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Original Article

The Comparison of Exponential Regression and Exponential Smoothing Holt Winter 2 Variable in Zakat Modelling

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Abstract *- Zakat is an important worship for Muslims, where some of the wealth of the rich will be distributed to the poor according to certain rules. Zakat can be used as a source of income for a country, such as Indonesia with a majority Muslim population. This study focuses on modeling zakat in Indonesia using zakat data from 2004 to 2019. The zakat data obtained continues to increase exponentially, therefore the main goal of this study is to find the best model to the zakat data. For this purpose two statistical models, namely the exponential regression model and the exponential smoothing 2 variables will be used and tested to determine the best model to describe zakat in Indonesia. The best model will be selected based on graphical inspection and, numerical criteria namely Mean Absolut Error (MAE) and Mean Square Error (MSE). In most the cases, graphical inspection gave the same result but their MAE and MSE result differed. The best model was chosen as the model with the lowest values of MAE and MSE. In general, the Exponential Smoothing 2 Variables has been selected as the best model.*

Keywords *- Exponential Regression, Exponential Smoothing 2 Variables, MAE, MSE, Zakat Model.*

1. Introduction

Zakat is one of the teachings of Islam where a portion of the income of the rich is distributed to the poor according to predetermined rules. A country with a very large population which is dominated by Muslims will make zakat as a form of income for the country with great potential if managed properly. Indonesia is one of the countries as mentioned above that has been able to manage these zakat funds for the purpose of improving people's welfare. The significant roles of zakat in the economy have triggered many studies to investigate them, especially its roles in poverty alleviation. For example, a study by Choiriyah et al [1]. has employed the welfare Index of BAZNAS to measure the impacts of zakat on decreasing the number of poor people. Meanwhile, Nadzri [2] has conducted a conceptual study to prove the role of zakat in alleviating poverty. The value of zakat continues to increase every year which forms an exponential pattern, this has resulted in research on zakat continuing to grow. Several researchers have conducted research on zakat models using mathematical equations Namdar [3] et al. who employs the accuracy and repetition feature of the Fourier series in the Matlab application to predict zakat potentials in Iran. Meanwhile, Parisi [4] has employed the multiplicative decomposition forecasting method to determine the zakat potentials in the future and discovered that voluntary zakat in Indonesia affects the total zakat collection. Belgacem [5] conduct a more complex study using a stochastic model to examine the dynamics of the wealth distribution of individuals in a population that obeys zakat systems. Research on zakat modeling in Indonesia has also increased rapidly, especially in the purpose of predicting the value of zakat in the future. A previous study that has forecasted zakat is conducted by Husti et al. who have discovered that zakat data in Indonesia is more appropriately forecasted using Holt's Exponential Smoothing (HES) model [6]. This finding is supported by Akbarizan et al [7]. Funds from zakat are also known to be very stable unaffected by the COVID-19 pandemic. Research conducted in Indonesia has shown that Zakat funds continue to increase significantly in 2020 and 2021, Ria Indah Sari et al [8]. The objective of this study is to propose two statistical modelling namely Exponential Regression and Exponential Smoothing 2 Variables Comparison of the proposed model with existing statistics functions is done to demonstrate their suitability in describing data of zakat characteristics. [9] Using q-exponential regression model for fitting data with descrepant observations. Maximum likelihood estimators for the model parameter dan the fisher information matrix are derived. Simulation study show that the proposed estimators present good behavior in the sense of decreasing in bias, and symmetric distribution when the sample size increases.

The objective of the study [10] is to determine the most appropriate forecasting model to achieve a good level of forecasting accuracy. There two methods for the study is Holt-Winter (HW) dan Seasonal Autoregressive Integrated Moving Averaging (SARIMA). The findings showed that all models provided accurate forecast values to according to error measures. Multiplicative model of HW achieved the highest forecasting accuracy followed by SARIMA and additive HW. [11] using exponential regression model at nursing data. We show that the new regression model can be applied to dispersion data since it represent a parametric family models that includes as sub-models some widely known regression model. In this paper using MLE and derive the appropriate matrices for assessing local influence on the parameter estimates under different pertubation schemes. And also investigated and simulation studies are performed to evaluated the accuracy of the estimate. The censored exponential regression model is commonly used for modeling lifetime data. In [12] derived a simple matrix formula for the second order covariance matrix of the MLE in this class of regression models. To show that the second order covariance can be using monte Carlo simulation. [13] uses the model of seasonal exponential smoothing (Holt-Winter) to predict Zakat. The finding shows that holt-winter model is suitable to forecasting zakat collection as it also account for seasonal variation. [14] aims to forecasting JII returns by employing various holt-winters models. The models used are Holt winter seasonality, Holt winter method, and Holt winter with maximum likelihood approach. The result showed that Holt winter seasonality forecast better than then the other methods. [15] Aimed to predict seasonal time series data using the Holt winters exponential smoothing additive model. The result showed that the holt-winter exponential smoothing method contained trend patterns and seasonal patterns by first determining the initial values and smoothing parameters minimize forecasting errors. [16] The objective of study was to model log-term U5MR with group method of data handling and compare the forecast with the commonly used conventional statistical method-ARIMA regression and holt-winters exponential smoothing models.

Data analysis in the research used partial least square-structural equation modelling (PLS-SEM). The findings of the study [17] explain that performance expectancy, social influence, and facilitating conditions positively affected behavioral intention to use digital payment. [18] aims to determine the following: the forecasting of zakat collection in Indonesia based on the historical data for the next year and the system used by Muslim countries to collect zakat fund. This study used the multiplicative decomposition forecasting method.

Three exponential smoothing models were compared to identify the most appropriate model in forecasting electricity consumption. The three exponential smoothing models are Simple, Holt, and Brown exponential smoothing. To identify the most appropriate model, a mean absolute percentage (MAPE) was chosen. The results show that Holt's exponential smoothing has the best performance with the lowest MAPE score of 2.299 [19]. In this study [20], two different Artificial Neural Network (ANN) models using two different learning algorithms are developed; Back Propagation (BP) and Levenberg-Marquardt (LM). Both models are developed and compared in terms of their accuracy performance. Empirical findings show that the weighted-exponential regression model provides better fits than the gamma regression model and could be a good choice for modeling the right-skewed response variable [21]. The purpose of [22] is to analyses the efficiency of zakat institutions in Malaysia. This study uses the Malmquist Productivity Index to estimate productivity and efficiency of zakat institutions in Malaysia and the Tobit model to determine the factors affecting efficiency of zakat institutions in Malaysia. The results suggest that Total Factor Productivity (TFP) of zakat institutions in Malaysia increased at an average rate of 2.4 per cent during the study period and is mainly attributed to technical progress rather than efficiency components.

Exponential smoothing is a sophisticated forecasting method that works based on previous forecast plus a percentage of the forecast error. n this study, a framework is developed for the selection of optimal value of smoothing constant that minimizes a measure of forecast errors like mean square error (MSE) and mean absolute deviation (MAD) [23]. This report concentrates on the analysis of seasonal time series data using Holt-Winters exponential smoothing methods. Two models discussed here are the Multiplicative Seasonal Model and the Additive Seasonal Model [24].

The purpose of this study [25] was to forecast APSI as a scientific-based reference for making decisions and policies that were appropriate in tackling the effects of air pollution on health. The research method used was time series to identify the time relationship using Holt-Winters Exponential Smoothing. [26] aims to investigate the probability of paying zakat and analysis using descriptive statistic and logit profit. The result show that higher probability of paying zakat among respondents determined by small household size, lower per capita income, higher education level and those living in Perak. [27] Was to identify a motivation muzaki for paying zakat using regression analysis. The result showed that factor formulation was valid to identify motivation of Muzakki for paying zakat. Time series analysis is an analysis used to predict the future, where ARIMA and Exponential Smoothing (ES) are part of time series Analysis. This study [28] aims to determine the best model and forecasting results in 2021 and 2022 from the data on the amount of collection and distribution of zakat, infaq and shadaqah.

2. Data

In this study, the source of the data is the site Rumah Zakat of Indonesia is reported by the statistics agency Indonesia. The data used in the analysis is that of the zakat collection from 2004 to 2019. Figure 1 shows that the plotted time series has an upward trend or strong increasing.

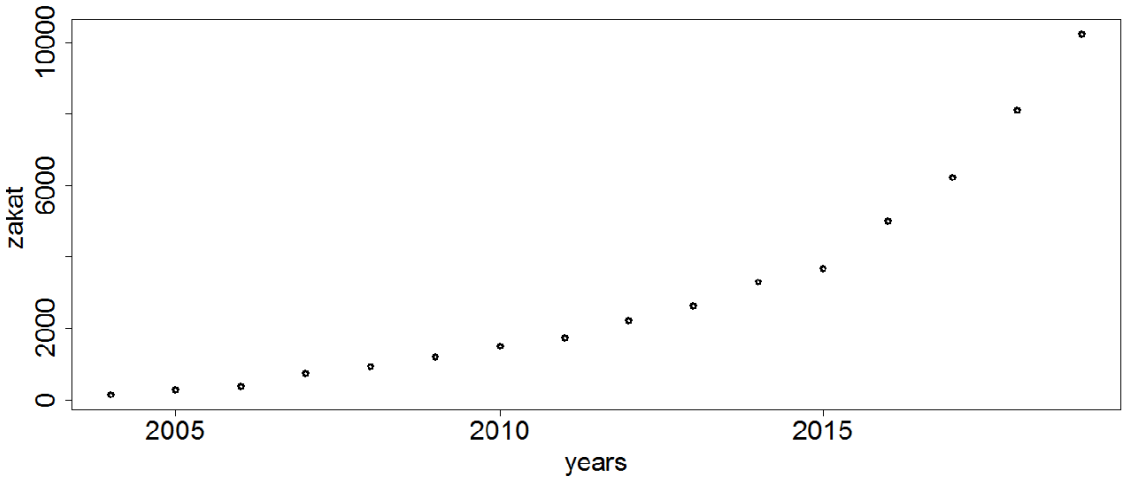

Fig. 1 Zakat Data in Indonesia (2004-2019)

Initial information in this research can be seen in the descriptive statistics for zakat data are presented in Table 2. The variations of zakat data that are so large (8868876) indicate that the zakat increase is very significant from the lowest of 150.1 to the highest of 10230 from year to year. The average zakat obtained is quite large (2.088), this shows that good zakat management will be able to improve the welfare of the Indonesian population. Indirectly this result can also be interpreted that the Muslim population has a fairly good wealth.

Table 1. The descriptive statistics for zakat in Indonesia (billion)

Statistics	Mean	Variation	Minimum	Maximum
	3018.0	8868876	150.1	10230.0

3. Methods

3.1. Exponential Regression

Mathematically, the equation of an exponential regression model is pretty simple. It looks like this: , α which describes the initial model value of y, when x=0 and β, which is the growth rate (if positive) or decay rate (if negative). In this paper y is the period time 1, 2, …,n and x the data of Indonesia zakat. An exponential regression model is nonlinear. But this is a linear equation for log y versus x, with intercept log α and slope β. The implication is that we can fit an exponential growth model using a linear regression for log y versus x. like this equation

3.2. Exponential Smoothing 2 Variables

This model is used in data that show a trend without a seasonal pattern. For example, $X_1, X_2, X_3, \cdots, X_n$ is a set of observations in a time series. The Exponential Smoothing 2 Variables formula could be obtained by using two smoothing constants, as follows.

$$A_t = \alpha X_t + (1-\alpha)(\alpha_{t-1} + T_{t-1}), 0 < \alpha < 1, t = 1,2,\cdots,n$$

$$T_t = \beta(A_t - A_{t-1}) + (1-\beta)T_{t-1}, 0 < \beta < 1, t = 1,2,\cdots,n$$

For the forecast the series of $\hat{X}_{t+p}$ can be obtained by $\hat{X}_{t+p} = A_t + pT_t,\ p = 1,2,\cdots,k$ and p is number of periods in the future. In this model for the first step is to obtain level estimate and trend estimate represented by A_0 *and* T_0 respectively. These estimates can also be determined by fitting a least squares trend line to half of the historical data. In the following equations, the intercept is A_0 and slope is T_0. The value of α and β that minimizes Mean Square Error (MSE) is preferred. The best model selection could be estimated using error sizes, such as mean absolute errors (MAE) and mean square errors (MSE). The formula is given as below respectively

$$MAE = \frac{1}{n}\sum_{t=0}^{n}\left|X_t - \hat{X}_t\right| \quad and \quad MSE = \frac{1}{n}\sum_{t=0}^{n}\left(X_t - \hat{X}_t\right)^2$$

4. Results and Discussion

The fitting of zakat data collected in Indonesia was considered using data from the period between 2004 and 2019. For the purpose of modelling the zakat, two statistical models have been used, such as Exponential Regression and Exponential Smoothing 2 variables. Behavior of the models for the estimated parameters shown in Figures 2, while the estimated parameters from the two statistical models used can be seen in Table 2. Based on behaviors models from this Figure 2, Exponential Smoothing 2 Variables is very close to the observation (zakat data recorded form 2004 to 2019), this can be interpreted this model is able to provide a good result for zaka data.

Table 2. The Estimated Parameters for Exponential Regression and Exponential Smoothing 2 Variables model

Methods	α	β
Exponential Regression	203.3984	0.2517976
Exponential Smoothing 2 variables	0.8326689	1

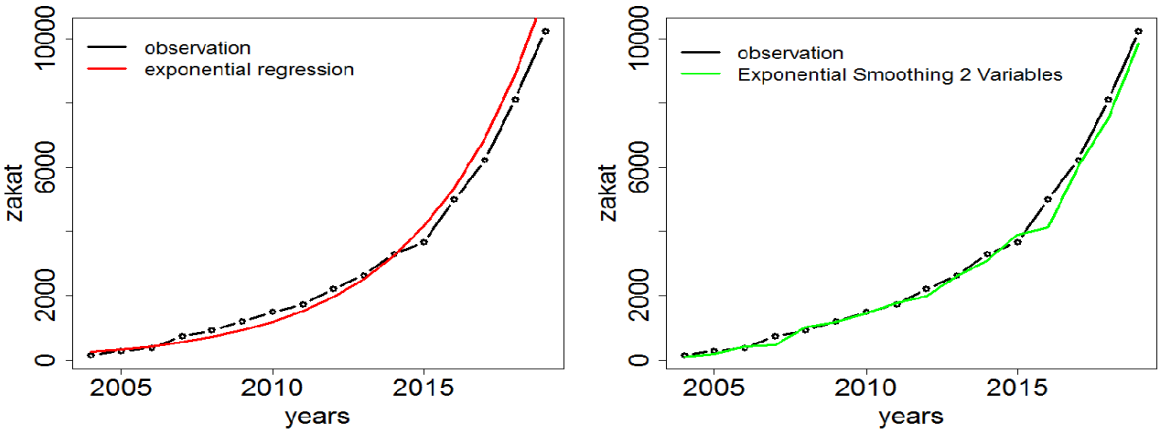

Fig. 2 Exponential regression and Exponential Smoothing 2 Variables model fitted to the observation zakat data respectively

The Comparison of the two models against the observation was again carried out to ensure the best model to describe the characteristics of the zakat data in Indonesia, therefore Figure 3 is presented for this purpose. From the figure, it can be seen that both models have the same ability to approach the actual zakat data for 10 years, while for the long term the Exponential Smoothing 2 Variables model is better than the other models

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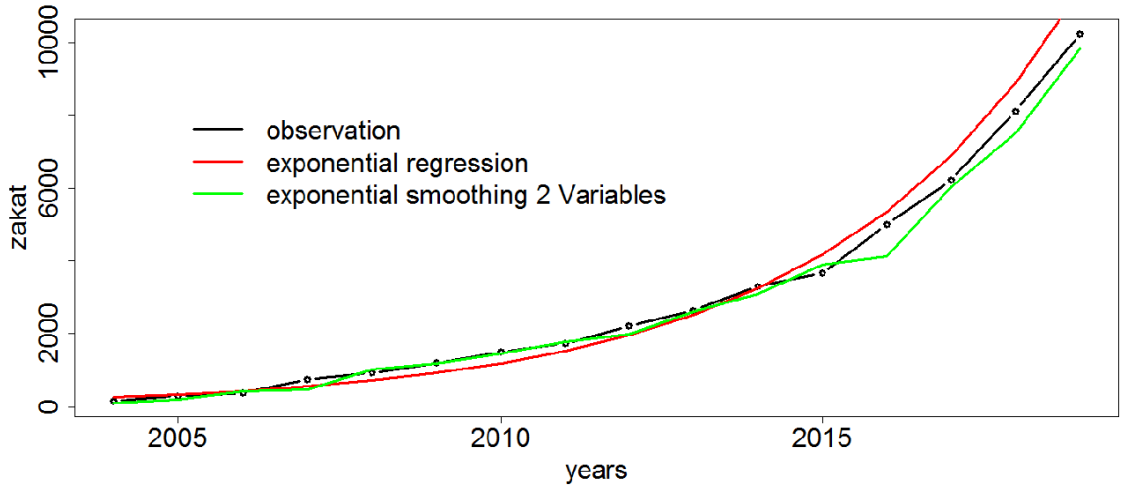

Fig. 3 The Comparison fitted models to observation zafat data

Table 3 show the statistical test by using numerical criteria for evaluation of models namely MAE and MSE currently analyzed for the Exponential Regression and Exponential Smoothing 2 Variables. From the Table, by comparing each model, it is clear that the Exponential Regression have the highest MAE and MSE values,

implying that the model is not a good for zakat data in Indonesia. However, Exponential Smoothing 2 Variables has the lowest MAE and MSC values, which implies that this model provides a model that more adequately fits the data.

Table 3. The MAE and MSE values for zakat data

Methods	MAE	MSE
Exponential Regression	334.1824	219211.8
Exponential Smoothing 2 Variables	215.2810	106630.3

To further clarify the results of the study, Figures 4 and 5 are also shown to reinforce the results of the study. Figure 4 and 5 shows the statistical test by using graphical criteria for evaluation of models namely MAE and MSE. From the Figure, it is clear that the Exponential Smoothing 2 Variables has the lowest MAE and MSE values, which implies that this models provides a model that more adequately fits the data
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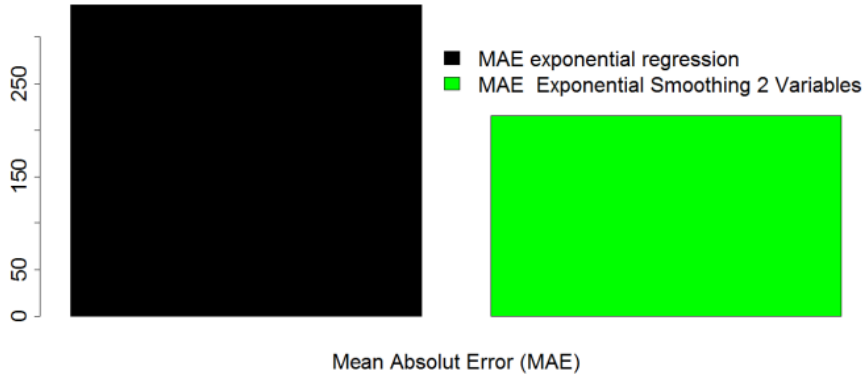

Fig. 4 MAE Zakat Comparison

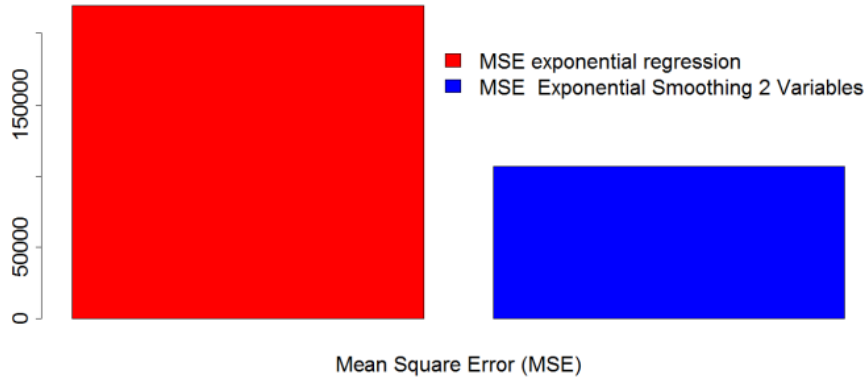

Fig. 5 MSE Zakat Comparison

5. Conclusion

In this research focused on determining the best statistical model Zakat Data in Indonesia. The Two Statistical Models namely Exponential Regression and Exponential Smoothing 2 Variables. The results obtained based on graphical and numeric criteria (MAE and MSE values) indicated that Exponential Smoothing 2 Variables adequately modelled the zakat data in Indonesia. Additionally,from the best model, can be seen that the zakat data always increases significantly every year, even though Indonesia is hit by the covid 19 virus.

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References

[1] E. Choiriyah, A. Kafi, I. Hikmah, and I. Indrawan, Zakat And Poverty Alleviation In Indonesia: A Panel Analysis At Provincial Level, Journal of Islamic Monetary Economics and Finance, 6(4) (2020) 811 - 832. https://doi.org/10.21098/jimf.v6i4.1122.

[2] F. A. Nadzri, A. Rahman, and N. Omar, Zakat and Poverty Alleviation: Roles of Zakat Institutions in Malaysia, International Journal of Arts and Commerce, 1(7) (2012) 61 –72.

[3] N. Namdar and R. Hassanzadeh, Developing A Mathematical Equation to Predict Khums and Zakat in the Iranian Economy, Int. J. Zakat, 6(2) (2021) 43-62.
[4] S. Al Parisi, Overview of Forecasting Zakat Collection in Indonesia Using Multiplicative Decomposition, Int. J. Zakat, 2(1) (2017) 45–59.
[5] F. Bin, M. Belgacem, H. R. H. Prince, and T. Bin, Modeling the stochastic dynamics of Zakaat, Math. Eng. Sci. Aerosp., 1(1) (2010) 91– 103
[6] A. Husti, Ilyas; Akbarizan; Marizal, Muhammad; Yendra, Rado; Fudholi, Forecasting Model Holt's for the Zakat Collection in Indonesia, Malaysia and Brunai, Soc. Sci., 12(12) (2017). 2370–2374
[7] Akbarizan, M. Marizal, M. Soleh, Hertina, M. A, R. Yendra, and A. Fudholi, Utilization of Holt's forecasting model for zakat collection in Indonesia, Am. J. Appl. Sci., 13(12) (2016) 1342–1346. https://doi.org/10.3844/ajassp.2016.1342.1346
[8] I. R. Sari, Z. Tomi, T. N. E. Sihombing, M. Mahiroh, R. Yendra, and A. Adnan, The Analysist Impacts of Covid-19 on Zakat Revenue in Indonesia Using an Exponential Smoothing Model, *International Journal of Mathematics Trends and Technology*, 68(5) (2022) 11-16, https://doi.org/10.14445/22315373/IJMTT-V68I5P503
[9] A. G. Partioata. A q-Exponential Regression Model, Sankhya: The Indian Journal of Statistics. 74(1) (2008), 149-170
[10] Z. Wael, and S. Sennaroglu, Performance Comparison of Holt-Winters and SARIMA Models for Tourism Forecasting in Turkey, Dogus Universitesi Dergisi. 21(2) (2020) 63-77.
[11] F. Prataviera, J. C. S. Vasconcelos, G. M. Cordeiro, E. M. Hashimoto, and E. M. M. Ortega, The exponential Power Exponential Regression Model with Different Regression Structures: applicating in nursing data, Journal of applied statistics. 11(1) (2019) 1-31.
[12] L. J. Arthur, Covariance matrix of maximum likelihood estimators in cencored exponential regression models. Communication in Statistic-Theory and methods. 47(24) (2020) 1-14.
[13] M. Fadlihisyam, and J. Asmah. Utilization of holt-winter Forecasting Modle in lembaga Zakat Selangor (LZS) for Zakat Collocttion. Pure and Applied Mathematics. 7(2020) 59-61.
[14] P. M. Regi, Forecasting of Jakarta Islamics Index (JII) Return Using Holt-Winter Family Models. Asian Journal of Islamic Management (AJIM). 3(2) (2021) 111-122.
[15] Nurhamidah, Nusyirwan and A. Faisol, Forecasting Seasonal Time Series Data Using the Holt winters Exponential Smoothing Method of additive Models. Jurnal Matematika Integratif. 16(2) (2020) 151-157.
[16] D. A. Adeyinka and N. Muhajerine, Time Series Prediction Of Under Fivve Mortality Rates For Nigeria:Comparative Analysis Of Artificial Neural Networks, Hol-Winters Exponential Smoothing And Autoregressive Integerated Moving Average Models. BMC medical Research Methodo logy. 20(1) (2020) 1-11
[17] U. Cahyani, Determinant of behavioral intention to use digital zakat payment:The Moderating Role of Knowledge of Zakat. Jurnal Zakat adan Wakaf. 9(1) (2022) 1-16
[18] S. Alfarisi, Overview of Forecasting Zakat Collection in Indonesia Using Multiplicative Decomposition, International Journal of Zakat. 2(1) (2017) 45-59.
[19] I. Ishak, N. S. Othman, and N. H. Harun, Forecasting Electry Consumption of Malaysisa's Residential Sector:Evidence From an Exponential Smoothing Model. IIARP Publication. [version 1; peer review: awaiting peer review]. *F1000Research* 2022, (2022) **11**:54
[20] S. H. Hafizah, S. U. Ubaidillah, and R. Sallehuddin, Forecasting Zakat Collection Using Artificial Neural Network. Proceeding of The 20th National Symposium on Mathematics Sciences AIP Conf.Proc.1552. (2013) 196-204.
[21] A. Emrah, Weighted-Exponential Regression Model:An alternative to the Gamma Regression Model. International Journal of Modeling, Simulation and Scientific Computing. 10(6,) (2019) 1-15.
[22] N. Wahab, and Rahman, Determinants of Efficienc of Zakat Institutions in Malaysia:A Non Parametric Approach. Asian Journal of Bussiness and Accounting. 6(2) (2013) 33-64.
[23] C. L. Karmaker, Determination of Optimum Smoothing Constant of Single Exponential Smoothing Method: A Case Study. International Journal of Resesarch in Industrial Engineering. 6(3) (2017) 184-192.
[24] P. S. Kalekar. Time Series Using Holt-Winters Exponential Smoothing. Kanwal Rekhi school of information Technology 4329008. 13(2004) 1-13.
[25] S. Muna, and Kuntoro. Application Of The Holt-Winters Exponential Smoothing Method On The Air Pollution Standard Index In Surabaya. Jurnal Biometrika dan Kependudukan. 10(1) (2021) 53-60
[26] J. Duasa, and N. H. Zainal, Probability of Paying Zakat From Micro Finnacing Project Returns. Etikonomi, 19(2) (2020) 333-348.
[27] M. A. Zakaria, M. Zakariah, I. Suciana, Hikmawati, R. Setiawan, Sultan, and A. H. Nasution, Regression Analyisis of Motivation Factors for Paying a Zakat to Strengtheness od Ummah in Kolaka Regency, Jurnal Ekonomi Bisnis Syariah. 1(1) (2017) 1-8.
[28] S. I. Wardani, W. P. Nurmayanti, S. A. Wulandya, and M. Gaali, Implementation of Exponential Smoothing and ARIMA on Collection and Distribution Data of Zakat, Infaq and Shadaqah 2015-2020, The First Seminar Nasional of Science and Technology for Society Development, (2021) 141-153.