Implementation of Bootstrap ARIMA Method to Forecasting Gross Domestic Products (GDP)

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Abstract. This study examines the application of bootstrap ARIMA method to forecasting the GDP of West Sulawesi Province. GDP data is time series data so to predict GDP of West Sulawesi Province for some future period used time series analysis technique. One method often used in time series modeling in forecasting data is ARIMA Box-Jenkins. A nonparametric approach that is free of assumptions, one of which is the bootstrap method. The bootstrap method is a computer-based method that is very potential to be used on accuracy problems where the method is based on data simulations for statistical inference purposes. From result of research obtained that model of GDP data is ARIMA Bootstrap (0,2,1).

Keywords: Please list your keywords in this section.

1 Introduction

One important indicator to know the economic condition in a region/region within a certain period is the data of Gross Regional Domestic Product (GDP). Data series GDP is one of measuring tools of development success. GDP data can be used as a basis for determining the target of economic growth and as an evaluation of the success of development that has been done. GDP in the future can be predicted using last year GDP data. Some of the most commonly used forecasting methods in *time series* modeling in forecasting data are ARIMA [1][2], α-Sutte Indicator[3][4], Holt-Winters[5], Fuzzy Time Series/Neural Network [6][7]. Sometimes in reality, small data can be obtained so that the forecasting process cannot be optimal due to lack of previous data information so that the need to do the addition of samples or in other words the size of the sample enlarged. One of the approaches that can be used is non parametric and free assumption is the bootstrap method. The bootstrap method used is the bootstrap method in the ARIMA process. The object of this research is West Sulawesi Province. If detailed by quarter, the West Sulawesi economy moves fluctuating.

2 ARIMA Bootstrap Method

In the bootstrap ARIMA method used two approaches: residual resampling and moving blocks bootstrap (Efron and Tibshirani, 1993) [8]. The residual resampling approach is basically doing sampling with returns from residual samples with replication B times($n << B << n$) e sample size. If the time series is known:

ICASI 2018, April 23-24, Medan, Indonesia

ISBN: 978-1-63190-162-1

$$Z_t = \phi Z_{t-1} + \varepsilon_t \quad (1)$$

With Z_t is the value in period *t*, Z_{t-1} is the value in the period $t-1$, ϕ is unknown parameter($-1 < \phi < 1$), and ε_t is a random error assumed to be from an unknown F distribution with a value of 0 then to obtain parameter estimation in the time series model can be performed bootstrap procedure as follows [8].

1) Time series model: $Z_t = \phi Z_{t-1} + \varepsilon_t$ has 2 unknown components ie (ϕ, F_ε) with F_ε is a distribution unknown of ε_t.
2) Parameter ϕ estimated with $\hat{\phi}$ using the least squares method *(least square)*. If $\hat{\phi}$ it has been known already, then we can calculate $\hat{\varepsilon}_t$ that is $\hat{\varepsilon}_t = Z_t - \hat{\phi} Z_{t-1}$. So that F_ε can be estimated with the empirical distribution function of $\hat{\varepsilon}_t$ ie by taking a chance period of 1/n against $\hat{\varepsilon}_t - \bar{\varepsilon}_t$ where $\bar{\varepsilon}_t = \frac{1}{n}\sum_{t-1}^{n} \varepsilon_t$ centered on 0 because F_ε has a mean of 0.
3) Bootstrap data is generated from the model with (ϕ, F_ε) replaced with $\left(\hat{\phi}, \hat{F}_\varepsilon\right)$. In other words independent data generated and distributed identically $\varepsilon_1^*, \varepsilon_2^*, \varepsilon_3^*, \dots, \varepsilon_n^*$ from $\hat{F}_\varepsilon$ and defined as $Z_t^* = Z_t + \varepsilon_t^*$.
4) By the least squares method is calculated $\hat{\phi}^*$ based on the data $(Z_1^*, Z_1), (Z_2^*, Z_2), \dots, (Z_n^*, Z_n)$ that is $\hat{\phi}^* = (Z^T Z)^{-1} Z^T z$ with $= Z_1^*, Z_2^*, \dots, Z_n^*$.
5) Repeat the steps above as much as B times as a bootstrap replication.

3 Research Method

This study was quantitative research. Data that used in this study is the data of GDP of West Sulawesi Province in the year 2006 quarter I to 2016 quarter IV. The data needed in this research is obtained from BPS of West Sulawesi Province.

Step-by-step analysis, namely:

a) From the data $Z_1, Z_2, \dots, Z_t$ done convergence ie replace Z_t with $Z_t - \bar{Z}$, so that new data (centralization) is obtained.
b) Estimating parameters based on ARIMA model.
c) Gets the best ARIMA model based on the parameter significance test for the centralized data.
d) Looking for residual values based on the best ARIMA model.
e) Re-resampling residuals by random sampling without returns so obtained $a_t^*, t = 1, 2, \dots, n$.
f) Set $Z_1 = Z_1^*, Z_2 = Z_2^*, \dots, Z_p = Z_p^*$ as the bootstrap initials sample.
g) Find bootstrap data based on best ARIMA model equations with parameter estimation obtained from initial estimation of ARIMA model.
h) Re-centralizing ie Z_i^* replaced with $Z_i^* - \bar{Z}^*$ with $\bar{Z}^* = \frac{\sum_{t=1}^{n} Z_t^*}{n}$.
i) Estimate the best ARIMA model parameters based on bootstrapped data that has been centralized Z_t^*.
j) Determine the bootstrap model equations in the best model ARIMA process based on bootstrap data that has been centralized Z_t^*.

k) Predicting GDP of West Sulawesi Province based on bootstrap model in best model ARIMA process.

4 Result and Discussion

The assessment and test parameters for the bootstrap ARIMA model (0,2,1) are shown in table 1.

Table 1. Parameter Assessment and Testing for the Bootstrap ARIMA (0,2,1) Model

Bootstrap Model	Parameter	Estimation	t_{count}	t_{table}	
ARIMA (0,2,1)	θ	-1,0000	-7,1788	2,01669	Sig

Based on the model, the equations obtained from the bootstrap ARIMA model (0,2, 1) are as follows.

$Z_t = \theta_q(B)a_t$
$(1-B)^2 Z_t = (1-\theta_1 B)a_t \qquad ; \theta_1 = (-1)$
$(1-B)^2 Z_t = (1+B)a_t$
$(1-2B+B^2)Z_t = (1+B)a_t$
$Z_t - 2BZ_t + B^2 Z_t = a_t + Ba_t$
$Z_t - 2Z_{t-1} + Z_{t-2} = a_t + a_{t-1}$
$Z_t = 2Z_{t-1} - Z_{t-2} + a_t + a_{t-1}$

with AIC values of 1189,47 and RMSE of 304289,50.

From equation bootstrap ARIMA (0,2,1) model, then obtained result of forecast of GDP of West Sulawesi Province with bootstrap data for some future period can be seen as table 2.

Table 2. Results Forecasting GDP West Sulawesi Provinces using ARIMA Bootstrap(0,2, 1)

Period	GDP Forecast (million rupiah) ARIMA Bootstrap (0,2,1)	SE
Triwulan I 2017	5118306	315049,5
Triwulan II 2017	5317297	450581,9
Triwulan III 2017	5516289	557945,8
Triwulan IV 2017	5715280	651225,5

5 Conclusion

From the result of analysis by using bootstrap method for GDP data of West Sulawesi Province (in this research used Bootstrap ARIMA (0,2,1) Method), obtained AIC value equal to 1189, 47 and RMSE 304289, 5 0. Forecasting result for Year 2017 Quarter I, II, III, and IV are 5118306 , 5317297 , 5516289 , and 5715280 , respectively .

References

[1] Ahmar, A.S., Guritno, S., Abdurakhman, Rahman, A., Awi, Alimuddin, Minggi, I., Tiro, M.A., Aidid, M.K., Annas, S., Sutiksno, D.U., Ahmar, D.S., Ahmar, K.H., Ahmar, A.A., Zaki, A., Arifin, A.N.M.: Modeling Data Containing Outliers using ARIMA Additive Outlier (ARIMA-AO). J. Phys. Conf. Ser. 954, 01010 (2018).

[2] Ahmar, A.S., GS, A.D., Listyorini, T., Sugianto, C.A., Yuniningsih, Y., Rahim, R., Kurniasih, N.: Implementation of the ARIMA(p,d,q) method to forecasting CPI Data using *forecast package* in R Software. J. Phys. Conf. Ser. 1028, 012189 (2018).

[3] Sutiksno, D.U., Ahmar, A.S., Kurniasih, N., Susanto, E., Leiwakabessy, A.: Forecasting Historical Data of Bitcoin using ARIMA and α-Sutte Indicator. J. Phys. Conf. Ser. 1028, 012194 (2018).

[4] Kurniasih, N., Ahmar, A.S., Hidayat, D.R., Agustin, H., Rizal, E.: Forecasting Infant Mortality Rate for China: A Comparison Between α-Sutte Indicator, ARIMA, and Holt-Winters. J. Phys. Conf. Ser. 1028, 012195 (2018).

[5] Rahman, A., Ahmar, A.S.: Forecasting of primary energy consumption data in the United States: A comparison between ARIMA and Holter-Winters models. In: AIP Conference Proceedings (2017).

[6] Haviluddin, Agus, F., Azhari, M., Ahmar, A.S.: Artificial neural network optimized approach for improving spatial cluster quality of land value zone. Int. J. Eng. Technol. 7, (2018).

[7] Surahman, Viddy, A., Gaffar, A.F.O., Haviluddin, Ahmar, A.S.: Selection of the best supply chain strategy using fuzzy based decision model. Int. J. Eng. Technol. 7, (2018).

[8] Efron, B., Tibshirani, R.J.: An introduction to the bootstrap. CRC press (1994).