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Understanding Short-Term and Long-Term Price Fluctuations of Main Staple Food Commodities in Aceh Province, Indonesia: An ARDL Investigation

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Abstract

Aceh Province still relies on external sources from other regions for its main staple food commodities, resulting in unpredictable price fluctuations. To address this issue, it is essential to identify the key determinants responsible for these fluctuations and implement suitable preventive measures and policies. Utilizing monthly time-series data from January 2016 to December 2020 and employing the Autoregressive Distributed Lag (ARDL) approach, we investigate the short-term and long-term impact of variables like raw material prices, rainfall, and price index received by farmers on the price fluctuations. The results of the ARDL estimation reveal that all selected independent variables play a crucial role and significant in influencing the price fluctuations of main staple food commodities. Armed with these findings, we suggest that policymakers can provide necessary resources to farmers, strengthen weather monitoring systems, and enhance market transparency, thus better controlling future price fluctuations of regional staple food commodities.



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1. Introduction

The fluctuations in prices of staple food commodities can create widespread unease, impacting the prices of other products in the market, and pose a threat to regional economic stability since it hold a significant position in the daily lives of people in the Indonesian market as they are essential necessities [1]. Conversely, maintaining

stable prices for staple foods offers numerous advantages for developing nations like Indonesia. It enables impoverished farmers and consumers to enhance their standard of living, break free from poverty traps, and realize socio-economic improvements [2–4].

According to a recent report by the Economist, Indonesia's position in the 2022 Global Food Security

Index improved slightly from 69th place in 2021 to 65th out of 113 countries. However, the country's rankings in other key indicators are still relatively unfavorable. Indonesia ranks 44th in terms of food affordability, 84th in food availability, 78th in food safety and quality, and 83rd in food sustainability and adaptation. These rankings highlight the necessity for concerted efforts to enhance national food security and achieve better outcomes in these areas.

To date, the government has consistently made efforts to stabilize the prices of primary staple food items, including rice, cooking oil, and chicken eggs. These measures involve conducting market operations and organizing low-cost markets, all aimed at ensuring price stability for these essential commodities [5]. The government of Aceh Province itself has taken proactive measures to secure local food supplies through the implementation of the Gerakan Aceh Mandiri Pangan (GAMPANG) program. This initiative is outlined in Aceh Governor Regulation Number 52 of 2020, which was issued on September 9, 2020. The program's primary objective is to address potential food shortages and mitigate the impact of regional economic downturns.

Historically, there have been very few price fluctuations in the agricultural and food commodity markets [3, 6–8]. It is unlikely for supply disruptions resulting from natural disasters or adverse weather conditions to cause price fluctuations in main staple food commodities, along with fluctuations in agricultural and raw material prices [1, 9–11]. However, in such situations, there is a significant risk that arises, providing opportunities for individuals to exceed their regular expenditure on food consumption. This, in turn, increases the likelihood of uncontrollable price spikes [12].

Similar to numerous prior studies on this subject, research on price fluctuations in main staple food commodities has typically examined and been influenced by factors such as population size, total agricultural/plantation commodity production, labor, harvested area, and exchange rates. Moreover, these studies have predominantly been conducted in regions other than Aceh Province [13–17]. Nevertheless, the impact of the previous period's prices of main staple food commodities, as well as raw material prices, weather conditions, and particularly the influence of the price index received by farmers on main staple food commodities, has not been adequately studied within the context of Aceh Province. Consequently, further research is needed to investigate these selected variables and their effects.

Aceh Province remains reliant on other regions in Indonesia for its main staple food commodities. Currently, the majority of rice, cooking oil, and chicken eggs are sourced from neighboring provinces. Similarly, the processing of most raw materials for these commodities is limited in Aceh Province, as there is a scarcity of rice refineries, palm oil mills, and animal feed factories. This situation can contribute to price fluctuations in main staple food commodities. With this in mind, the study aims to analyze both short-term and long-term price fluctuations in main staple food commodities within Aceh Province. The findings of this analysis can serve as an additional reference for policymakers in their efforts to manage price stability and ensure a consistent regional food supply.

The remainder of the paper is structured as follows: Section 2 presents the type and source of the data, variable definitions, and the method of analysis. Section 3 outlines the results of the Autoregressive Distributed Lag (ARDL) estimation, including the stationary test, cointegration test, and ARDL model stability test. Finally, Section 4 provides a summary of the research along with conclusions and policy recommendations.

2. Materials and Methods

2.1. Data and Variable

The data used in this paper consists of monthly time-series secondary data from January 2016 to December 2020, which was obtained from various sources, including the Statistics of Aceh Province, the Aceh Agriculture and Plantation Department, and the National Strategic Food Price Information Center (PIHPS).

Table 1. Dependant and independant variable synopsis.

Variable	Indicator Name	Sources
RC	Rice Price (Rupiah per Kilogram)	PIHPS
CO	Cooking Oil Price (Rupiah per Liter)	PIHPS
CE	Chicken Egg Price (Rupiah per Kilogram)	PIHPS
MDG	Milled-Dry Grain Price (Rupiah per Kilogram)	Distanbun of Aceh Province
PFM	Palm Fresh-Fruit Marks (Rupiah per Kilogram)	Distanbun of Aceh Province
DSC	Dry-Shelled Corn Price (Rupiah per Kilogram)	Distanbun of Aceh Province
RF	Rainfall (Millimeter)	Statistics of Aceh Province
FC	Food Crops Sub-sector Price Index (Percent)	PIHPS
PT	Plantation Sub-sector Price Index (Percent)	PIHPS
LS	Livestock Sub-sector Price Index (Percent)	PIHPS

Table 2. Descriptive statistics.

Variable	Mean	Median	Maximum	Minimum	Std. Dev.
LnRC	9.2434	9.2447	9.2827	9.2103	0.0144
LnCO	9.5719	9.5521	9.6719	9.4727	0.0651
LnCE	9.9908	10.0033	10.2524	9.8086	0.1069
LnMDG	8.6388	8.6293	8.8880	8.5202	0.0690
LnPFM	7.2845	7.2715	7.5888	6.9373	0.1339
LnDSC	8.5923	8.5364	8.7796	8.3853	0.1372
LnRF	5.1299	5.1570	6.3603	3.0106	0.7271
FC	117.3098	119.1850	129.7600	100.1900	8.3454
PT	109.0492	110.9950	120.0700	96.9100	5.9284
LS	116.4308	120.5150	136.6300	98.7100	13.3644

Based on Table 1, this study's dependent variable is the price of main staple food commodities, including rice, cooking oil, and chicken eggs. The first independent variable is the price of raw materials, which includes the milled-dry grain price for rice, the palm fresh-fruit marks price for cooking oil, and the dry-shelled corn price for chicken eggs. The second independent variable is rainfall. The third independent variable, representing the price index received by farmers, includes the food crops sub-sector price index for rice, the plantation sub-sector price index for cooking oil, and the livestock sub-sector price index for chicken eggs.

2.2. Autoregressive Distributed Lag (ARDL)

Table 2 illustrates that the average value of the three price indexes received by farmers exceeds 100, indicating that the price index obtained by farmers is lower than the price index they pay. Nevertheless, the standard deviation values deviate significantly from zero, indicating a high level of volatility in the index numbers throughout the study period. The data pertaining to main staple food commodities, raw material prices, and rainfall utilized in this research are represented in the form of natural logarithms.

The purpose of the ARDL approach is to examine the impact of the independent variable on the dependent variable in both the short-term and long-term. One of the advantages of using the ARDL method, as opposed to other methods, is its unbiased nature and applicability to studies with limited observations. Additionally, the ARDL method allows for simultaneous estimation of short-term and long-term effects, while also addressing any violations of the autocorrelation assumption.

To measure the relationship between main staple food commodities prices and the main explanatory variables, this paper describes main staple food commodities prices as a function of raw material prices, rainfall, and price index received by farmers. Therefore, the main staple food commodities function can be presented as:

$$MSF_t = f(RM_t, RF_t, PI_t) \tag{1}$$

where MSF is the main staple food commodities prices, RM is the raw material prices, RF is the rainfall, and PI is the price index received by farmers.

Furthermore, the econometric ARDL model representing the relationship is given in equations 2, 3, and 4.

$$LnRC_t = \beta_0 + \beta_1 LnMDG_t + \dots + \beta_q LnMDG_{t-q} + \beta_2 LnRF_t + \dots + \beta_q LnRF_{t-q} + \beta_3 FC_t + \dots + \beta_q FC_{t-q} + \epsilon_t \tag{2}$$

$$LnCO_t = \beta_0 + \beta_1 LnPFM_t + \dots + \beta_q LnPFM_{t-q} + \beta_2 LnRF_t + \dots + \beta_q LnRF_{t-q} + \beta_3 PT_t + \dots + \beta_q PT_{t-q} + \epsilon_t \tag{3}$$

$$LnCE_t = \beta_0 + \beta_1 LnDSC_t + \dots + \beta_q LnDSC_{t-q} + \beta_2 LnRF_t + \dots + \beta_q LnRF_{t-q} + \beta_3 LS_t + \dots + \beta_q LS_{t-q} + \epsilon_t \tag{4}$$

where β_0 is an intercept, β_1 , β_2 , and β_3 are the coefficients, ϵ represents the error term.

3. Results and Discussion

The stationarity test was conducted prior to estimating the ARDL model using the unit root test. In this study, the Augmented Dickey-Fuller approach, also known as the ADF unit root test, was employed for the stationarity test. For the ARDL approach to be applicable, all variables in the data needed to be stationary at first difference.

The results of the stationarity test at Table 3 indicated that the variables of rice price, milled-dry grain price, and rainfall were already stationary at the level. Subsequently, the variables of cooking oil price, chicken egg price, palm fresh-fruit marks price, dry-shelled corn price, food crops sub-sector price index, plantation sub-sector price index, and livestock sub-sector price index were retested at first difference, and all variables were found to be stationary. These findings confirm the feasibility of estimating the determinants of price fluctuations in main staple food commodities using the ARDL approach.

Then, a cointegration test is necessary to determine whether the formed model exhibits a short to long-term equilibrium, using the Johansen cointegration approach.

Table 3. Unit root test.

Variable	ADF	
	I(0)	I(1)
LnRC	0.0343**	-
LnCO	0.7496	0.0000*
LnCE	0.7223	0.0000*
LnMDG	0.0002*	-
LnPFM	0.2076	0.0000*
LnDSC	0.7320	0.0000*
LnRF	0.0000*	-
FC	0.6567	0.0000*
PT	0.4647	0.0000*
LS	0.7035	0.0000*

Note: I(0) & I(1) stands for order of integration at level & on first difference; Significant *(1%), **(5%), and ***(10%)

Table 4. Johansen cointegration test.

ARDL Model	Trace Statistic	Critical Value	Prob.
LnRC	65.3702	47.8561	0.0005
LnCO	51.5337	47.8561	0.0217
LnCE	53.8755	47.8561	0.0122

Note: Significant *(1%), **(5%), and ***(10%)

The results of the test in Table 4 indicate that the trace statistic value for all three models exceeds the critical value, and the probability value for each model is below 0.05. These findings indicate the presence of a cointegration condition, leading to the conclusion that the three models exhibit cointegration between short and long-term equilibrium.

The next phase involves conducting a stability test for the ARDL model using the CUSUM test, which aims to observe changes in the average variables of the econometric model. The criterion states that the ARDL model is considered stable if the CUSUM line falls within or between the significant lines. Figures 1a, 1b, and 1c present the results of the CUSUM test for all three ARDL models, indicating that the models are in a stable state. This is evidenced by the CUSUM line (blue color) remaining within or between the 5 percent significant lines (red color).

3.1. Results of short-term ARDL estimation

The results presented in Table 5 reveal that the CointEq value for all three models of main staple food commodities is statistically significant at a 5% test level. Moreover, the negative value of the CointEq suggests the presence of short-term cointegration in the models. Therefore, the estimation results obtained through the ARDL approach can be interpreted in the context of the short-term dynamics of the variables.

The results of the RC model's estimation showed that two independent variables, namely the price of dry milled

grain and rainfall, had a notable impact on the price of rice. Conversely, the price index of the food crops sub-sector did not demonstrate a significant short-term effect on rice prices. More specifically, the price of dry milled grain two and four months prior had a significant positive effect on the price of rice, while the price of dry milled grain three months earlier had a significant negative effect. Likewise, the amount of rainfall one month prior had a significant positive effect, whereas the rainfall four months earlier had a significant negative effect on the price of rice.

As proven in previous research, raw materials play a crucial role in rice production, and changes in their prices can have a significant impact on the overall cost of rice since the prices of these agricultural inputs directly affect the production cost of rice. Furthermore, adequate sunlight and sufficient rainfall are essential for healthy crop development. Adverse weather conditions such as drought, floods, or extreme temperatures can damage or destroy rice crops, leading to lower yields. Reduced crop yields can result in a decrease in the overall rice supply, which can push prices higher due to limited availability [3].

Maintaining stability in rice prices can yield significant macroeconomic advantages, especially in low-income nations where rice is a fundamental staple food. This stability can foster a conducive environment for private investment and facilitate steady economic growth. In Indonesia, Bulog carefully monitors the fluctuations in rice prices and harvest forecasts, focusing on specific regions where issues are expected to emerge. When it becomes apparent that a crisis may arise due to fluctuating raw material prices and unpredictable weather conditions, a team is deployed to that particular area to initiate purchasing operations [14].

Subsequent to that, the estimation outcomes from the CO model offer proof that all chosen independent variables had a noteworthy impact on short-term cooking oil prices. Specifically, the variable representing the current period's price of palm fresh-fruit marks exhibited a significant positive effect, whereas the price of palm fresh-fruit marks from one month earlier was found to have a significant negative impact on cooking oil prices. Similarly, the variable representing rainfall seven months prior demonstrated a significant positive influence on cooking oil prices. Additionally, the plantation sub-sector price index during the current period was observed to have a significant positive effect on cooking oil prices.

According to a previous study, it has been found that the prices of raw materials for cooking oil play the most significant role in determining the fluctuations in

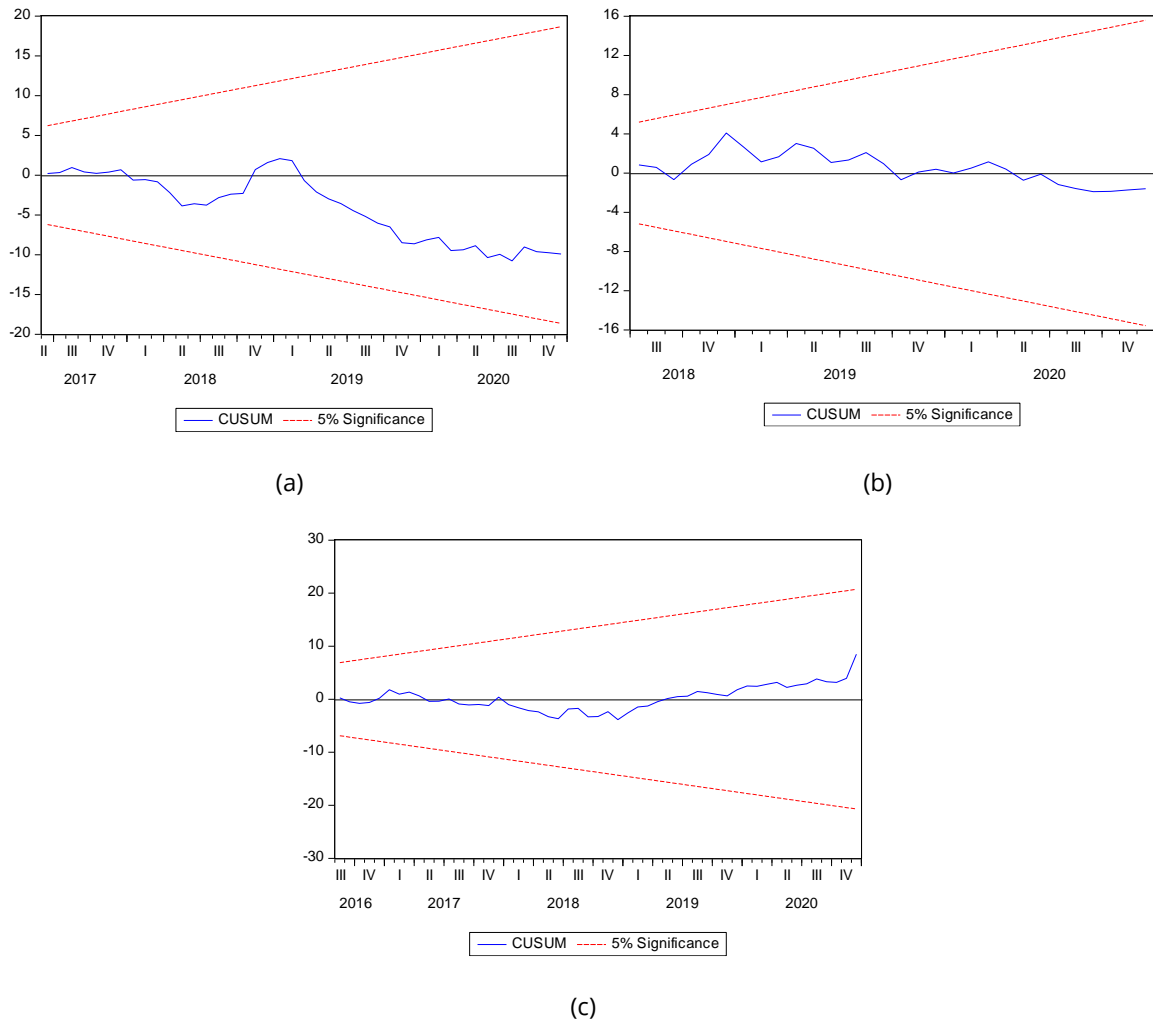


Figure 1. Stability test results of (a) RC model; (b) CO model; (c) CE model.

Table 5. Results of short-term ARDL estimation.

Independent Variabel	LnRC Model	LnCO Model	LnCE Model
LnRC _{t-1}	0.7264*		
LnMDG _{t-2}	0.1145**		
LnMDG _{t-3}	-0.1131**		
LnMDG _{t-4}	0.1104*		
LnRF _{t-1}	0.2195**		
LnRF _{t-4}	-0.3553*		
FC _t	0.5866		
CointEq(-1)	-0.2736*		
LnCO _{t-1}		0.8134*	
LnPFM _t		1.4584*	
LnPFM _{t-1}		-0.1298*	
LnRF _{t-7}		0.5057**	
PT _t		21.6697*	
CointEq(-1)		-0.1189*	
LnCE _{t-1}			0.7503*
LnDSC _t			0.6297**
LnRF _t			0.3486
LS _{t-1}			37.0199***
CointEq(-1)			-0.2497**

Significant: *1%, **5%, ***10%

domestic cooking oil prices in Indonesia [11]. Price fluctuations in cooking oil can be influenced by various factors, including adverse weather conditions that hinder production and contribute to price hikes. Additionally, government policies, such as establishing price limits for farmers and allocating a portion of crude palm oil for the biodiesel industry, can impact production and supply, thereby causing fluctuations in prices [18].

Lastly, the CE model reveals that two independent variables, namely the price of dry-shelled corn and the price index of the livestock sub-sector, have a notable short-term impact on chicken egg prices. Conversely, rainfall is determined to have no significant effect on the price of chicken eggs. The variable representing the current period's price of dry-shelled corn is found to have a significant positive effect on chicken egg prices. Similarly, the variable representing the price index of the livestock sub-sector one month prior is also determined to have a significant positive effect on chicken egg prices.

Research conducted in the Pemakasan district of Madura, Indonesia, reveals that the primary factor influencing the

Table 6. Results of long-term ARDL estimation.

Independent Variabel	LnRC Model	LnCO Model	LnCE Model
LnMDG	0.3435		
LnRF	0.5340		
FC	2.1438		
LnPFM		0.8139	
LnRF		6.4977	
PT		182.3240*	
LnDSC			2.5217**
LnRF			1.3961
LS			91.6741

Significant: *1%, **5%, ***10%

fluctuation of chicken egg prices is the cost of raw materials used in animal feed [19]. Furthermore, a study conducted in the Biringkanaya district of Makassar, Indonesia, offers empirical proof of the correlation between the demand and price of chicken eggs. These prices are prone to fluctuations during customary periods in Indonesia, such as religious and annual holiday celebrations [20].

3.2. Results of long-term ARDL estimation

In the long-term findings of the ARDL estimation as shown at Tabel 6, it was discovered that among the determinant of main staple food commodities, only the variable representing the price index of the plantation sub-sector had a significant impact on cooking oil prices. Similarly, only the variable representing the price of dry-shelled corn had a significant effect on chicken egg prices. However, no independent variables were identified to have a significant impact on rice prices.

The long-term analysis revealed that the variable representing the price index of the plantation sub-sector had a notable impact on cooking oil prices, whereas the variables of palm fresh-fruit marks price and rainfall were found to be insignificant factors. On the other hand, when examining the CE model, it was determined that only the variable representing the price of dry-shelled corn had a significant effect on chicken egg prices in the long term. In contrast, the variables of rainfall and livestock sub-sector price index did not demonstrate a significant impact on chicken egg prices.

Based on empirical evidence from previous studies, it is widely observed that price fluctuations in staple food commodities in the long-term can be attributed to a range of factors, both economic and non-economic, with changes in the supply and demand for these commodities being the primary drivers [6, 21–23]. Factors such as population growth, changes in dietary preferences, and shifts in consumption patterns can lead to alterations in demand. Meanwhile, variations in

weather patterns, natural disaster, pandemic, or changes in agricultural practices including price index received by farmers can affect the supply side of these commodities [3, 13, 24].

4. Conclusions and Recommendations

The analysis of various models and studies provides valuable insights into the factors influencing price fluctuations in staple food commodities, particularly rice, cooking oil, and chicken eggs. The results indicate that variables such as the price of raw materials, weather conditions, and government policies play significant roles in determining price movements.

The price of dry milled grain and rainfall are found to be significant factors affecting short-term rice price fluctuations. Additionally, the stability of rice prices can have macroeconomic benefits, especially in low-income countries, by promoting private investment and sustained economic growth.

In the case of cooking oil, the prices of raw material palm fresh-fruit marks, weather conditions, and the price index received by farmers in the plantation sub-sector have a significant impact on short-term price fluctuations. Government policies, such as price limits and the allocation of crude palm oil for biodiesel, also influence production and supply dynamics, leading to price fluctuations.

Regarding chicken eggs, the price of dry-shelled corn and the price index of the livestock sub-sector are found to be influential factors in short-term price fluctuations. Similar to cooking oil, the demand for chicken eggs tends to fluctuate during customary periods, such as religious and annual holidays, reflecting the impact of cultural and seasonal factors.

In the case of long-term, it was discovered that among the determinants of main staple food commodities, the price index of the plantation sub-sector had a significant impact on cooking oil prices, and the price of dry-shelled corn had a significant effect on chicken egg prices. However, no specific determinant factors were identified to have a significant impact on rice prices.

Based on the findings and understanding of the factors influencing price fluctuations in staple food commodities, our policy recommendations include: 1) Mitigate price fluctuations in main staple food commodities by achieved through investments in research and development, adoption of advanced farming techniques, and provision of necessary resources to farmers; 2) Given the significant impact of weather conditions on staple food commodity prices, it is essential to strengthen weather

monitoring systems and disaster preparedness measures; and 3) Enhancing market transparency through timely dissemination of accurate information on supply and demand, and this can help reduce market uncertainties and minimize speculative behavior that contributes to price volatility. Overall, understanding the drivers of price fluctuations in staple food commodities is crucial for policymakers and market participants to develop effective strategies to stabilize prices, ensure food security, and promote sustainable regional economic development.

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