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Seasonal Variation In Rice Price Transmission In Indonesia

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ABSTRACT

Rice is a strategic commodity serving as the staple food in Indonesia. Price transmission in the rice supply chain is critical for market efficiency and food security, yet existing studies often overlook seasonal variations and nonlinearity. This study aims to analyze seasonal variations in rice price transmission across producer, wholesaler, and traditional market levels in Indonesia during different seasons (February-May, June-September, October-January). The study employs monthly time-series data on medium rice prices from February 2020 to February 2025. The Nonlinear Autoregressive Distributed Lag model is used to capture short and long-run price transmission. Stationarity, cointegration, and Wald tests are conducted to validate the model. The findings reveal significant asymmetric price transmission during February-May and June-September, with farmers more vulnerable to price declines. Meanwhile, wholesalers and traditional markets responding faster to price increases. The October-January period shows stagnant dynamics due to low market activity. Long-run asymmetry is prevalent, indicating persistent market inefficiencies. Seasonal variations significantly influence rice price transmission in Indonesia, highlighting the need for season-based policy interventions to stabilize prices and protect farmers. Enhancing farmers' bargaining power and implementing technology-driven price monitoring systems are recommended to mitigate asymmetry and improve market efficiency.

Keywords: *Asymmetry, NARDL model, price transmission, rice, seasonal variation*

BACKGROUND

Rice is a strategic commodity in Indonesia. The reason for this is because rice is the staple food of the people. According to data from the National Food Agency, Indonesia's per capita rice consumption in 2023 reached 81.23 kilograms/capita/year, making Indonesia the country with the third highest rice consumption in the world (Ahdiat, 2024; Rahim et al., 2024). Due to the high level of household consumption, rice has become an inflation-driving food (Fahrezi et al., 2024; Habibah et al., 2024; Nurul et al., 2024). In addition, the government is also paying extra attention to the vulnerability of rice prices and supply given its impact on economic and social stability (Dwi Ariyanti et al., 2024). External factors such as climate change and trade policies also need the government's attention, especially mitigating their impact on rice commodities.

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One aspect of vulnerability that needs attention is price transmission. Rice prices have a transmission in each supply chain from farmers (producer prices), middlemen/wholesalers (wholesale prices), traditional/modern markets (retail prices), to consumers (Asrin et al., 2022). The price variable is vital to monitor as it is an indicator of market efficiency and food security in terms of affordability. The government also needs to ensure that there are no cases of price asymmetry that make certain actors benefit the most in the distribution process (Setyawati et al., 2023). The phenomenon of price asymmetry itself refers to the imbalance of price responses between markets when supply or demand shocks occur, which indicates the inefficiency of the supply chain (S. K. Nasution & Rahmanta, 2022).

Several researchers have looked at the price transmission of agricultural commodities in Indonesia. Santoso et al., (2025) used Vector Autoregressive (VAR) analysis and found that there is a transmission of premium rice prices from producer to consumer level in Indonesia in the post-Covid-19 era. Kusumaningsih, (2024) using the Error Correcttion Model (ECM) method found that there was rice price asymmetry at the farmer and consumer levels before and during the COVID-19 pandemic in Indonesia. Mariyah et al., (2025) using price transmission elasticity analysis found that rice prices have not been transmitted efficiently from producers to consumers in East Kalimantan Province. Existing research has successfully captured the transmission phenomenon but still uses methods that ignore non-linearity aspects. Non-linearity includes the effects of government policies (reference price or market operations). In addition, studies that include seasonal variables are still rare.

Both aspects, if ignored, can result in policies that are not timely and targeted. Moreover, ignoring the seasonality aspect also has the potential to distort the market if the price response is asymmetric between surplus and deficit seasons. The Nonlinear Auto-Regressive Differentiated Lag (NARDL) method, a development of ARDL, has the advantage of capturing such nonlinearity (Shin et al., 2014). This method is able to capture the asymmetry of rice price response over time. In addition, NARDL is also able to provide short-term and long-term models for each season. To date, most of NARDL's studies in agriculture have been conducted abroad (Akber & Paltasingh, 2019; Fiaz et al., 2021; Panagiotou, 2021; Sharma et al., 2025; Zafar et al., 2023). In fact, the agricultural sector in Indonesia has unique dynamics (protectionist policies, import dependency, seasonal diversity).

The novelty of this study is to integrate seasonal variations into the NARDL model. This study also provides a more detailed model that captures price transmission in different seasons, according to the condition of rice stocks and policies that apply in a particular season. This method is still not widely applied to rice price studies, even though theoretically seasonality significantly affects the nonlinearity of the market.

The results of this study are expected to form the basis of a more specific (season-based) price stabilization policy. In addition, the results of this study can also increase stakeholders' awareness of rice price volatility during certain seasons. Therefore, this study aims to identify rice price transmission patterns at the producer, wholesaler, and traditional market levels during the February-May, June-September, October-January, and year-round seasons. It also aims to identify whether or not there is asymmetry in the price response to positive/negative shocks in a particular season).

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RESEARCH METHODS

The data used in this study is time series data in the form of medium rice prices at the producer, wholesaler, and traditional market levels with a time span from February 2020 to January 2025 which is source from Food Price Information Center (PIHPS). This study specifically uses medium II rice because it is the most common category consumed by the majority of Indonesians, especially lower-middle class households. In addition, medium II rice is one of the staple commodities that is most sensitive to price changes and market policies, making it important to analyze in the context of price transmission between distribution chain actors.

The method used to analyze the data is the Nonlinear Autoregressive Distributed Lag (NARDL) model. The model was used for several main reasons. First, the data used is non-stationary so a method capable of handling data of this nature is necessary. Secondly, the level of data non-stationarity is not always at the same order. Third, the relationship between the variables in this study is non-linear so that linear methods cannot fully capture the complex dynamics of the relationship. Therefore, to obtain more comprehensive results, this study applies the NARDL model developed by Shin et al., (2014) as an extension of the ARDL linear cointegration model. The main advantage of this model is its ability to capture Asymmetric Price Transmission, both in magnitude and speed of price transmission, thus providing a deeper understanding of the relationship between the variables studied.

Stationarity Test

To test for data stationarity, a unit root test can be performed on each variable. This unit root test can be done using the Augmented-Dickey Fuller (ADF) test. If the data is declared non-stationary at the previous level, testing will be carried out at the first difference level. If the t-statistic value is greater than the Mackinnon critical value, the data can be said to be stationary. The Unit Root Test uses the ADF test with the following decision making:

a. If ADFstatistic > ADFcritical, then reject H0, meaning that the data does not contain unit roots which means that the data is stationary.
b. If ADFstatistic ≤ ADFcritical, then fail to reject H0, meaning that the data contains unit roots which means that the data is not stationary

Determination of Optimal Lag

A common problem that often arises in the analysis of time series data is the determination of the optimal lag. Determining the optimal lag is very important in time series data analysis, because economic policies usually do not have an immediate impact on economic activity in the same period, but require time for the impact to be seen and felt. In this study, the Akaike Information Criterion (AIC) method was used to determine the optimal lag.

Cointegration Test

The long-run relationship between variables in ARDL modelling can be determined using the Bound test approach cointegration test developed by Pesaran et al., (2001). The test is conducted based on the F statistical test. There are two critical F values, namely the lower bound or I(0) and the upper

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bound or I(1). If the calculated F value is greater than the upper bound value then there is cointegration and if the value is smaller than the lower bound then there is no cointegration. However, if the calculated F value is between the lower bound and upper bound values then there is no decision.

Model Estimation

The model in NARDL allows for the estimation of price transmission that occurs in speed and magnitude adjustments. The formulation of the NARDL model in this study is based on Shin et al., (2014), so the NARDL model is formulated as follows:

$$\Delta Y_t = \rho Y_{t-1} + \theta^+ \Delta X^+{}_{t-1} + \theta^- \Delta X^-{}_{t-1} + \theta^+ \Delta X_{t-1}{}^+{}_{t-1} + \theta^- \Delta X_{t-1}{}^-{}_{t-1} + \sum_{j=1}^{p-1} \gamma \Delta Y_{t-j} + \sum_{j=0}^{q-1} (\varphi^+ \Delta X^+_{t-j} + \varphi^- \Delta X^-_{t-j}) + \varepsilon_t$$
$$= \rho \xi_{t-1} + \sum_{j=1}^{p-1} \gamma \Delta Y_{t-j} + \sum_{j=0}^{q-1} (\varphi \Delta X^+_{t-j} + \varphi \Delta X^-_{t-j}) + \varepsilon_t$$

Where, $\rho \xi_{t-1} = y_t + \beta^+ X_t^+ + \beta^- X_t^-, \ \beta^+ = \theta^+/\rho \ dan \ \beta^- = \theta^-/\rho$

Description:
ΔY_{t-j} : Price changes at the follower market level
ΔX^+_{t-j} : Positive changes in prices at the benchmark market level
ΔX^-_{t-j} : Negative price changes at the benchmark market level
ξ_{t-1} : *nonlinear error correction term*

Wald Test

The Wald test is used to ascertain whether the coefficients of the variables being analyzed are identical or not. The results of this test will show whether in the short run and long run, they are similar in the dynamic asymmetric model. The hypothesis used in the long-term Wald test is as follows:

$H0: \beta^+ = \beta^-$ (symmetric)
$H1: \beta^+ \neq \beta^-$(asymmetric)

Where: $\beta^+ = -\frac{\theta^+}{\rho}$ dan $\beta^- = -\frac{\theta^-}{\rho}$ is the long-run asymmetric parameter, while the hypothesis used in the short-run Wald test is as follows:

$H0: \sum_i^q \varphi^+ = \sum_i^q \varphi^-$ (symmetric)
$H1: \sum_i^q \varphi^+ \neq \sum_i^q \varphi^-$ (asymmetric)

A variable is said to have an asymmetric effect if the Wald test results show rejection of the null hypothesis. The null hypothesis is considered rejected if the p-value of the F-statistic is smaller than the specified significance level. This indicates that the independent variable has an asymmetric effect on the dependent variable.

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Model Stability Test
The model stability test is conducted by comparing the Cumulative Sum of Recursive Residual (CUSUM). This test is included in the stability diagnostic test. The CUSUM test is used to evaluate the stability of variables in the model (Pesaran et al., 2001). The model is considered stable if the CUSUM line remains within the 5% significance limit. However, if the line exceeds the 5% significance limit, the model is declared unstable

RESULT AND DISCUSSION

Stationarity Test
Testing the stationarity of producer, wholesaler, and traditional market prices at the level shows a high p-value, indicating that the data has an average and variance that is inconstant throughout the time period observed at that level. Therefore, further testing at the first difference level is required to assess the stationary nature of the time series data used. The results of stationarity testing at the first difference level show a p-value of 0.000, which is lower than the 1% significance limit. This finding indicates that the price data at the producer, wholesaler, and traditional market levels are significant and stationary at the first difference level.

Table 1. Stationarity Test Result

Variable	Level		First Difference	
	Prob	Description	Prob	Description
Producer Price (PP)	0.853	Non-stationary	0.000*	Stationary
Wholesaler Price (WP)	0.945	Non-stationary	0.000*	Stationary
Traditional Market Prices (TP)	0.758	Non-stationary	0.000*	Stationary

Cointegration Test
The table of cointegration test results using the bound test approach shows that there are several price relationships between rice commodity distribution levels that do not meet the cointegration requirements. This is reflected in the F-statistic values that are lower than the critical lower bound (I(0) = 3.100), which indicates the absence of a long-run relationship between the tested variables. Some of the relationships that are not cointegrated include: the relationship between farmer prices and wholesaler prices (PP → WP) in February-May and October-January; farmer prices and traditional market prices (PP → TP) in February-May; and the relationship between traditional market prices and farmer prices (TP → PP) and wholesalers (TP → WP) in October-January. Therefore, these relationships are excluded from further analysis of asymmetric price transmission.

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Table 2. Cointegration Test Result

Relation	I(0)	I(1)	FEB -MAY	JUN - SEP	OCT -JAN
PP – WP	3.100	3.870	2.887	6.889	0.805
WP – PP	3.100	3.870	5.871	8.587	3.040
PP – TP	3.100	3.870	2.195	41.917	21.519
TP – PP	3.100	3.870	7.290	22.299	0.956
WP – TP	3.100	3.870	10.603	11.848	23.096
TP – WP	3.100	3.870	13.951	8.357	1.494

Based on the estimation results of the NARDL model, there are indications of positive and negative shocks reflected through the long-term parameters β^+ and β-. These results indicate that the rice price transmission mechanism in the domestic market is asymmetric in the long-term, especially in the relationship between market levels: farmers, wholesalers, and traditional markets. However, this asymmetry phenomenon is not observed during the October to January period. The different responses to positive and negative shocks suggest that the two types of price changes need to be considered separately in the model, as each impacts differently on prices at the next market level. This finding provides evidence that price dynamics at one market level, such as wholesalers or traditional markets, can have an unequal effect on price increases and decreases at the farm level, and vice versa. Therefore, this phenomenon reflects the existence of asymmetric price transmission with different magnitude adjustment patterns between distribution levels in the rice marketing system in Indonesia.

Table 3. NARDL Estimation Result

Period	Relation	ΔX^+	ΔX^-	ΔX_{t-1}^+	ΔX_{t-1}^-	β^+	β^-	Wald SR	Wald LR
FEB–MAY	WP→PP	1.085*	0.533*	-0.077	0.406*	1.185*	1.539*	0.779	0.002
	WP→TP	0.869*	0.306*	0.279*	0.420*	0.863*	0.788*	0.058	0.025
	TP→WP	0.846*	0.069*	-0.039	0.272*	1.124*	1.153*	0.000	0.124
	TP→PP	1.005*	0.024	-0.125*	0.498*	1.310*	1.544*	0.002	0.001
JUN–SEP	PP→WP	0.455*	0.163*			1.017*	0.774*	0.000	0.000
	WP→PP	0.817*	1.219*	0.169*	0.196*	0.976*	1.501*	0.358	0.000
	WP→TP	0.784*	0.387*			0.832*	0.616*	0.138	0.000
	TP→WP	0.916*	-0.165*	-0.002*	0.465*	1.190*	1.228*	0.000	0.000
	PP→TP	0.420*	0.159			0.857*	0.611*	0.005	0.000
	TP→PP	0.867*	-0.142	-0.036	0.529*	1.151*	1.287*	0.000	0.003
OCT–JAN	PP→TP	0.131	0.649			1.101	0.652	0.750	0.288
	WP→TP	-0.078	0.957	-0.867	-7.851*	1.212	1.092	0.186	0.664

February-May Period

The estimation results of the NARDL model in the February-May period show that the price at the wholesale level affects the price at the farm level both during price increases and price

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decreases. This suggests that farmers respond to both increases and decreases in prices at the wholesale level. Meanwhile, in the long run, both parameters β^+ and β- are significant and show a positive sign. Thus, it can be concluded that there is price transmission asymmetry in the long run and the impact of price changes from wholesale traders on farmers' prices will not return to the initial equilibrium. This result is in line with the research of Kusumah et al., (2018) which states that if there is a price increase at the consumer level, traders do not pass on the price increase to farmers perfectly, in other words, the price increase received by farmers is lower than the price increase at the retailer level.

Prices at wholesalers influence prices in wet markets, with both current and past price increases and decreases showing significance. This indicates that traditional markets respond quickly and significantly to price changes from large traders. In the long run, an asymmetric price transmission pattern is found, with traditional markets responding faster to price increases than to price decreases.

Prices at the traditional market level influence prices at the wholesale level both during price increases and price decreases. In accordance with Surbakti et al., (2022), changes in red chili pepper prices at the consumer level follow price changes at the wholesale level. However, large traders do not respond to price increases at the traditional market level in the previous period. This indicates imperfect price transmission in the short term, especially to price increase signals. This strategy reflects the tendency of wholesalers to postpone purchase price adjustments to maintain profit margins, as well as the imbalance of market power in the distribution chain. However, in the long run, the values of β^+ and β- are significant, but the Wald test results show that this relationship is not asymmetric in the long run, and price changes tend to correct back to equilibrium.

In the traditional market-to-farmer relationship, only the price decline is not significant. This suggests that farmers respond to price increases in traditional markets with faster price adjustments than when there are price decreases. Meanwhile, in the long run, both β^+ and β- are significant and the Wald test indicates a strong long-run asymmetry. This means that farmers' prices are more sensitive to changes in traditional market prices, especially under downward pressure, and these changes are not automatically corrected to equilibrium in the long run. In contrast, Novianti et al., (2020) concluded that the increase or decrease in rice prices at the consumer level has no effect on rice prices at the producer level and vice versa.

Overall, in the Feb-May period, the majority of price relationships show long-run asymmetry, especially in the WP → PP, WP → TP, and TP → PP relationships. This indicates that the market structure is not yet efficient in conveying price signals in a balanced manner. Hutami (2018) states that price asymmetry is a result of uncompetitive market competition. In agricultural commodities, the market structure formed in intermediary traders leads to an imperfect competitive market structure compared to the farmer and consumer levels.

Omrani et al., (2016) revealed that during the harvest period, price increases at the producer level are transmitted to the retail level at a higher rate than price decreases. This indicates that during the harvest season, despite abundant supply, producers or marketers are able to maintain market

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power and push prices upward faster when there is a signal of producer price increases, but are resistant to price decreases. In rice commodities, farmers face a high level of competition especially during the harvest season. The abundant supply of rice leads to a weak bargaining position for farmers in determining selling prices. In contrast, companies as sole agents and fewer intermediary traders have more power to influence market prices. These companies or intermediary traders have the potential to form cartels through price agreements. In addition, the seasonal nature of rice production limits farmers' ability to increase the volume of crops when there is an increase in market prices (Novianti et al., 2020).

June-September Period

In the June-September period, when farm-gate prices affect wholesale prices, both increasing and decreasing price shocks show significant effects. In contrast to the findings of Artika et al., (2019), who observed that price transmission from wholesalers to producers only occurs when prices decrease. Meanwhile, Fitria et al., 2020) reported that price transmission only occurs when prices increase. The short-term and long-term Wald test indicate that there is price asymmetry in both the short and long term. This means that when farmer prices rise or fall, wholesalers respond in different directions and at different speeds. Thus, changes in farmer prices not only have a direct, but also an unbalanced impact on wholesaler prices.

When the price at the wholesaler level affects the price at the farm level, the results show that the price increase and price decrease are significant. The short-run variables ΔX_{t-1}^{+} and ΔX_{t-1}- are also significant, indicating that farmers respond to price changes from wholesalers directly in the previous period. The short-run Wald test value of 0.358 and long-run value of 0.000 indicate that although there is long-run asymmetry, the short-run response tends to be symmetric. The implication is that farmers respond to price changes directly, but with different effects between price increases and decreases in the long run. In line with Destiarni et al., (2021) found that every 1 % change in shallot prices at the wholesale level will reduce shallot prices at the farm level by 0.146 %.

In the relationship between wholesalers and traditional markets, all short-term variables show statistical significance. Both shocks to price increases and decreases, as well as the effect of price increases and decreases in the previous period, proved to be significant in influencing price dynamics in wet markets. The long-term coefficients β^{+} and β- are 0.832 and 0.616, respectively, and the Wald test results show values of 0.138 for the short run and 0.000 for the long run. Thus, it can be concluded that there is asymmetric pricing in the long run, but in the short run the price response between the two markets is relatively balanced. The same thing was found in the research of Harshana & Ratnasiri (2023); Nasution & Rahmanta (2022), which found that there is a long-term asymmetric relationship of vegetables and fruits from the wholesale level to the retail level.

Meanwhile, when the price in traditional markets affects the price of wholesalers, both ΔX^{+} and ΔX- show significant effects. ΔX_{t-1}^{+} is insignificant, but ΔX_{t-1}- is 0.465 and significant, indicating that large traders are more sensitive to a decrease in traditional market prices than to an increase in prices. The significant values of β^{+} and β- and the short-term and long-term Wald test confirm that there is overall asymmetric price transmission. This implies that price changes in traditional markets

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affect wholesale prices in different directions and strengths, and the effects are unbalanced, both in the short and long term. In line with Artika et al., (2019), who found that retail prices are not transmitted to wholesale prices either during price decreases or increases.

In the farmer-to-traditional market relationship, price increase shocks are significant, while price decreases are not. This suggests that traditional markets respond more strongly to price increases from farmers than price decreases. The same result was also found by Fitria et al., (2020) which revealed that an increase in potato prices at the farm level influenced the increase in potato prices at the retailer level and was transmitted faster than a decrease in prices at the farm level.

In the long run, the Wald test indicating that there is long-term asymmetric price transmission. Meanwhile, in the traditional market-to-farmer relationship, price increase shocks and previous price decrease adjustments show significant effects. In contrast, price decreases and previous price increases are insignificant, indicating that farmers are more sensitive to current price increases and previous price decreases in traditional markets. Similar to the research results of Ayomi et al., (2020) where price increases at the consumer level are not passed on to farmers, this is certainly detrimental to farmers because price increases cannot be enjoyed by farmers in obtaining farming profits. The Wald test value confirms that price transmission from traditional markets to farmers is asymmetric across the board, both in the short and long term.

This is the period with the highest asymmetry intensity, both in the short and long term. Almost all relationships between market levels show significant coefficients and Wald test results that support the existence of asymmetry. This suggests that price transmission in this period is disproportionate, with market participants reacting differently to price increases and decreases. A strong response to a particular direction (e.g. falling prices) becomes a recurring pattern.

October-January Period

The October-January period shows a different phenomenon compared to the other two periods. In the relationship between farmers and traditional markets, neither the increase nor decrease in prices is significant. The Wald test results also show that there is no asymmetric price transmission, either in the short or long term. This means that price changes from farmers were not significantly responded to by traditional markets during this period, and there was no difference in the direction or magnitude of the response. Similarly, the relationship of wholesalers to wet markets shows that both increases and decreases in prices are insignificant, but significant when prices decrease in the previous period. The short and long-term Wald test values also confirm that there is no price asymmetry in this relationship. Thus, during the October-January period, price changes from large traders did not trigger a significant response in traditional markets, either for price increases or decreases. In line with Asrin et al., (2022) there is no relationship between producer and consumer rice prices during the Covid-19 pandemic, indicating that there is no price transmission between the two.

During this period, all price relationships show no significant price transmission, either in the short or long-term. The model coefficients are mostly insignificant and the Wald test value also shows no asymmetry. This is because this period is the early phase of the planting season, where rice buying and selling activities at the producer level are still low, supplies have not entered the distribution

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chain on a massive scale, and the market tends to be passive in responding to price signals. In addition, the role of speculators or wholesale traders in determining prices also tends to be minimal because they have not made large purchases, so market pressure on retail prices in traditional markets has not been established. This situation reflects stagnant market conditions, with low price elasticity, so that price fluctuations at the producer or wholesaler level are not immediately transmitted to the consumer level. In contrast, (Omrani et al., 2016) found price asymmetry with producer price increases transmitted more slowly and with smaller coefficients. During the normal season (limited supply), producers have less control over prices. However, the increase in price transmission tendency remains larger than the decrease, indicating a persistent asymmetry.

CONCLUSION AND SUGGESTION

Seasonality is an important aspect that needs to be taken into account in identifying rice price transmission in Indonesia. This study identifies different price responses to positive and negative shocks across market levels (producers, wholesalers, and wet markets) especially in the February-May and June-September periods. This asymmetry indicates market inefficiencies, where farmers tend to be more vulnerable to price declines, while wholesalers and wet markets respond more quickly to price increases. The October-January period shows more stagnant dynamics due to the early phase of the planting season and low market activity. This finding suggests the importance of considering seasonal variations in price transmission analysis.

The suggestion from this study is that government intervention through season-based policies is needed to overcome the imbalance of market power and protect farmers' interests. Furthermore, the government also needs to establish and foster farmers' marketing institutions to reduce dependence on intermediary traders and thus increase farmers' bargaining power. Then, the government also needs to create a technology-based price monitoring system to detect price asymmetries early so as to facilitate faster policy responses or market interventions. Future research can be conducted by increasing the coverage of other agricultural commodities. In addition, downscaling the region to a more specific level can also help capture price dynamics that occur at the regional level.

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