Forecasting of Red Chilli Prices in Banyumas Regency: The ARIMA Approach

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Abstract. Chilli is one of the national strategic commodities in Indonesia. The price of chilli tends to fluctuate every season which may contribute to inflation. In June 2022, chilli price contributed to the food group inflation as 0.24%. At the same period, in Banyumas it contributed as 0.20%. This study aimed: 1) to analyse the performance of red chilli price in Banyumas, 2) to analyse the forecasting of red chilli prices in Banyumas. This study used a descriptive method for assessing performance of red chilli price and method for forecasting of red chilli prices using the Autoregressive Integrated Moving Average (ARIMA) model. The secondary data of the average price of chilli used in the study was obtained from PIHPS. There were 69 data from April 2017 until December 2020. The red chilli prices in Banyumas Regency shows an upward trend in a fluctuating during April 2017 to December 2022. ARIMA 1.11 has been estimated as the most suitable model for predicting prices. The result showed that the price of chilli in Banyumas during January-December 2023 was predicted as 39.703 to 42.815 rupiahs per kilo, and it tends to increase every season.

1 Introduction

Chilli is a horticultural product with a high economic value and offers great opportunities for further development in Indonesia, as known as one of the National Strategic Goods [1]. In addition, chilli is a vegetable with large price fluctuations that contribute to inflation [2]. Price fluctuations often occur during the rainy season, in the month of Ramadan, before the New Year or other holidays and religions [3]. Nationally, red chilli contributed to an inflation rate of 0.24% in the food group in June 2022. In Banyumas regency, red chilli contributed to an inflation rate of 0.20% over the same period.

For Indonesian citizen, red chilli is an agricultural product which is not only necessary for consumption as a cooking ingredient, but also very popular for harvesting chilli and offer profit to the farmers. Based on data from Center of National Data and Agriculture System [4], the average consumption of red chilli in Indonesia in 2022 is 0.037 kg/capita/week, an increase of 5.70% year-on-year. The high consumption of red chilli leads to a decline in chilli consumption when the price of red chilli rises quite high while was not balanced with gaining income. In addition, price volatility also affects to uncertain profits and risk management to farmers the as the chilli producers. According to a previous finding [5], fluctuations in chilli

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prices will affect the effectiveness of agricultural commodity price stabilization policies as one of the basic needs. The problem of fluctuating and rising red chilli prices can lead to country and society loss. One solution to overcome this problem is creating price forecasters which is quick, validated and accurate to predict the possibility of a red chilli price increase [6].

[7] One of the solutions to support decision-makers regarding price stabilization is to carry out price predictions. The Autoregressive Integrated Moving Average (ARIMA) is a time series analysis technique often used to predict future data. The ARIMA model fully disregards independent variables when making forecasts. For precise short-term predictions, ARIMA uses the dependant variable's historical and current values. ARIMA is appropriate when the observations from the time series are statistically related [8,9].

Several studies used the ARIMA model to forecast prices for various agricultural commodities in the future, as performed by [10] who used the ARIMA method to predict chilli prices in Telangana state. Furthermore, [3] used the ARIMA model to forecast the price of red chilli in Indonesia. The results of this study showed that the best version of ARIMA model for forecasting the price of red chilli is the ARIMA model (1,1,0). The forecast results showed that the price of red chilli is expected to fall in the future. Sukiyono and Janah studied the selection of prediction models for curly chilli and found that ARIMA model is the best model to predict Curly Chilli prices [2].

Based on the above description, the difference between this study and previous studies lies in the time frame examined and the location of the study, which was conducted at a more specific level, which is district level. Therefore, the objectives of this study are: 1) to analyse the price variance of red chilli in Banyumas Regency, 2) to analysis the price prediction of red chilli using the ARIMA method. The result of this studi, is hoped to be useful for decision maker of stakeholders in the development of red chili in Banyumas Regency and in the expectation of stabilization of red chili prices. The findings of this research can also be used by farmers to help them decide whether to produce red chili farming.

2 Research methods

2.1 Data Sources

This study used secondary data in the form of the average monthly price of red chillis at the Banyumas Regency level, sourced from the National Strategic Food Price Information Centre (PIHPS Nasional). The amount of data used is 69 dates, starting from April 2017 to December 2022.

2.2 Metode Analysis Data

The analytical method used in this study is the descriptive analysis method, the ARIMA (Autoregressive Integrated Moving Average) time series prediction method. Descriptive analysis was used to achieve the first objective, to see the performance of red chillis in Banyumas Regency. Meanwhile, the ARIMA method is used to forecast the price of red chillis in Banyumas Regency for the next 24 months. The ARIMA model is part of a mono-variate time series analysis. The Jenkins-Box procedure consists of several steps, namely [10]:
1. Identification. At this point, three things were identified: data patterns, whether there is a seasonal element or not. Second: identification of data stationarity. Third, identify the pattern or behaviour of ACF and PACF.

2. Model estimation. In this phase, trial and error method is used, that is, testing different values and choosing the ones that minimize the sum of squares of the residuals.
3. Evaluation of the model. After the preliminary model equation has been determined, a diagnostic test is performed to test whether the model is close to the data. This test is performed by testing the residual value and testing the significance and relationships between parameters. If test results are found that are unacceptable or non-compliant, the model should be repaired, and the previous steps repeated.
4. Forecast. The last step is to make predictions or forecasts based on the chosen model. Forecast values are provided in the computer output. The best model is the model with the smallest prediction error, namely the model with the smallest MSE value.

The ARIMA model is a combination of the autoregressive (AR) and moving average (MA) models. This model forms ARIMA(p,d,q), where p is the order of AR, d is the order of integration, and q is the order of MA. The general form of the ARIMA model (p,d,q) [11] is:

$$P_t = \alpha 0 + (1 + \alpha 1)P_{t-1} + \dots P_{1-q} + (1 + \alpha \rho)P_{t-\rho} + \theta 1_{et-1} + \theta 2_{et-2} + \dots + \theta q_{et-q} \quad (1)$$

3 Results and Discussion

3.1 Performance of Red Chilli Prices in Banyumas Regency

Red chili is a horticultural product that plays an important role in the national economy. The presence of fluctuations in the price of red chilli has a significant impact on inflation [12]. Fluctuations in chilli prices will affect producers, consumers, and the effectiveness of government action. The price development of red chillis shows how the prices of red chillis develop over a certain period. The development of red chilli prices in Banyumas Regency is shown in Figure 1.
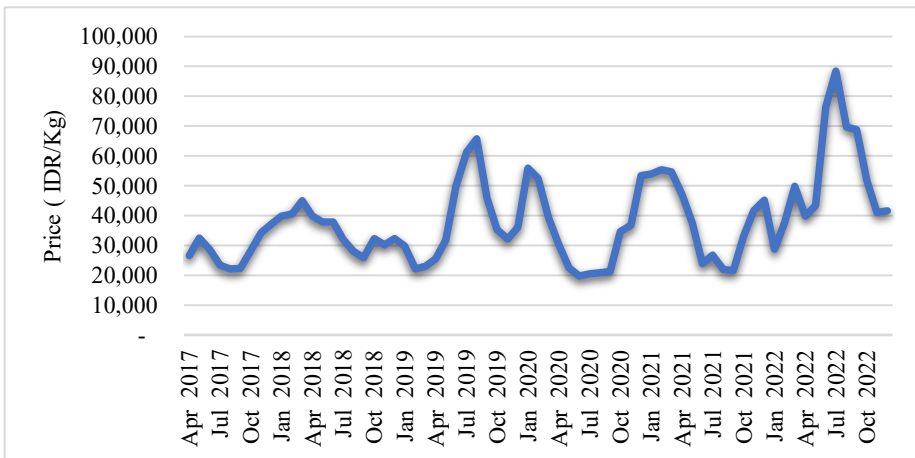

Fig 1. Performance of red chilli prices in Banyumas Regency for the period April 2017-December 2022.

In the period from April 2017 to December 2022, the price of red chillies in Banyumas Regency fluctuates with the gap between the highest and lowest price of IDR 68,700. The highest price was reached at a price level of IDR 88,450/kg in July 2022. The price increase for red chillis in July was affected by weather disturbances in the chilli production centres, disrupting the supply of chillis to the market. The increase in chilli prices in July also occurred

at the national level, where the impact of the price increase for red chilli chillis impacted the contribution of red chilli chillis to inflation by 0.15% [13]. The lowest price for red chillies during the observation period was IDR 19,750/kg in June 2020. This was due to the abundant supply of chillies on the market due to the harvest season, which lasted from March 2020. In addition, the low chilli prices in June 2020, according to BI, also caused by government policies regarding the transition period to a New Normal due to the Covid-19 pandemic. This was partly because market activities were still relatively limited, and the hotel and catering sector (hospitality, hospitality and catering) had not yet fully got going. due to different guidelines during the Covid-19 pandemic [14]. The research results [19] show that the demand for peppers is decreasing during SMT I 2020, which leads to a decrease in the prices of peppers in the market. Figure 1 shows that the development of red chilli prices in Banyumas Regency shows an upward trend in a fluctuating pattern from April 2017 to December 2022. This is evidenced by the average positive price growth of 3.207%.

3.2 Forecasting of Red Chilli Prices in Banyumas Regency

Before forecasting chilli prices with the ARIMA model, one of the conditions that must be fulfilled is that the data is stationary. Tests are also performed on stationary data to determine whether differentiation should be performed or not. [10] To test whether or not the data is stationary, two approaches can be used, namely taking into account the ACF (autocorrelation function) and PACF (partial autocorrelation function) plots and applying the Augmented Dickey-Fuller (ADF) unit root test.

Tabel 1. Augmented Dickey-Fuller (ADF) Test

Augmented Dickey-Fuller test statistic		t-Statistic	Prob.*
		-6.236346	0.0000
Test critical values:	1% level	-3.536587	
	5% level	-2.907660	
	10% level	-2.591396	

The stationarity of the data can be checked using the Augmented Dickey Fuller (ADF) test. Data is declared stationary if the ADF p-value is less than the significant value α (5%) or 0.05. The processing results show that the p-value of consumption is 0.0546, so differentiation must be performed first. Differentiated chilli price data yields a p-value less than 0.05, which is 0.000 (Table 1). Therefore, the data at the first difference level is declared stationary.

Based on the model estimation performed using a trial-by-error method, ARIMA (1,1,1) is the best ARIMA model to use. This is because this model meets the criteria for the best ARIMA model to use. The criteria met by the ARIMA model (1,1,1), namely [15]:

1. The Parsimonious model, the preliminary model obtained, namely the ARIMA model (1,1,1), already shows the simplest form.
2. The number of parameters is significant. This is reflected in the output estimation results when the p-value coefficient is below the significance level α = 0.05
3. The reversibility condition given by the sum of the AR and MA coefficients, each of which must be less than 1. The output estimation results for the value of AR and MA coefficients are -0.52 and -0.87, respectively.
4. Convergent iteration process. This is shown by the statement that the relative change of each estimate in the iteration results is less than 0.0010.

5. The model should have the smallest AIC and SC values. The ARIMA model (1,1,1) has the smallest AIC and SC values compared to other preliminary models. The results of the ARIMA model estimation (1,1,1) are shown in Table 2.

Table 2. ARIMA Model of Red Chilli Prices in Banyumas Regency

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	123.4562	1340.309	0.092110	0.0269
AR (1)	-0.524407	0.184599	-2.840795	0.0061
MA (1)	0.865477	0.108344	7.988263	0.0000
SIGMASQ	68958770	11915639	5.787249	0.0000
R-squared	0.142661	Mean dependent var		144.6154
Adjusted R-squared	0.100497	S.D. dependent var		9038.266
S.E. of regression	8572.086	Akaike info criterion		21.01758
Sum squared reside	4.48E+09	Schwarz criterion		21.15139
Log likelihood	-679.0713	Hannan-Quinn criter.		21.07037
F-statistic	3.383455	Durbin-Watson stat		1.981294
Prob(F-statistic)	0.023710			
Inverted AR Roots	-.52			
Inverted MA Roots	-.87			

Based on the results of the assessment of the criteria for the best ARIMA model, a forecast can then be made for the price of red chillis for the coming months. The estimated results of the 24-month forecast using the ARIMA model (1,1,1) are shown in Table 3.

Tabel 3. Forecast of Red Chilli Prices in Banyumas Regency

Period	Price (IDR)	Period	Price (IDR)
Jan 2023	39,702.70	Jan 2024	43,035.21
Feb 2023	40,938.82	Feb 2024	43,255.87
Mar 2023	40,672.30	Mar 2024	43,476.32
Apr 2023	41,126.38	Apr 2024	43,696.86
May 2023	41,234.89	May 2024	43,917.36
Jun 2023	41,509.11	Jun 2024	44,137.89
Jul 2023	41,703.87	Jul 2024	44,358.39
Aug 2023	41,936.74	Aug 2024	44,578.91
Sep 2023	42,151.33	Sep 2024	44,799.43
Oct 2023	42,374.68	Oct 2024	45,019.94
Nov 2023	42,593.84	Nov 2024	45,240.46
Dec 2023	42,815.01	Dec 2024	45,460.97

The results of forecasts using the ARIMA model (1,1,1) show that the prices of Banyumas Regency red chillis increase over the year from January 2023 to December 2024. Based on overnight results, the lowest price was for Chile reached in January 2023 with 39,702.7/kg and the highest in December 2024 with 45,460.97 IDR/kg. [16] The rise in the price of chillies could be due to the high public demand for chilli products. According to [17], over the last 30 years there has been a trend towards rising chilli prices with an average increase of 12.13% at the producer level and a price increase of 13.66% at the consumer level.

Based on the results of the forecast of red chilli price in Banyumas Regency, which is on an upward trend, several efforts are needed to stabilize the price of chilli. This is important considering that an increase in the price of red chilli will affect the formation of inflation.

[18] Red chilli is one of the 11 foods that are major contributors to inflation rates, especially volatile food inflation. For this reason, stabilization of red chilli prices is necessary.

4 Conclusion

The Performance of red chilli prices in Banyumas Regency for the period April 2017-December 2022 often fluctuated with the difference between the highest price and the lowest price of IDR 68,700. The highest price for red chilli was recorded in July 2022 and the lowest price for red chilli was recorded in June 2020. The results of the analysis of red chilli price prediction in Banyumas Regency using the ARIMA model provided the best ARIMA model estimation results to predict the national price of red chilli is the ARIMA model (1,1,0). The price predictions for red chillis show that the price of red chillis will increase in the future. Therefore, several efforts are needed to maintain the stability of chili prices in the market. Various policies that can be implemented by the government are: (1) the development policies of intensification and extensification of chili cultivation to maintain production stability, (2) the development of chili production centers that provide year-round production enable (3) Implement post-harvest chilli technology to support chilli storage during the main harvest season. (4) Improving the chili supply chain to become more efficient.

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