,1,1) error.

D. The Evaluation Model

The MAPE value shown in Table 5 is the MAPE value of the 7 models built. This model is built from two different model approaches. The selection of the best model is based on the smallest MAPE value. In ARIMAX model, the smallest MAPE value was found in ARIMAX (0,1,2) model with interest rate variable of 32.01%. In regression model with ARIMA error, the smallest MAPE value was found in the regression model with ARIMA (1,1,1) error with variable of exchange rate. In overall, the model built from two different model approaches was found in the model of ARIMAX (0,1,2) with interest rate variable and MAPE value of 27.64%.

Table 4. The value of MAPE of all selected models

Model Approach	Model	MAPE
ARIMAX (0,1,2)	$ARIMAX_{(Interest\ rates)}$	**27.64%**
	$ARIMAX_{(exchange\ rates)}$	375.78%
	$ARIMAX_{(Inflation)}$	34.14%
ARIMA *Error*	ARIMA $Error_{(Interest\ rates)}$ (0,1,1)	109.84%
	ARIMA $Error_{(change\ rates)}$ (1,1,1)	**32.01%**
	ARIMA $Error_{(Inflation)}$ (0,1,1)	33.30%

IV.CONCLUSION

The best model is determined from the smallest SBC value, significant parameter estimator, and the smallest MAPE value. The model selected based on those criteria is the regression model with ARIMA

(1,1,1) error, that is the best model of the 6 models built using two approaches, namely ARIMAX model approach and regression model with ARIMA Error approach. The best model had the smallest MAPE forecasting accuracy of 32.013%, which means that the average percentage of absolute error in predicting 384 data only reached 32.013%. Therefore, there is sufficient evidence that exchange rate variable affected the profitability of Islamic banking in Indonesia for the period January 2010-December 2017. As for the model equations can be written of regression with ARIMA errors as follows:

$$Z'_t = -0.0003X_{Kurs} + \left(\frac{0.4298Z_{t-1}}{-0.8401\varepsilon_{t-1}}\right)\varepsilon_t$$

Assumption for the best model which included no autocorrelation between residuals was fulfilled, but other assumption, namely the residual normality was not fulfilled. The unfulfilled assumption for normality proved that the data had high volatility.

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