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Lia Puspita Sari, Abdulloh Hamid, and Hani Khaulasari

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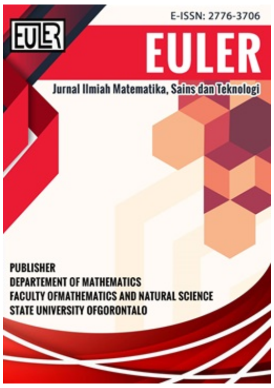

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Research Article

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Forecasting Zakat Potential in BAZNAZ East Java Using the ARIMAX Method with Calendar Variation Effects

Lia Puspita Sari[1], **Abdulloh Hamid**[1], **Hani Khaulasari**[1,*]

[1]*Departement of Mathematics, UIN Sunan Ampel Surabaya, Surabaya, Indonesia*

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ABSTRACT. *Zakat is a Muslim act of worship that is related to wealth and is one of the instruments used in economic development so that it can solve the problem of poverty. According to the Central Statistics AgencyZakat is an Islamic obligation related to wealth distribution and functions as a key instrument in economic development, particularly in alleviating poverty. According to the Central Statistics Agency, East Java had the highest number of poor people in Indonesia in 2023. BAZNAS (Badan Amil Zakat Nasional) plays a strategic role in managing zakat funds to support poverty reduction efforts. Accurate information on zakat potential is crucial for ensuring the effective management and distribution of zakat. This study aims to model, evaluate the accuracy, and forecast the zakat potential at BAZNAS East Java untuk Januari sampai dengan Desember 2024 using the Autoregressive Integrated Moving Average with Exogenous (ARIMAX) Variables method. ARIMAX extends the ARIMA model by incorporating exogenous variables. In this study, the exogenous variables used are a deterministic trend and a Hijri calendar dummy variable representing the month of Ramadan, The results show that the best-performing model is ARIMAX([12],1,1), with a MAPE value of 18%, indicating a reasonably accurate forecast. The zakat potential for the next 12 months is projected to remain relatively stable, with a significant increase of IDR 6,674,988,827.25 expected in April 2024. This spike coincides with the month of Ramadan, when Muslims customarily pay zakat fitrah and zakat mal.*

1. Introduction

Zakat is a form of worship related to wealth. Islam requires all Muslims who have a certain amount of wealth to purify their wealth by setting aside half of their wealth or paying zakat to groups entitled to receive zakat to help meet their needs [1]. BAZNAZ (National Zakat Agency) is an institution tasked with collecting and distributing zakat, and also acts as a supplier of social security benefits for the poor. Zakat is one of the instruments used in economic development so that it can solve the problem of poverty [2]. Poverty is considered as the inability of the economy to meet primary needs, food or other very important needs [3].

According to the Central Statistics Agency, the total number of poor people in Indonesia for five consecutive years is East Java province and in 2023 the poor people in East Java province are 4,188.81 residents [4]. Poverty can be handled in two steps, namely cultural and structural steps. Cultural steps are aimed at individuals, both as subjects who are expected to play a role in economic empowerment for the poor and needy and as objects that receive empowerment, while structural steps are more aimed at special institutions for their action, so that they can run well [5]. Therefore, in alleviating poverty in East Java province, BAZNAZ East Java has several programs in distributing zakat funds to zakat recipient (mustahik).

Zakat contributions can continue to be increased, especially to alleviate poverty. However, there are several challenges faced in zakat management, including fluctuations in zakat income, growth in the number of zakat recipients, and transparency issues in managing zakat funds can create uncertainty among people who want to give zakat. Information about the total potential zakat receipts will help BAZNAZ in managing and distributing the zakat, therefore a forecast is needed regarding the potential zakat that may be collected in the future. Forecasting is a strategy used to estimate future situations based on historical data information from previous periods [6]. BAZNAZ East Java has never previously made a forecast of the potential zakat that will be obtained. Forecasting potential zakat needs to be done so that zakat management can move efficiently and BASNAS East Java can take appropriate policies.

One of the methods created to analyze time series data is ARIMA (Autoregressive Integrated Moving Average). Previous research by Han et al compared ARIMA and LSTM in predicting CO2 concentrations in vehicles, ARIMA was better with a MAPE value of 0.46% [7]. Another study that obtained the same results was conducted by Moftakhar et al. who compared it with Neural Network to predict COVID-19 patients in Iran [8].

Previous research on the ARIMA method used one variable, namely the dependent variable, while there are several cases of time series data influenced by independent variables involving the effects of calendar variations, such as in this study the use of zakat potential data in a monthly period. Forecasting zakat potential in a monthly period must consider the effects of calendar

*Corresponding Author.

Email : *hani.khaulasari@uinsa.ac.id* (H. Khaulasari)
Homepage : http://ejurnal.ung.ac.id/index.php/euler/index / E-ISSN : 2776-3706

variations in its calculations, because in Islam there are months that have priority for zakat. Therefore, the ARIMA method is not good enough to practice modeling. One method for forecasting by identifying independent variables is ARIMAX (Autoregressive Integrated Moving Average Exogenous). ARIMAX is a development of the ARIMA model and time series regression which is equipped with calendar-based dummy variables. This model not only captures the internal patterns of time series data, but also accommodates the influence of exogenous variables and temporal events, such as specific days in the calendar [9]. The use of time series regression with dummy variables was first performed to test the significant influence of a particular temporal event or time category on the response variable, before the model was further developed using an approach such as ARIMAX [10]. The function of adding exogenous variables in ARIMAX is to identify other patterns and increase the level of accuracy of forecasting results [11]. Research by Luo et al on forecasting scarlet fever infectious diseases in China using the ARIMAX method, this study includes BSI (Baidu Search Index) as an exogenous variable and considers seasonal transmission patterns in building the model, the final result obtained is the ARIMAX model (1, 0, 2) (2, 0, 0) (12) with a MAPE accuracy of 2.16% [12]. This study aims to model, evaluate the level of accuracy, and forecast the potential of zakat in BAZNAS East Java for the period January to December 2024 using the Autoregressive Integrated Moving Average with Exogenous Variables (ARIMAX) method. The ARIMAX model is expected to provide better forecasting accuracy than the conventional ARIMA model because it includes relevant exogenous variables, such as deterministic trends and dummy variables for specific months.

2. Methods

2.1. Time Series Regression

Time series regression consists of variations in impacting components, including trends, seasonal variations, and calendar variations. The equation is:

$$Z_t = \delta_t + \sum_{m=1}^{M} \alpha_m M_{m,t} + \sum_{j=1}^{J} \beta_j D_{m,t} + \varepsilon_t, \tag{1}$$

with δ is the trend, α is the coefficient of the seasonal component, β is the coefficient of calendar variation, $M_{m,t}$ is the seasonal dummy variable, $D_{m,t}$ is the dummy variable, and ε is the error [13]. Dummy variables that have a perfect collinearity case, namely a precise linear relationship between variables or variables that have m categories, must follow the rule $(m-1)$ dummy variables [14].

2.2. ARIMA Model with Addition of Exogenous Variables (ARIMAX)

The ARIMAX (Autoregressive Integrated Moving Average Exogenous) method is seen as an extension of the ARIMA model [15]. ARIMA is a time series forecasting method that takes advantage of the relationship between current values, past values, and past errors, and requires the data to be stationary before modeling can be done. The constants in the ARIMA model are (*p, d, q*), where *p* is the Autoregressive constant, *d* is the differencing constant, and *q* is the Moving Average constant. The ARIMA model is represented by the order (*p, d, q*) with the equation form below [16].

$$\phi_p(B)(1-B)^d Z_t = \theta_q(B)\gamma_t, \tag{2}$$

where ϕ_p is the coefficient of AR of order p, B is the Backshift operator, d is the differencing parameter, and θ_q is the coefficient of MA of order q. The ARIMAX model extends ARIMA by including exogenous variables, allowing it to account for external influences and thereby improve the accuracy of forecast results [17]. Exogenous variables refer to variables that can influence other variables without being influenced by other variables in the model being considered. The ARIMAX model formed with the presence of deterministic trends, monthly dummies, and calendar variations is as follows [18]:

$$Z_t = \delta_t \sum_{m=1}^{M} \alpha_m M_{m,t} + \sum_{j=1}^{J} \beta_j D_{m,t} + \frac{\theta_q(B)}{\phi_p(B)(1-B)^d} + \gamma_t. \tag{3}$$

2.3. Forecasting Accuracy Level

Forecasting accuracy serves to evaluate the extent to which the forecasting results align with reality or actual data. By knowing the level of accuracy, one can assess how good the forecasting model is [19]. The level of model accuracy can be determined using the Mean Absolute Percent Error (MAPE). The MAPE equation is stated as follows [20].

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Z_t - \hat{Z}_t}{Z_t}\right| \times 100, \tag{4}$$

where *n* is the amount of data, Z is the initial data, and $\hat{Z}$ is the forecast data.

2.4. Modeling Procedure

This study applies secondary data obtained from related institutions in the form of financial reports of BAZNAZ East Java, starting from January 2016 to August 2023. The variables applied in this study are one response variable and a dummy variable as in the Table 1.

Table 1. Research variables

Variables	Information
Z_t	Data on total zakat receipts at BAZNAZ East Java in month t
Trend	t, with $t = 1, 2, 3, \ldots, n$
Monthly Effect Dummy	$M_{1,t} = \begin{cases} 1, & \text{For January} \\ 0, & \text{For other months} \end{cases}$ $M_{2,t} = \begin{cases} 1, & \text{For February} \\ 0, & \text{For other months} \end{cases}$ $\vdots$ $M_{12,t} = \begin{cases} 1, & \text{For December} \\ 0, & \text{For other months} \end{cases}$
Calendar Variation Dummy	$D_{1,t} = \begin{cases} 1, & \text{For Muharram} \\ 0, & \text{For other months} \end{cases}$ $D_{2,t} = \begin{cases} 1, & \text{For Ramadan} \\ 0, & \text{For other months} \end{cases}$ $D_{3,t} = \begin{cases} 1, & \text{For Dzulhijjah} \\ 0, & \text{For other months} \end{cases}$

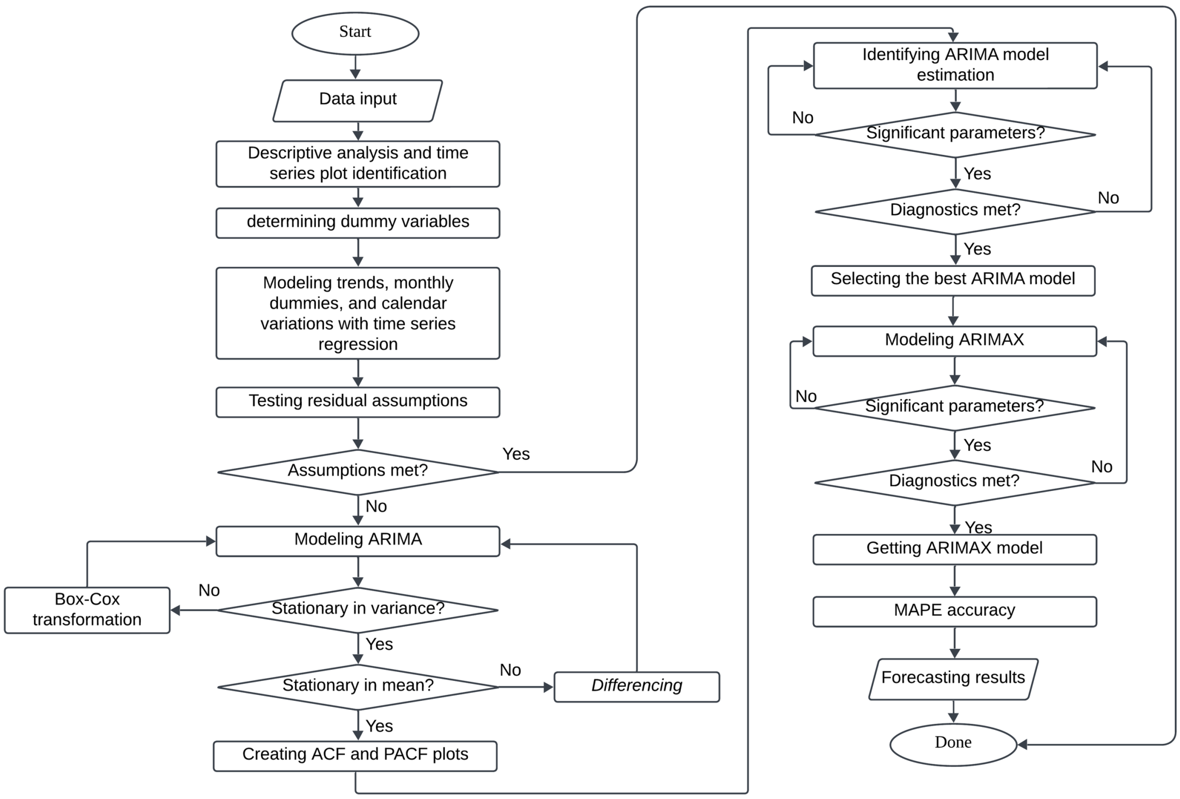


Figure 1. ARIMAX method flowchart

This study begins with data exploration to determine events that affect the increase in zakat potential at BAZNAZ East Java. Next, modeling the independent variables with time series regression. After that, looking for the best model from ARIMA. Finally, ARIMAX modeling is carried out by entering significant independent variables. This method is displayed in the form of a flowchart in Figure 1.

3. Results and Discussion

3.1. *Descriptive Potential of Zakat at BAZNAZ East Java Province*

This research analysis uses data on the acquisition of zakat fitrah and zakat mal at BAZNAZ East Java Province for 92 months, starting from January 2016 to August 2023. The characteristics of zakat acquisition can be identified through the results of descriptive analysis shown in Table 2.

Table 2. Descriptive analysis of zakat potential at BAZNAZ East Java province

Year	Mean	St.Dev
	918,441,858	890,972,501
(2016-2023)	Min	Max
	71,425,750	6,333,203,576

Based on Table 2, the data on zakat potential at BAZNAS East Java during the period 2016 to 2023, obtained an average value of IDR 918,441,858, with a standard deviation of IDR 890,972,501. This shows that there are huge fluctuations from year to year. The minimum value was recorded at IDR 71,425,750, while the maximum value reached IDR 6,333,203,576, indicating a significant spike in a given year. The long distance between the minimum and maximum values, as well as the high standard deviation, indicates the possibility of outliers or the influence of seasonal factors such as the month of Ramadan, which has an impact on a sharp increase in the potential of zakat in certain years.

3.2. *Data Exploration*

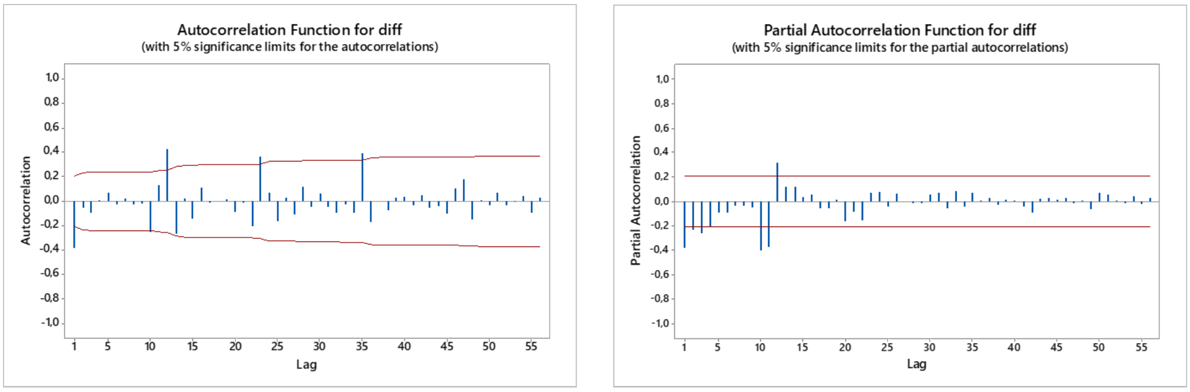
The increase in the potential for zakat at BAZNAZ East Java occurred in the month of Ramadan. This significant increase occurred because there was payment of zakat fitrah and mal, but an increase in the potential for zakat could occur in other hijriah months besides the month of Ramadan, such as the months of Muharram and Dzulhijjah which have good virtues in paying zakat mal. Therefore, the potential for zakat is influenced by seasonal factors and calendar variations, for the dummy variable of the seasonal factor is:

$$M_{i,t} = \begin{cases} 1, & \text{Month } - i \\ 0, & \text{Other month} \end{cases}$$

where $i = 1, 2, 3, \ldots, 12$ which are the months of January to December, for the dummy variable of the effect of variation of the hijriah calendar is:

$$D_{i,t} = \begin{cases} 1, & \text{Month } - i \\ 0, & \text{Other month} \end{cases}$$

where $i =$ the months of Muharram, Ramadan, and Dzulhijjah.



(a) A **(b)** B

Figure 2. Plot (A) Autocorrelation Function (ACF) and (B) Spatial Autocorrelation Function (PACF)

Table 3. Parameter estimation, diagnostic test, and ARIMA model accuracy

Model	Parameters	Diagnostic Test (P-Value)		AIC
		Ljung-Box	Kolmogorov-Smirnov	Accuracy
ARIMA([11],1,1)	IMA(1,1)	0.86670	0.2744	3929.131
	ARI(1,1)	0.58395	0.208051	
ARIMA([12],1,1)	IMA(1,1)	0.74285	0.3325	**3886.786***
	ARI(1,1)	1.00000	0.208051	

*) Best Model

3.3. Deterministic Trend Modeling, Monthly Dummy, and Calender Variation

The model that contains trend components, seasonal elements, and calendar variations, then the calculation utilizes the regression model according to eq. (2), which can be written:

$$\begin{aligned}Z_t = \delta_t &+ \alpha_1 M_{1,t} + \alpha_2 M_{2,t} + \alpha_3 M_{3,t} + \alpha_4 M_{4,t} + \alpha_5 M_{5,t}\\ &+ \alpha_6 M_{6,t} + \alpha_7 M_{7,t} + \alpha_8 M_{8,t} + \alpha_9 M_{9,t} + \alpha_{10} M_{10,t}\\ &+ \alpha_{11} M_{11,t} + \beta_1 D_{1,t} + \beta_2 D_{2,t} + \beta_3 D_{3,t} + \varepsilon_t.\end{aligned}$$

The process of estimating the parameters of the equation model above uses the dummy regression method. While for the parameter significance test, it is completed as a whole using the F test and partially with the t test. From the F test, the decision is obtained that one of the variables has a significant influence on the potential zakat obtained, and from the t test, it is obtained that there are only two significant variables, namely the deterministic trend variable and the Ramadan calendar variation. From the significant simultaneous test and the partial test where several parameters are not significant, the new model approach is tested again by deleting insignificant variables, a new model is obtained with significant variables, namely:

$$\begin{aligned}Z_t &= \beta_0 + \beta_1 \delta_t + \beta_{14} D_{2,t} + \varepsilon_t\\ &= -377833153 + 250787797\delta_t + 748138081 D_{2,t} + \varepsilon_t.\end{aligned}$$

3.4. Residual Assumption Testing

Assumption testing is carried out by observing whether the residuals from the regression analysis are identical, independent, and normally distributed. If the residuals do not meet the assumptions, they are modeled again with the ARIMA model. It is found that in the model there is heteroscedasticity or not identical, autocorrelation is detected or not independent, and it is not normally distributed. Therefore, it can be modeled with the ARIMA model.

3.5. ARIMA

The regression model obtained will be checked for stationarity in the variance and mean. The stationarity test in the variance obtained a value of $\lambda = 0.00$, which means it is not stationary in the variance, therefore a Box-Cox transformation is needed. After the Box-Cox transformation, the value of $\lambda = 1$, so it can be considered that the data is stationary in the variance. Furthermore, the stationary in the mean of the zakat potential data needs to be differencing once to obtain data that is stationary in the mean. After obtaining data that is stationary in the variance and mean, the ARIMA order can be identified.

Figure 2 shows the ACF and PACF plots of the zakat potential data at BAZNAS East Java. In the ACF plot, autocorrelation lags at 1, 12, 22, and 34 are observed to be outside the significance limits, while in the PACF plot, significant spikes occur at lags 1, 2, 3, 10, 11, and 12. These patterns provide initial guidance for model identification in ARIMA-based forecasting. The Partial Autocorrelation Function (PACF) is used to determine the appropriate order of the autoregressive component AR(p), while the Autocorrelation Function (ACF) helps identify the order of the moving average component MA(q). In addition, the data has been differentiated in the mean once until $d = 1$. Possible models are presented in Table 3.

Table 3 obtains possible ARIMA models, parameter estimation, diagnostic tests, and selection of the best model. The best ARIMA model is based on the smallest AIC value, so the ARIMA model ([12],1,1) is concluded to be the best model. The ARIMA model equation ([12],1,1). By substituting the estimated parameters in Table 3, it can be concluded that the ARIMA model

([12],1,1) is as follows equation:

$$\begin{aligned} Z_t &= Z_{t-1} - \phi_{12} Z_{t-12} + \phi_{12} Z_{t-13} + \theta_1 \alpha_{t-1} + \alpha_t \\ &= Z_{t-1} - Z_{t-12} + Z_{t-13} - 0.74285\alpha_{t-1} + \alpha_t. \end{aligned}$$

3.6. ARIMAX

ARIMAX is a combination of the ARIMA model ([12],1,1) with a regression model of significant exogenous variables, namely deterministic trends and variations in the Ramadan calendar.

Table 4. Significance of ARIMAX model parameters ([12],1,1), trend variables, and variations in the Ramadan calendar

Parameters	Estimation	t_{count}
Konstan	-104265585	-1.73
MA1,1	0.64135	5.78
AR1,1	1.00000	6.66
t	1122686.1	0.73
D_2	617991413	3.76

The significance test of the ARIMAX model parameters ([12],1,1), trend variables, and variations in the Ramadan calendar are shown in Table 4, with the results that there are insignificant parameters, namely $t_{count} < t_{(\propto/2,100)}$ by (1.98793), so a new model approach will be applied by removing insignificant variables, namely deterministic trends.

Table 5. Significance of ARIMAX model parameters ([12],1,1) and variations in the Ramadan calendar

Parameters	Estimation	t_{count}
Konstan	-82162569	-2.30
IMA(1,1)	0.87580	14.52
ARI(1,1)	1.14451	8.21
D_2	422222750	2.93

The significance test of the ARIMAX model parameters ([12],1,1) of the Ramadan calendar variation in Table 5 shows that all parameters are significant. Therefore, it is continued with diagnostic model testing can be seen in Table 6, and the following is the ARIMAX modeling of calendar variations obtained from eq. (3):

$$\begin{aligned} Z_t = &-82162569 + 422222750 D_2 + Z_{t-1} - 1.14451 Z_{t-12} \\ &+ 1.4451 Z_{t-13} - 0.87580\alpha_{t-1} + \alpha_t. \end{aligned}$$

Table 6. Model diagnostics and forecast accuracy

Model	Diagnostic Test (P-Value)		MAPE
	Ljung-Box	Kolmogorov-Smirnov	Accuracy
ARIMAX ([12],1,1)	0.2488	0.15842	18%
ARIMA ([12],1,1)	0.3325	0.208051	38%

Table 6 presents the results of residual diagnostic tests and forecast accuracy comparisons between the ARIMAX([12],1,1) and ARIMA([12],1,1) models. Based on the Ljung-Box test, both models yield p-values greater than 0.05 (0.2488) for ARIMAX and (0.3325) for ARIMA, indicating that the residuals of both models do not exhibit significant autocorrelation and are thus considered white noise. The Kolmogorov–Smirnov test also shows p-values above 0.05 for both models (0.1584) for ARIMAX and (0.2081) for ARIMA, suggesting that the residuals are normally distributed. In terms of forecast accuracy, the ARIMAX model outperforms the ARIMA model, with a lower MAPE of 18% compared to 38%. This significant difference indicates that incorporating exogenous variables, specifically a deterministic trend and a Ramadan dummy, enhances the predictive performance of the ARIMAX model. Therefore, the ARIMAX([12],1,1) model is considered more suitable for forecasting zakat potential at BAZNAS East Java.

These findings are consistent with prior studies, such as those by [21], which demonstrate that including exogenous variables relevant to seasonal or religious patterns improves forecasting accuracy in socio-economic time series. Research by [22] also highlights the effectiveness of ARIMAX in modeling donation trends, especially when influenced by religious events such as Ramadan. This further supports the relevance of religious calendar variations in modeling zakat-related data.

ARIMAX Model Forecast ([12],1,1) with Calendar Variations can be seen in Figure 3.

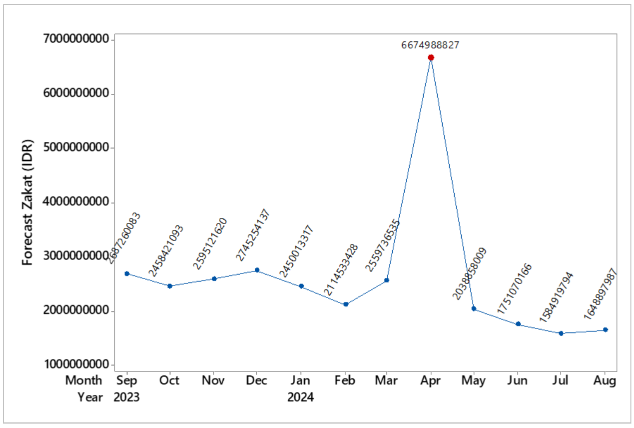


Figure 3. ARIMAX model forecast ([12],1,1) with calendar variations

Figure 3 shows that the potential for zakat in BAZNAS East Java tends to be stable. However, in the 8th month of the forecast results, namely April, there was a significant increase of IDR 6,674,988,827.25. This surge coincides with the month of Ramadan, during which Muslims traditionally pay zakat al-fitr and zakat al-mal.

These findings are in line with previous studies, as reported by [23] which showed an increase in zakat payments during the month of Ramadan due to religious motivation and seasonal giving patterns. Similarly, Syamsuri et al. [24] emphasizes that the contribution of zakat usually reaches its peak in the fasting month. The consistency of this pattern with previous research reinforces the importance of including religious calendar variations in forecasting models for a more accurate estimation of zakat potential.

The consistency of this seasonal pattern with previous research confirms the importance of incorporating calendar-based dummy variables, especially those related to religious events, into the time series regression model [25]. In this context, ARIMAX becomes a relevant method because it is an extension of the ARIMA framework by integrating exogenous variables, including dummy variables for certain calendar periods such as Ramadan. This allows the model to capture external and temporal influences that cannot be explained by standard ARIMA models, thereby improving forecasting accuracy. For future research, it is recommended to explore the inclusion of additional exogenous variables, such as macroeconomic indicators (e.g., inflation rate, unemployment rate), digital campaign intensity, or public income levels [26] which may also influence zakat contributions. Moreover, comparing the performance of ARIMAX with more advanced machine learning [27] or hybrid time series models [28] could provide further insights into optimizing zakat forecasting for strategic planning and policy formulation.

4. Conclusion

Based on the research conducted by incorporating exogenous variables specifically, a deterministic trend and a Hijri calendar dummy variable for the month of Ramadan into the forecasting model for zakat potential at BAZNAS East Java, the forecast results for the next 12 months tend to remain stable. However, in April 2024, there is a notable spike of IDR 6,674,988,827.25. This increase aligns with the occurrence of Ramadan during that month, when Muslims traditionally pay zakat fitrah and zakat mal. The best-performing forecasting model was identified as ARIMAX([12], 1, 1), as indicated by an MAPE value of 18%, which suggests that the model is reasonably accurate for predicting zakat potential at BAZNAS East Java over the next year.

Further research is recommended to include additional exogenous variables, such as macroeconomic indicators, digital campaign intensity, or revenue levels, as well as identify other relevant dummy variables. In addition, a comparison of ARIMAX's performance with machine learning models or hybrid models can provide further insights to optimize zakat forecasting.

Author Contributions. **Lia Puspita Sari**: Conceptualization, methodology, software, formal analysis, visualization, data curation. **Abdulloh Hamid**: Validation, resources, editing, supervision. **Hani Khaulasari**: Validation, resources, writing-review, editing, supervision, project administration. All authors discussed the results and contributed to the final manuscript.

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References

[1] S. A. Muhammad and R. A.-J. Saad, "Moderating Effect of Attitude Toward Zakat Payment on the Relationship Between Moral Reasoning and Intention to Pay Zakat," *Procedia – Social and Behavioral Sciences*, vol. 219, pp. 520–527, 2016. doi: 10.1016/j.sbspro.2016.05.029.

[2] M. A. Miah, "Effectiveness of Zakat–Based Poverty Alleviation Program: Evidence from Bangladesh," *International Journal of Zakat*, vol. 6, no. 2, pp. 27–42, 2021. doi: 10.37706/ijaz.v6i2.325.

[3] F. Siddiqui, R. A. Salam, Z. S. Lassi, and J. K. Das, "The Intertwined Relationship Between Malnutrition and Poverty," *Frontiers in Public Health*, vol. 8, Art. 00453, pp. 1–5, 2020. doi: 10.3389/fpubh.2020.00453.

[4] Badan Pusat Statistik Indonesia, *Profil Kemiskinan di Indonesia Maret 2023*. Jakarta, Indonesia: BPS, 2023.

[5] S. Haris, "Analisis Pendayagunaan Zakat dalam Upaya Pengentasan Kemiskinan pada LAZIS Al-Ihsan Jawa Tengah," M.S. thesis, Universitas Islam Negeri Walisongo Semarang, 2021.

[6] H. Zhang, H. Song, L. Wen, and C. Liu, "Forecasting Tourism Recovery Amid COVID-19," *Annals of Tourism Research*, vol. 87, Art. 103149, 2021. doi: 10.1016/j.annals.2021.103149.

[7] J. Han, H. Lin, and Z. Qin, "Prediction and Comparison of In-Vehicle CO_2 Concentration Based on ARIMA and LSTM Models," *Applied Sciences*, vol. 13, Art. 10858, 2023. doi: 10.3390/app131910858.

[8] L. Moftakhar, M. Seif, and M. S. Safe, "Exponentially Increasing Trend of Infected Patients with COVID-19 in Iran: A Comparison of Neural Network and ARIMA Forecasting Models," *Iranian Journal of Public Health*, vol. 49, pp. 92–100, 2020.

[9] J. Berger, T. Yalcinoz, and K. Rudion, "Investigating the Intraday Continuous Electricity Market Using Auto-Regression Integrated Moving Average Model with Exogenous Inputs," in *Proc. IEEE Int. Conf. Environment and Electrical Engineering & Industrial and Commercial Power Systems Europe (EEEIC/I&CPS)*, 2020, vol. 6, pp. 1–6. doi: 10.1109/EEEIC/ICPSEurope49358.2020.9160595.

[10] N. B. Behmiri, C. Fezzi, and F. Ravazzolo, "Incorporating air temperature into mid-term electricity load forecasting models using time-series regressions and neural networks," *Energy*, vol. 278, p. 127831, Sep. 2023, doi: 10.1016/j.energy.2023.127831.

[11] Y. P. Chen *et al.*, "Modeling and Predicting Pulmonary Tuberculosis Incidence and Its Association with Air Pollution and Meteorological Factors Using an ARIMAX Model: An Ecological Study in Ningbo of China," *International Journal of Environmental Research and Public Health*, vol. 19, Art. 5385, pp. 1–11, 2022. doi: 10.3390/ijerph19095385.

[12] T. Luo *et al.*, "Early Warning and Prediction of Scarlet Fever in China Using the Baidu Search Index and Autoregressive Integrated Moving Average with Explanatory Variable (ARIMAX) Model: Time-Series Analysis," *Journal of Medical Internet Research*, vol. 25, Art. 49400, pp. 1–12, 2023. doi: 10.2196/49400.

[13] A. L. Schaffer, T. A. Dobbins, and S.-A. Pearson, "Interrupted Time-Series Analysis Using Autoregressive Integrated Moving Average (ARIMA) Models: A Guide for Evaluating Large-Scale Health Interventions," *BMC Medical Research Methodology*, vol. 21, Art. 212, pp. 1–12, 2021. doi: 10.1186/s12874-021-01235-8.

[14] D. N. Gujarati, *Basic Econometrics*, 4th ed. New York, NY, USA: McGraw-Hill, 1995. doi: 10.2307/2230043.

[15] W. K. Adu, P. Appiahene, and S. Afrifa, "VAR, ARIMAX and ARIMA Models for Nowcasting Unemployment Rate in Ghana Using Google Trends," *Journal of Electrical Systems and Information Technology*, vol. 10, Art. 78, pp. 1–16, 2023. doi: 10.1186/s43067-023-00078-1.

[16] R. Ospina, J. A. M. Gondim, V. Leiva, and C. Castro, "An Overview of Forecast Analysis with ARIMA Models During the COVID-19 Pandemic: Methodology and Case Study in Brazil," *Mathematics*, vol. 11, Art. 3069, pp. 1–18, 2023. doi: 10.3390/math11143069.

[17] P. Almaleck, S. Massucco, G. Mosaico, M. Saviozzi, P. Serra, and F. Silvestro, "Electrical Consumption Forecasting in Sports Venues: A Proposed Approach Based on Neural Networks and ARIMAX Models," *Sustainable Cities and Society*, vol. 100, Art. 105019, pp. 1–16, 2024. doi: 10.1016/j.scs.2023.105019.

[18] M. Monica and A. Suharsono, "Forecasting Cash Outflow and Inflow in Jember with ARIMAX Calendar Variation Effect," *AIP Conference Proceedings*, vol. 2326, Art. 050013, pp. 1–7, 2021. doi: 10.1063/5.0039283.

[19] J. P. A. Ioannidis, S. Cripps, and M. A. Tanner, "Forecasting for COVID-19 Has Failed," *International Journal of Forecasting*, vol. 38, pp. 423–438, 2022. doi: 10.1016/j.ijforecast.2020.08.004.

[20] E. Vivas, H. Allende-Cid, and R. Salas, "A Systematic Review of Statistical and Machine Learning Methods for Electrical Power Forecasting with Reported MAPE Score," *Entropy*, vol. 22, Art. 1412, pp. 1–24, 2020. doi: 10.3390/e22121412.

[21] P. Bertoli and V. Grembi, "The Ramadan Effect in the Workplace," *Journal of Economic Behavior & Organization*, vol. 227, Art. 106711, Nov. 2024. doi: 10.1016/j.jebo.2024.106711.

[22] D. Devianto *et al.*, "An Innovative Model for Capturing Seasonal Patterns of Train Passenger Movement Using Exogenous Variables and Fuzzy Time-Series Hybridization," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 10, no. 1, Art. 100232, Mar. 2024. doi:

10.1016/j.joitmc.2024.100232.

[23] T. W. Oktavendi and I. Mu'ammal, "Acceptance model for predicting adoption of Zakat, Infaq, and Sodaqoh (ZIS) digital payments in Generation Z," *Journal of Islamic Accounting and Business Research*, vol. 13, no. 4, pp. 684–700, Mar. 2022. doi: 10.1108/JIABR-09-2021-0267.

[24] S. Syamsuri, F. Johari, N. Nadhilah, and Y. Sa'adah, "Forecasting the Financial Soundness of Indonesia's National Board of Zakat (BAZNAS) Using Artificial Neural Network Models," *TEM Journal*, vol. 13, no. 1, pp. 605–615, Feb. 2024. doi: 10.18421/TEM131-63.

[25] A. R. P. Syam, "Application of the Autoregressive Integrated Moving Average Exogenous (ARIMAX) with Calendar Variation Effect Method for Forecasting Chocolate Data in Indonesia and the United States," *Jurnal Matematika, Statistika dan Komputasi*, vol. 18, no. 2, Art. no. 2, Jan. 2022. doi: 10.20956/j.v18i2.18460.

[26] C. Aranda Reina, J. Bouchez, and J. L. Druhan, "Quantifying the impacts of exogenous dust inputs to the critical zone using reactive transport modeling," *Geochimica et Cosmochimica Acta*, vol. 393, pp. 254–267, Mar. 2025. doi: 10.1016/j.gca.2025.01.023.

[27] G. P. D. Sohibien, Setiawan, and D. D. Prastyo, "Spatial Vector Autoregressive with Metric Exogenous Variable (SpVARX) for Inflation and Outflow Forecasting," *Procedia Computer Science*, vol. 234, pp. 140–147, Jan. 2024. doi: 10.1016/j.procs.2024.02.160.

[28] G. Jang, J. Seo, and H. Lee, "Analyzing the impact of COVID-19 on seasonal infectious disease outbreak detection using hybrid SARIMAX-LSTM model," *Journal of Infection and Public Health*, vol. 18, no. 7, p. 102772, Jul. 2025. doi: 10.1016/j.jiph.2025.102772.