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Time-Series Forecasting of Red Chili Prices in Bogor City, Indonesia

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ABSTRACT

Red chili is an important horticultural commodity in Indonesia, characterized by substantial price fluctuations that can affect household expenditure and food market stability. This study aims to forecast consumer-level red chili prices in Bogor City, Indonesia, using the Autoregressive Integrated Moving Average (ARIMA) method. The study uses 218 weekly price observations obtained from Statistics Indonesia (BPS) for the 2022–2026 period. The Box–Jenkins procedure was applied, including stationarity testing, model identification, parameter estimation, and diagnostic checking. The results indicate that the data became stationary after first-order differencing. Among four candidate models, ARIMA(3,1,1) was selected based on the lowest Akaike Information Criterion (AIC) and Hannan–Quinn Criterion (HQC), with values of 21.58900 and 21.61417, respectively. The model forecasts a gradual increase in red chili prices from 42,658 in the second week of February 2026 to 43,356 in the fourth week of December 2026, in the price units reported by BPS. These findings provide a local price outlook that may support consumer expenditure planning and market monitoring. However, forecast accuracy should be further evaluated using out-of-sample error measures, and future research may compare ARIMA with seasonal models and models incorporating external variables.

Keywords: *ARIMA, Bogor City,Price Forecasting, Red Chili Prices, Time Series*

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INTRODUCTION

Red chili (*Capsicum annuum L.*) is an important horticultural commodity in Indonesia due to its widespread use in household consumption (Sonia et al., 2019). However, its price often fluctuates due to changes in supply and demand, as well as the price of red chili peppers in the previous month (Nurjati, 2021). These fluctuations can affect household purchasing power, consumer spending, and food price stability (Andayani et al., 2025). Price instability also poses challenges for agricultural stakeholders, as sudden price increases can burden consumers, while price declines can reduce the income received by producers. Therefore, forecasting red chili prices becomes crucial for providing information that supports household expenditure planning, market management, and the formulation

of local government policies aimed at maintaining food price stability (Septarena et al., 2025).

At the consumer level, the price of red chili peppers reflects not only production conditions, but also distribution processes and market dynamics between producing regions and markets at various levels (Maulana et al., 2023). The interaction between supply availability and consumer demand can cause short-term fluctuations, while seasonal patterns and unexpected supply disruptions can increase price uncertainty. These characteristics make the price of red chili peppers an appropriate subject for time series forecasting, which uses historical observations to identify patterns and estimate future values (Andayani et al., 2025). Forecasting can provide useful information for consumers in planning household expenditures, for traders in managing purchasing and inventory decisions, as well as for local governments in monitoring the potential for food price instability. Therefore, the development of a red chili price forecasting model at the consumer level in Bogor is relevant to enhance the availability of local price information and to support more responsive food market management.

Bogor, as one of the urban centers in West Java, relies heavily on the agricultural supply chain to meet its population's food needs. Understanding consumer-level red chili prices is crucial in efforts to maintain economic stability. Various studies have examined red chili price forecasting using methods such as Autoregressive Integrated Moving Average (ARIMA), Exponential Smoothing, and Long Short-Term Memory (LSTM). National-level red chili price forecasting research using ARIMA (Windhy & Jamil, n.d.), while research predicts the price of red chili peppers in West Java using the LSTM model (Falah & Rachmaniah, 2022). These studies demonstrate the potential of time series forecasting, although model performance may vary depending on geographic coverage, market characteristics, and the observed data. Although previous research exists, the accuracy of forecasting models cannot be directly generalized across different geographic regions, as consumer-level prices may have unique temporal patterns and market dynamics.

Therefore, research specifically focusing on consumer-level red chili prices in Bogor City needs to be conducted. This study aims to analyze the forecasting movement of red chili in Bogor City. The contribution of this research lies in providing local empirical evidence related to forecasting performance and price prediction, which can assist consumers, traders, and local policymakers in anticipating price fluctuations as well as monitoring food prices in Bogor City.

METHOD

Source of Data

This study employs a quantitative approach using time series analysis to forecast red chili prices in Bogor City, Indonesia. The data used are secondary data on consumer-level red chili prices obtained from Statistics Indonesia (BPS). The data are recorded at a weekly frequency, covering the period from 2022 to 2026, and consist of 218 observations. The use of weekly data enables an analysis of short-term price fluctuations and dynamics.

Data Analysis Methods

The analytical method employed in this study is the Autoregressive Integrated Moving Average (ARIMA) model. This method is a time series forecasting approach that utilizes the dependency patterns between current observations and previous observations, as well as forecasting errors from previous periods (Rizvi, 2024). The ARIMA model was selected because this study focuses on forecasting red chili prices based on historical patterns without incorporating external explanatory variables.

The ARIMA model is expressed as ARIMA (p,d,q), where (p) represents the order of the autoregressive (AR) component, (d) indicates the degree of differencing, and (q) represents the order of the moving average (MA) component. Model selection follows the Box–Jenkins methodology, which consists of model identification, parameter estimation, diagnostic checking, and forecasting performance evaluation.

a. Stationarity Test

The first stage involves testing for stationarity to determine whether the data exhibit relatively constant statistical properties over time. The test is conducted using the Augmented Dickey–Fuller (ADF) test. The hypotheses tested are:

$$H_O : \delta = 0$$

$$H_1 : \delta < 0$$

The null hypothesis of the ADF test states that the data contain a unit root and are therefore non-stationary. If the data are non-stationary, differencing is performed iteratively until stationarity is achieved.

b. Identification of the ARIMA Model Order

After determining the stationarity characteristics, the next step is to identify candidate AR and MA orders through Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) analyses. The ACF is used to identify the correlation pattern between observations at a given period and those at previous periods, whereas the PACF identifies the partial correlation after controlling for the effects of intervening lags (Chung et al., 2018). The ACF and PACF patterns serve as initial guidelines for determining the values of (p) and (q). Model selection also takes into account the Akaike Information Criterion (AIC) and the Hannan–Quinn Criterion (HQC).

c. Model Parameter Estimation

Parameter estimation is performed on the selected ARIMA model candidates. In general, the ARIMA model can be expressed as follows:

$$\phi_p(B)(1-B)^d Z_t = \mu + \varepsilon_t - \theta_q(B)\varepsilon_t$$

Where

Z_t : Observed value at time t

ϕ_p : Autoregressive parameters

θ_q : Moving average parameters

B : Backshift operator

d : Order of differencing

μ : Constant parameter

ε_t : Error term

p : Order of the autoregressive (AR) component

q : Order of the moving average (MA) component

d. Diagnostic Checking

Following parameter estimation, model adequacy testing is conducted to verify whether the preliminary model is suitable for forecasting. The diagnostic checking process begins with a white noise test.

FINDING AND DISCUSSION

RESEARCH RESULT

Historical Data

Based on Figure 1, the 218 observations of weekly red chili prices in Bogor City over the 2022–2026 period indicate substantial fluctuations throughout the observation period. Prices did not remain constant but exhibited varying degrees of increase and decrease. This pattern suggests that red chili prices have temporal dynamics that require further analysis using a time series approach. Descriptive statistical analysis shows that the lowest recorded red chili price was IDR 16,000/kg, while the highest reached IDR 97,142/kg. Thus, the price range during the observation period was IDR 81,142/kg. The average price was IDR 47,671/kg.

Overall, the historical pattern indicates considerable fluctuations in red chili prices, characterized by both increases and decreases. These characteristics provide a basis for further analysis using the Autoregressive Integrated Moving Average (ARIMA) model, particularly to identify intertemporal price dependencies and evaluate the model's forecasting performance for subsequent periods.

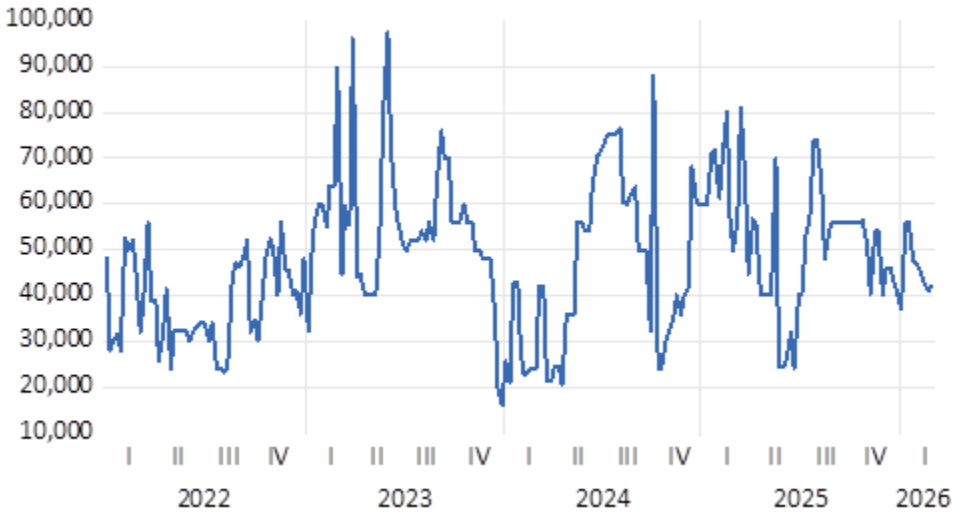


Figure 1: Historical Data on Red Chili Prices in Bogor City (Rp/kg)

Unit Root Test

The stationarity test results indicate that the consumer-level red chili price data in Bogor City became stationary after first differencing, with a p-value of 0.0000, as presented in Table 1. This value is lower than the 5% significance level (0.05); therefore, the null hypothesis of a unit root is rejected. These results indicate that the data satisfy the stationarity assumption after first differencing. Accordingly, the differencing order in the ARIMA model is set to d=1, while the autoregressive (p) and moving average (q) orders are determined through ACF and PACF pattern analyses.

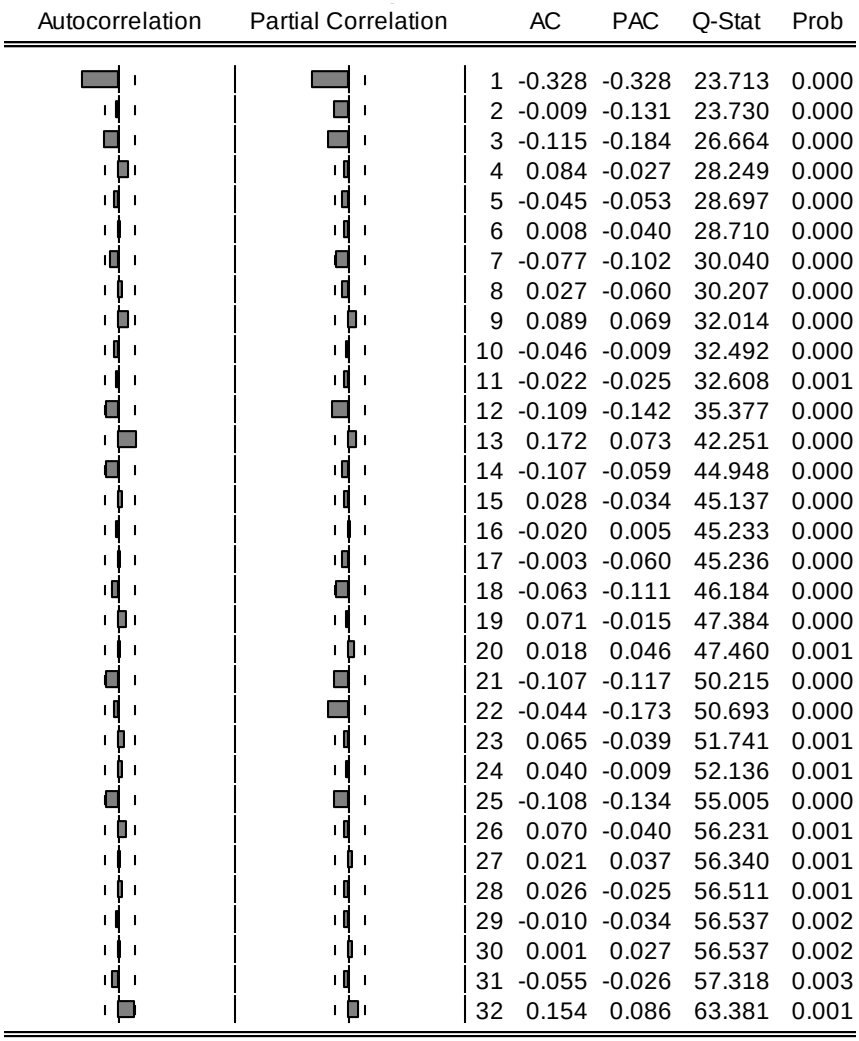
Table 1: Unit Root Test Results with ADF Test Method

Augmented Dickey-Fuller test statistic		**T-Statistic**	**Prob.**
		-11.9360	0.0000
Test critical values	1% level	-3.4608	
	5% level	-2.8748	
	10% level	-2.5739	

Identification of the ARIMA Model Structure

The ARIMA model structure was identified by examining the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) patterns of the red chili price data after first differencing. Based on the PACF plot in Figure 2, several lags exceeded the significance bounds, namely lags 1, 3, 12, and 22. These findings were used as a basis for determining candidate autoregressive (p) orders, while the differencing order (d) was set to 1 based on the preceding stationarity test results. The moving average (q) order was set to 1 based on the ACF plot in Figure 2, resulting in four candidate models: ARIMA (1,1,1), ARIMA (3,1,1), ARIMA (12,1,1), and ARIMA (22,1,1). These models were subsequently estimated and compared based on their AIC and BIC values, parameter significance, and

residual diagnostic test results to determine the most suitable model for forecasting red chili prices in Bogor City.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.328	-0.328	23.713	0.000
		2	-0.009	-0.131	23.730	0.000
		3	-0.115	-0.184	26.664	0.000
		4	0.084	-0.027	28.249	0.000
		5	-0.045	-0.053	28.697	0.000
		6	0.008	-0.040	28.710	0.000
		7	-0.077	-0.102	30.040	0.000
		8	0.027	-0.060	30.207	0.000
		9	0.089	0.069	32.014	0.000
		10	-0.046	-0.009	32.492	0.000
		11	-0.022	-0.025	32.608	0.001
		12	-0.109	-0.142	35.377	0.000
		13	0.172	0.073	42.251	0.000
		14	-0.107	-0.059	44.948	0.000
		15	0.028	-0.034	45.137	0.000
		16	-0.020	0.005	45.233	0.000
		17	-0.003	-0.060	45.236	0.000
		18	-0.063	-0.111	46.184	0.000
		19	0.071	-0.015	47.384	0.000
		20	0.018	0.046	47.460	0.001
		21	-0.107	-0.117	50.215	0.000
		22	-0.044	-0.173	50.693	0.000
		23	0.065	-0.039	51.741	0.001
		24	0.040	-0.009	52.136	0.001
		25	-0.108	-0.134	55.005	0.000
		26	0.070	-0.040	56.231	0.001
		27	0.021	0.037	56.340	0.001
		28	0.026	-0.025	56.511	0.001
		29	-0.010	-0.034	56.537	0.002
		30	0.001	0.027	56.537	0.002
		31	-0.055	-0.026	57.318	0.003
		32	0.154	0.086	63.381	0.001

Figure 2: ACF Plot and PACF Plot

Model Estimation

Model estimation was conducted on the four ARIMA candidate models identified in the previous stage. The selection of the best model was based on a comparison of the Akaike Information Criterion (AIC) and Hannan–Quinn Information Criterion (HQC) values, as well as the statistical significance of the estimated parameters. The estimation results presented in Table 2 show that ARIMA (3,1,1) has an AIC value of 21.58900 and an HQC value of 21.61417. Both values are the lowest among the candidate models evaluated; therefore, ARIMA (3,1,1) was selected as the best model based on these information criteria.

Nevertheless, the estimation results indicate that the AR(3) coefficient in the ARIMA (3,1,1) model is not statistically significant (p-value = 0.1217), whereas the MA(1) coefficient is significant at the 5% level (p-value = 0.0000). The constant term is also not statistically significant (p-value = 0.9736). These findings indicate that the MA(1) component makes a statistically significant contribution to the model, whereas the statistical evidence supporting the AR(3) component and the constant term is insufficient at the 5% significance level.

Overall, ARIMA (3,1,1) yields the lowest information criterion values among the four candidate models. Therefore, this model was selected for further residual diagnostic testing and forecasting accuracy evaluation.

Table 2: Best Model Estimation

Model	Variable	Coef	Std Error	Prob	AIC	HQC
Arima (1,1,1)	AR(1)	0.2834	0.1055	0.0078	21.59054	21.61571
	MA(1)	-0.6930	0.0904	0.0000		
	C	17.1427	393.8210	0.9653		
Arima (3,1,1)	AR(3)	-0.1202	0.0773	0.1217	21.58900	21.61417
	MA(1)	-0.4349	0.0525	0.0000		
	C	15.1141	455.4544	0.9736		
Arima (12,1,1)	AR(3)	-0.0993	0.0644	0.1250	21.59351	21.61867
	MA(1)	-0.4566	0.0524	0.0000		
	C	14.7191	436.1075	0.9731		
Arima (22,1,1)	AR(3)	-0.0806	0.0688	0.2429	21.59679	21.62196
	MA(1)	-0.4627	0.0512	0.0000		
	C	20.3692	448.6810	0.9638		

Diagnostic Checking

Diagnostic testing was conducted by examining the ARMA Structure diagram of the ARIMA (3,1,1) model. Based on Figure 3, all root points appear to lie within the unit circle. This indicates that the model roots satisfy the stability and invertibility criteria, with no apparent violations of either condition based on the root diagram. Therefore, the ARIMA (3,1,1) model can proceed to the forecasting accuracy evaluation stage.

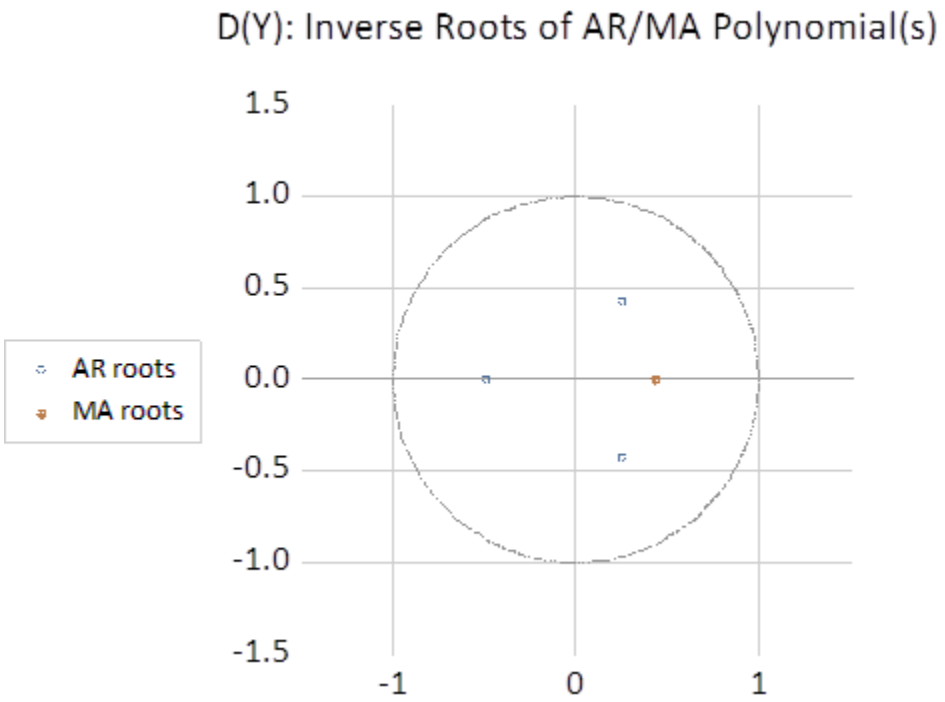


Figure 3: ARMA Structure Diagram

Red Chili Price Forecasting

The red chili price forecasts at the consumer level in Bogor City using the ARIMA (3,1,1) model for the February–December 2026 period are presented in Table 3 and Figure 4. The forecast covers 44 weekly observations, beginning in the second week of February 2026 and ending in the fourth week of December 2026.

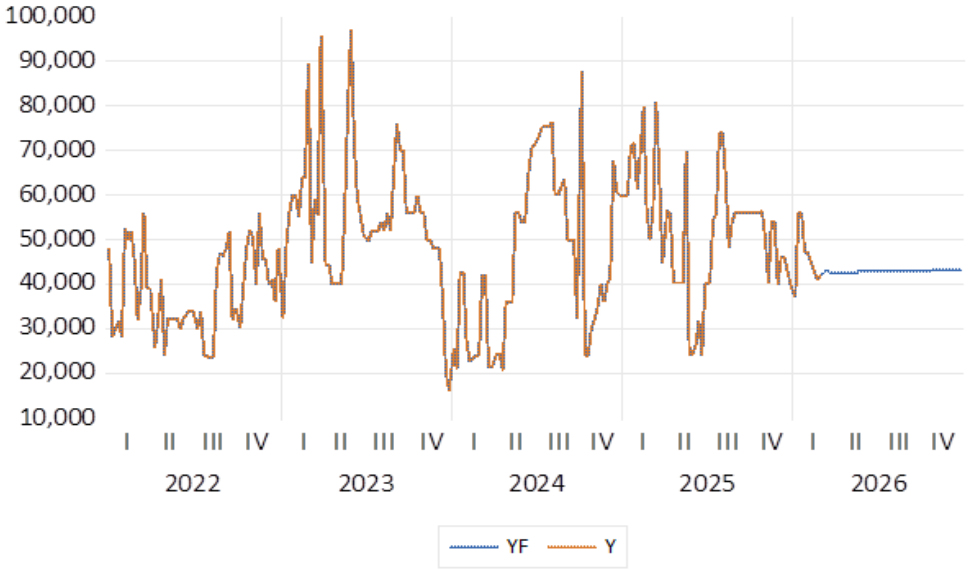


Figure 4: Red Chili Price Forecasting Chart

The forecasting results indicate that red chili prices are projected to range from IDR 42,658 to IDR 43,356 per kg. At the beginning of the forecast period, the price is projected to be IDR 42,658 in the second week of February 2026. Subsequently, the forecast values fluctuate from week to week, with prices reaching the IDR 43,000 range starting in July 2026. By the end of the forecast period, the price is projected to reach IDR 43,356 in the fourth week of December 2026. Overall, the forecasts indicate a relatively gradual pattern of price changes throughout the projection period. The weekly forecast values generated by the model provide a basis for describing the projected movement of red chili prices from February to December 2026.

Table 3: Red Chili Price Forecasting

Month	Week	Price Forecasting (Rp/kg)	Month	Week	Price Forecasting (Rp/kg)
Feb-26	II	42,658	Aug-26	I	43,069
	III	42,940		II	43,084
	IV	42,837		III	43,099
Mar-26	I	42,774		IV	43,114
	II	42,757	Sep-26	I	43,129
	III	42,787		II	43,145
	IV	42,811		III	43,160
Apr-26	I	42,830		IV	43,175
	II	42,844	Oct-26	I	43,190
	III	42,857		II	43,205
	IV	42,872		III	43,220
May-26	I	42,887		IV	43,235
	II	42,903	Nov-26	I	43,250
	III	42,918		II	43,265
	IV	42,933		III	43,281
Jun-26	I	42,948		IV	43,296
	II	42,963	Dec-26	I	43,311
	III	42,978		II	43,326
	IV	42,993		III	43,341
Jul-26	I	43,009		IV	43,356
	II	43,024			
	III	43,039			
	IV	43,054			

DISCUSSION

This study demonstrates that the ARIMA (3,1,1) model can be used to forecast consumer-level red chili prices in Bogor City based on weekly data for the 2022–2026

period. Historical prices exhibited considerable variation, with a coefficient of variation of 32.96%, indicating substantial price fluctuations throughout the observation period. These findings are consistent with Prihandi et al. (2025), who applied ARIMA to forecast red chili prices in Indonesia, and Tami & Owda (2024), who used the Long Short-Term Memory (LSTM) method to predict commodity price. Both studies demonstrate that time series approaches can be applied to examine red chili price patterns, although model performance may vary depending on data characteristics, geographical coverage, and the methods employed.

Among the four candidate models, ARIMA (3,1,1) yielded the lowest AIC and HQC values, at 21.58900 and 21.61417, respectively. However, the AR(3) coefficient was not statistically significant, whereas the MA(1) coefficient was significant at the 5% level. Furthermore, the difference in AIC between ARIMA (3,1,1) and ARIMA (1,1,1) was relatively small. Therefore, model selection based on information criteria should be complemented by forecasting accuracy evaluation and residual diagnostics to provide a more comprehensive assessment of the selected model's performance. Hegde et al. (2024) also highlighted the importance of considering data characteristics, including outliers, in commodities price modeling.

The ARIMA (3,1,1) forecasting results indicate a gradual increase in projected prices from IDR 42,658 in the second week of February 2026 to IDR 43,356 in the fourth week of December 2026, representing an increase of approximately 1.64%. This pattern suggests a relatively stable projection compared with historical price variations. However, these values represent extrapolations based on historical price patterns rather than a guarantee of actual price movements. As the model is univariate, the forecasts do not explicitly account for changes in production, weather conditions, distribution costs, or market demand. Mathenge Mutwiri (2019) demonstrated that the SARIMA model, which incorporates external variables, can serve as an alternative for forecasting agricultural prices. Future research could therefore compare ARIMA with SARIMA or SARIMAX to evaluate potential seasonal patterns and the contribution of external variables. In practical terms, these forecasts may provide supporting information for consumers, traders, and policymakers in monitoring price developments, although their application should take forecasting accuracy on test data into account.

CONCLUSION

This study employs the ARIMA method to forecast consumer-level red chili prices in Bogor City using 218 weekly observations covering the 2022–2026 period. The stationarity test results indicate that the data became stationary after first differencing. Based on a comparison of four candidate models using the AIC and HQC criteria, ARIMA (3,1,1) was selected as the model with the lowest information criterion values. The forecasts for February–December 2026 indicate a gradual increase in prices from IDR 42,658 to IDR 43,356. These findings provide insights into red chili price movements based on historical patterns and demonstrate the potential of ARIMA as a supporting tool for local food price

monitoring. Future research could compare ARIMA with seasonal models or models incorporating external variables to improve red chili price forecasting accuracy.

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