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Comparison Of ARIMA And Exponential Smoothing Holt-Winters Methods For Forecasting CPI In The Tegal City, Central Java

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Abstract

The Consumer Price Index (CPI) is an essential economic index that shows the level of prices for goods and services consumed by the public in a certain period in a specific region so that forecasting the ICP is needed to find out the pattern of economic movement in the area. The purpose of this study is to determine the forecasting rate for CPI from July 2021 to June 2022 by comparing two forecasting methods, i.e., ARIMA and Exponential Smoothing Holt-Winters. The data used in this study is Tegal City CPI data for January 2014 - June 2021, with the year 2018 as the base year equals 100 with a time series of 90 observations. The backcasting technique was implemented to the CPI figures of January 2014 – December 2019 (Base Year 2012=100) to adjust the new Base Year following 2018 on Classification of Individual Consumption According to Purpose (COICOP). The results from the two methods show that the Exponential Holt-Winters method has a minor Mean Absolute Percentage Error (MAPE) value, which is 0.281 compared to the MAPE of ARIMA value of 0.311. Hence, the Exponential Holt-Winters Additive method is chosen as the best CPI forecasting model for Tegal City.

INTRODUCTION

The Consumer Price Index (CPI) is one of the important economic indicators that can provide information on the development of prices for goods and services paid by consumers in a certain period and region (Mankiw et al., 2013). Price is defined as the exchange rate of goods or services, expressed in monetary units (Rizaldy, 2017). The CPI calculation is carried out to determine changes in the index number of the prices of a fixed group of goods and services generally consumed by the public. Changes in the CPI from time to time can describe the rate of increase (inflation) or the rate of decline (deflation) of goods and services for daily household needs (Biri et al., 2013, Mukron et al., 2021). The higher the inflation, the lower the value of money and the lower the purchasing power is (Boediono, 1995). Therefore, inflation is one of the economic measures that challenge every local government to improve their region's economy.

One way the find out the possibility of inflation or deflation in an area is to forecast as an objective calculation basis using inflation data in the previous period. So that, optimal efforts in development planning and economics handling strategies can be carried out by the government (Mahmudi et al.,

2018). Many kinds of research that raise forecasting problems for various forecasting purposes have been carried out previously, either by using one forecasting method, including the Autoregressive Integrated Moving Average (ARIMA) (Desvina & Desmita, 2015, Hartati: 2017), Singular Spectrum Analysis Method (Sari et al., 2019), the Naïve method (Nugraha et al., 2017) and the Exponential Smoothing Holt-Winters method (Biri et al., 2013, Mahmudi, 2018).

Other researches tried to compare two forecasting methods, such as comparing the Moving Average method and the Naïve Method (Ais Kumila et al., 2019), the Statistical method and the Neural Network method (Wahyuningsih et al., 2008, Gunaryati & Suhendar, 2015), and the Auto-Regressive Integrated Moving Average method or ARIMA and the Holt-Winters Exponential Smoothing method (Arumningsih & Darsyah, 2018). These studies indicated that the model with the smallest forecasting error size value could be selected as the best forecasting model.

Several previous researchers have carried out CPI forecasting (Mukron et al.: 2020, Arumningsih & Darsyah, 2018) by forecasting methods for past seasonal data. However, forecasting using CPI figures by comparing two models, i.e., ARIMA and Exponential Smoothing Holt-Winters, has not been done and has never been carried out in Tegal City, Central Java. Hence, this paper aims to do CPI forecasting by comparing the last two mentioned models to determine the best CPI forecasting model in Tegal City for July to December 2021 as an early warning system for economic conditions. BPS-Statistics of Tegal City CPI data is used in the study for January 2014 to June 2021 (2018 = 100). It is expected that this model's results can contribute to developing inflation modeling in Tegal City, and interested stakeholders can use the estimation results of PCI.

RESEARCH METHODS

This study uses secondary data on CPI figures, monthly time series data from January 2014 to June 2021 with the base year of 2018 = 100, released by the BPS-Statistics of Tegal City, Central Java Province. The 2018 base year index figures were used in January 2020 following the 2018 International Classification of Individual Consumption According to Purpose (COICOP) reference. Before January 2020 (2012=100), the index numbers were backcast based on inflation figures. The forecasting is done by comparing two forecasting methods, namely the ARIMA Method and the additive Exponential Smoothing Method from Holt-Winters (Omane-adjepong & Oduro, 2013, Gusti Ayu & Ni Putu, 2017, Arumningsih & Darsyah, 2018, Yulinar & Novianita, 2020) by choosing a model with the minor Mean Absolute Percentage Error (MAPE). The forecasting period used is the medium term, based on one to three years (Kasmir, 2009).

Specification of the ARIMA Method

The ARIMA forecasting method, also called Box-Jenkins, has been studied intensely by George Box and Gwilym Jenkins (1976). Therefore their name is often synonymous with the ARIMA process. The Auto-Regressive

(AR) method was first introduced by Yule (1927), while the moving average (MA) method was first used by Slutsky (1937). The ARIMA model consists of two aspects, i.e., Auto-Regressive and Moving Average. In general, the ARIMA model is written with ARIMA notation (p, d, q), where p represents the order of the autoregressive process, d means the differentiation, and q represents the order of the moving average (MA) process (Aswi & Sukarna, 2006).

The stages of research using the ARIMA method include plotting factual data, determining the method with the Expert Modeler in SPSS 25, testing the static data in the mean using the Stationary R-Squared test, estimating parameters, and testing the significance of the ARIMA model parameters and forecasting factual data.

Specification of the Exponential Smoothing Holt-Winters additive Method

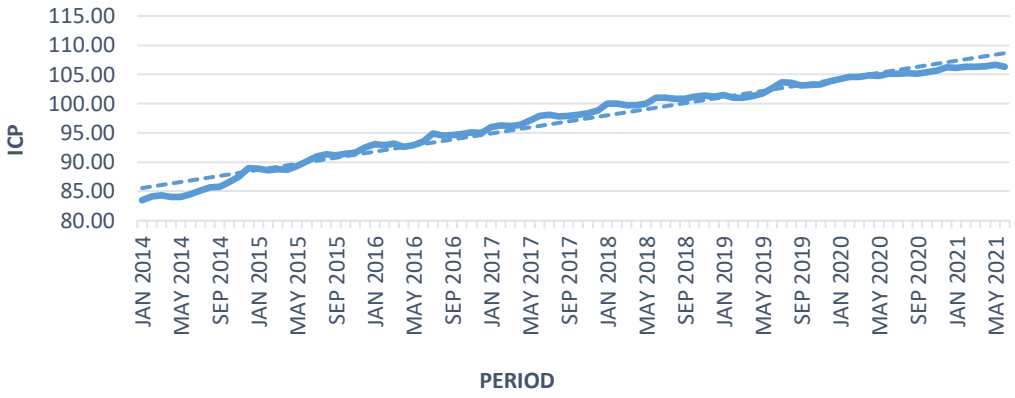
The Exponential Smoothing Holt-Winters method is a forecasting method to handle data assumed to have a trend pattern and seasonal behavior (Makridakis, 1999). The research stages using the Holt-Winters Exponential Smoothing method include plotting factual data, determining the process utilizing the Expert Modeler in SPSS 25, testing the static data in the mean using the Stationary R-Squared test, performing parameter estimates, and testing the significance of the Exponential Smoothing model parameters, which is additive Holt-Winters, from the error values Alpha, Gamma, Delta and performing factual data forecasting.

RESULT AND DISCUSSION

The initial stage in the forecasting comparison process, which is carried out using both the ARIMA forecasting method and the Exponential Holt-Winters method (Gusti Ayu & Ni Putu, 2017, Arumningsih & Darsyah, 2018, Yulinar & Novianita, 2020), is to plot factual data on the model to see the static data in the mean, The CPI data used in this study is with n = 90.

Figure 1 shows the development of Tegal CPI from January 2014 to June 2021, from which we can see that the CPI tends to increase from time to time. This indicates an element of trend in the data, i.e., an increase or positive direction. However, there is also a seasonal pattern, where some are moving up, and some are moving down (Makridakis, 1999).

Figures 1. CPI Data Plotted of Tegal City January 2014 – June 2021



Source: BPS Statistics of Tegal City

ARIMA Results

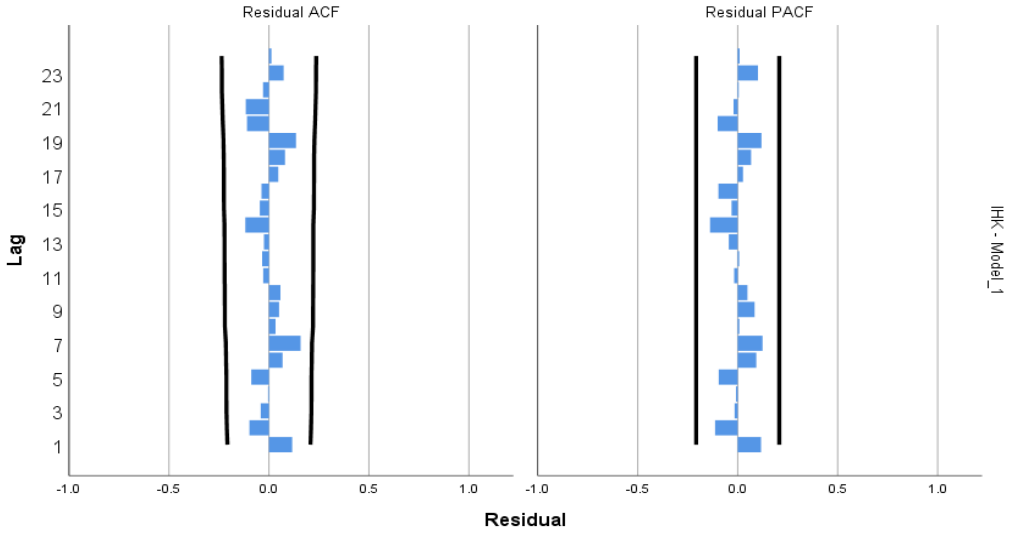
The ARIMA model is produced in the model (0,1,3). The results of the expert modeler in the program show that the fit model is of the order AR = 0 and MA = 3 by differencing one time to get the data stationary, as shown in Table 1.

Table 1. Model Description

Model ID	Data Source	Model Type
ARIMA	CPI	ARIMA(0,1,3)(1,0,0)

Figure 2 shows the results where the ACF and PACF plots of residual values are all in a stationary condition, not correlated with each other.

Figures 2. ***ACF (Auto Correlation Function) and PACF (Partial Auto Correlation*** **Function) Residual Model ARIMA (0,1,3), Not Correlated and Do Not Intersect The Left and Right Correlation Line**



The results of the significance test of the ARIMA parameter model are shown in Table 2. In the constant, the t-count value with 16 degrees of freedom is 6.026, higher than the t-table value of 4.7. Likewise, in MA lag 3, the calculated t value with 16 degrees of space with a significance of 0.015 is 2.476, while the t table is 2.3815. The t-count value, higher than the t-table, indicates that the model is acceptable.

Table 2. ARIMA Model Parameters CPI

Model		Estimate	SE	t	Sig.
Constant		0.262	0.043	6.026	0
Difference		1			
MA	Lag 3	0.27	0.109	2.476	0.015
AR, Seasonal	Lag 1	0.362	0.104	3.478	0.001

Exponential Holt-Winters Results

The forecasting stage using the Exponential Smoothing Holt-Winters method plots factual data on the SPSS program. The results of the Expert Modeler on the Tegal City CPI data show that the Exponential Smoothing Holt-Winters Additive is chosen. The results of the significance test of the Exponential Smoothing Holt-Winters Additive parameter model are shown in Table 3.

Table 3. Exponential Smoothing Model Parameters

Model	Estimate	SE	t	Sig.
Alpha (Level)	0.975	0.11	8.856	0
Gamma (Trend)	3.73E-05	0.018	0.002	0.998
Delta (Season)	0.999	4.476	0.223	0.824

At the Alpha level, the calculated t value with 15 degrees of freedom is 8.856, higher than the t table value of 6.1089. Likewise, for the Gamma Trend data, the estimated t value with 15 degrees of space with a significance of 0.998 is -3.3948, while the t table is 0.002, and the Delta t calculated value is 0.223 while the t table is -0.906. The t-count value, higher than the t-table, indicates that the model is acceptable.

Comparison of ARIMA Results and Holt-Winters Exponential Results

The comparison of forecasting results is carried out by looking at the accuracy of the effects of each forecasting method, i.e., by looking at the size of the forecasting error of the forecast results with the actual value of Tegal CPI. The size of this error is seen from the average absolute error or what is referred to as MAPE (Makridakis, 1999). Forecasting results with the lowest error, the smallest MAPE, show a good model and, therefore, can be accepted (Amstrong: 2001).

Based on the previous description, forecasting models using ARIMA or Exponential Smoothing Holt-Winters can both be used. However, if we look at the stationary test of the data in the mean using the Stationary MAPE test. Which is the average error of the forecast value compared to factual data (Arumningsih & Darsyah, 2018, Yulinar et al., 2020); the forecast method chosen for the CPI of Tegal City of January 2014 – June 2021 is Exponential Smoothing Holt-Winters, which has a smaller MAPE value than ARIMA, as shown in Table 4.

Tabel 4. Comparison of the Results of The Fit: ARIMA Model with The Holt-Winters.Exponential Smoothing additive

Fit Statistic	ARIMA (0,1,3)	Aditif Holt-Winters
R-squared	0.997	0.997
RMSE	0.384	0.372
MAPE	0.311	0.281
MaxAPE	1.32	1.137
MAE	0.298	0.27
MaxAE	1.175	1.041
Normalized BIC	-1.762	-1.829

Forecast Results

Table 5. Comparison of ARIMA and Holt-Winters Forecasting Results with Factual Data

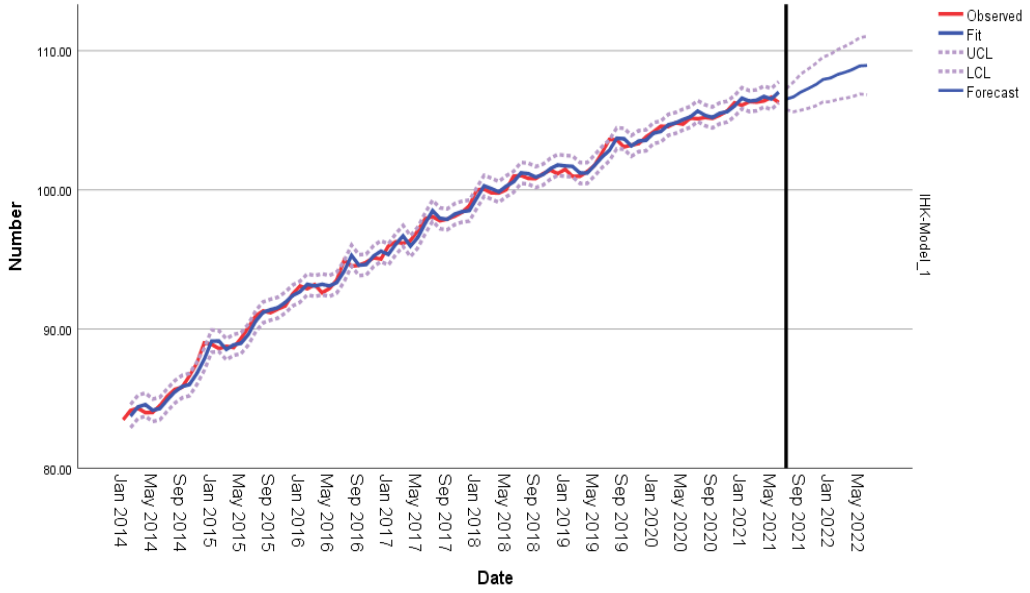
Period	CPI	Forecast Result ARIMA	Error	Forecast Result Holt-Winters Aditif	Error
21-Jan	106.08	106.59	-0.51	106.48	0.4
21-Feb	106.34	106.38	-0.04	106.11	-0.23
21-Mar	106.31	106.44	-0.13	106.37	0.06
21-Apr	106.39	106.71	-0.32	106.29	-0.1
21-May	106.66	106.53	0.13	106.71	0.05
21-Jun	106.28	107.02	-0.74	107.32	1.04

The forecasting results of these two methods for July 2021 to June 2022 can be seen in Table 6.

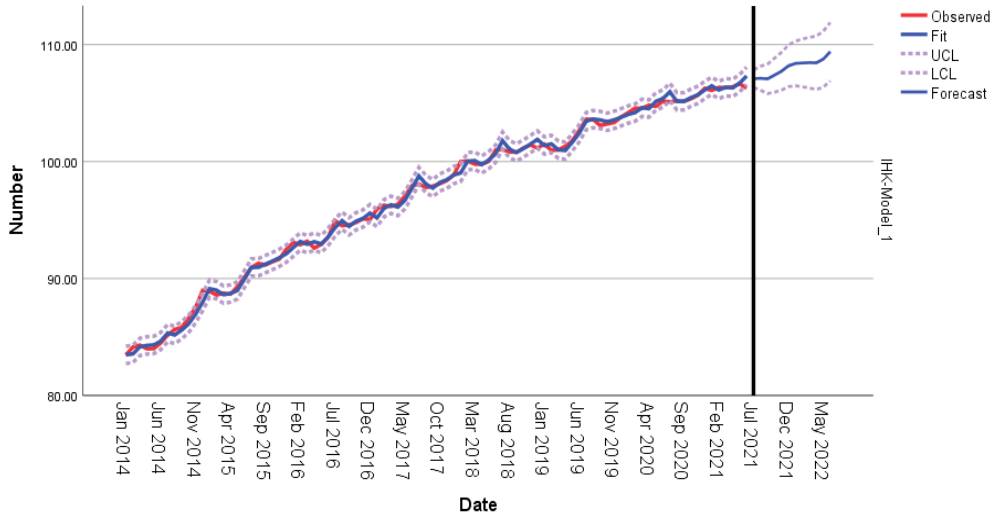
Table 6. Forecasting Results, Optimistic Forecast Values and Pessimistic Forecast Value of ARIMA and Holt-Winters Method

ARIMA				HOLT-WINTERS			
Month	Forecast	UCL	LCL	Month	Forecast	UCL	LCL
21-Jul	106.52	107.27	105.77	21-Jul	107.09	107.83	106.35
21-Aug	106.68	107.74	105.62	21-Aug	107.12	108.15	106.09
21-Sep	107.03	108.33	105.73	21-Sep	107.07	108.33	105.81
21-Oct	107.28	108.69	105.86	21-Oct	107.39	108.84	105.94
21-Nov	107.55	109.07	106.04	21-Nov	107.72	109.34	106.11
21-Dec	107.93	109.54	106.32	21-Dec	108.19	109.96	106.42
22-Jan	108.03	109.74	106.33	22-Jan	108.39	110.3	106.48
22-Feb	108.3	110.08	106.51	22-Feb	108.43	110.48	106.39
22-Mar	108.45	110.32	106.58	22-Mar	108.46	110.62	106.29
22-Apr	108.65	110.6	106.7	22-Apr	108.44	110.73	106.16
22-May	108.91	110.94	106.89	22-May	108.76	111.15	106.37
22-Jun	108.94	111.04	106.84	22-Jun	109.39	111.89	106.89

Figures 3. Plotting of ARIMA Forecast Results, Actual Value, Forecast Value, Optimistic Forecast, and Pessimistic Forecast Value



Figures 4. ***Holt-Winters Exponential Smoothing Prediction*** **Plotting Additive Actual Value, Forecast Value, Forecast Value Optimistic and Pessimistic Forecast Value.**



CONCLUSION

This paper aims to determine the best Consumer Price Index (CPI) forecasting model by comparing the results of two forecasting models for Tegal City for July to December 2021. This study indicates that the best-chosen method is the Exponential Holt-Winters method additives. That conclusion is derived from comparing the Exponential Holt-Winters Additive method MAPE value of 0.281, which is smaller than the ARIMA value of 0.311. These

results indicate that the Exponential Holt-Winters method is best chosen for forecasting the CPI rather than the ARIMA method for Tegal City.

This research is still far from perfect and relies on statistical conditions, assumptions, and time frames. Future studies to prove the best forecasting using the Exponential Smoothing Holt-Winters method or other methods can be continued by subsequent researchers by adding assumptions about the conditions in various regions and for multiple purposes.

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