# Market integration and rice price transmission in Indonesia

*Lidya R.* Shaffitri[1*], *Esty A.* Suryana[1], and *Julia F.* Sinuraya[1]

[1]Indonesian Center for Agricultural Socio-Economic and Policy Studies, Ministry of Agriculture, Bogor, Indonesia

**Abstract.** Rice is a strategic commodity in Indonesia. Prices at the producer level fluctuate relatively due to shifts in supply and demand. These fluctuations make government intervention in stabilising rice prices important, mainly if market integration exists. This study aims to analyse market integration and rice price transmission. The Vector Error Correction Model (VECM) and descriptive analysis methods were used. The results show rice market integration in both the long and short term. Long-term integration occurs in the relationship between prices at the producer and consumer levels. Long-term integration also occurs in the connection between wholesale and retail costs. The VECM model shows that short-term price transmission occurs when consumer and producer prices in this month are significantly impacted by changes in producer prices from the previous month. However, changes at the consumer level do not affect prices at the producer level. Thus, price stabilisation efforts must be made at the producer level. This is especially necessary when grain supply disruptions cause price fluctuations due to weather factors and plant pest attacks in certain months, which cause grain prices to spike.

## 1 Introduction

The main staple food commodity for the Indonesian population is rice [1,2,3], so the maintenance of accessibility to this commodity is deemed highly important [3,4]. One indicator of product accessibility is pricing [5], including rice [6,7,8]. The government has designated rice through the Regional Inflation Control Team (TPID) as a commodity necessitating price maintenance [9]. To ensure the upholding of these prices, a monitoring system must be established, spanning from the producer level, namely farmers, to the retail trade level [10−14].

The relationship between changes in grain prices at the farm level and changes in rice prices at various trade levels has been the subject of numerous studies. Only a limited number have delved into the duration required to transmit changes in grain prices to rice prices, or vice versa. An enquiry into the velocity of price transmission was conducted by Guo and Tanaka [15], uncovering distinctions in the speed of transmitting shifts in international commodity prices for agricultural products in China. Another research effort by Chaudhary [16] focused on the scale, swiftness, and asymmetry of the rice trade at wholesale and retail

* Corresponding author: lidya.rahma1989@gmail.org

tiers in several major cities in the Philippines. This enquiry revealed that the timeframe necessary for adjustments in rice prices at the wholesale stage to be reflected in rice prices at the retail stage was approximately two months.

The availability of rice in the domestic market starts with rice producers who process farmers' grain into rice. The price of rice as of August 2023 has grown at the consumer level compared to the same period in the previous year. The cost of rice for individual consumers will increase starting at the end of 2022 [19]. Rice processors have difficulty obtaining raw materials because of the low supply from farmers. The components that form the price of rice are the price of grain, the level of operational efficiency of the RMU, and the market margin from the distribution of the market supply chain to consumers. A further description of this condition is that the grain and rice markets are different but related (seek source). It is essential to identify the focus of grain price control policies.

One reason for the uneven transmission of prices between interconnected markets within a single marketing chain is the presence of non-competitive practices among intermediary traders, particularly when they dominate their respective markets. Additionally, the inflexibility in adjusting prices across different levels of the marketing chain often arises from various supplementary expenses that businesses must bear to make price adjustments, commonly referred to as adjustment or menu costs.

Acquiring knowledge about the pace of transmitting changes in rice prices will aid stakeholders in gauging the timing of enacting policies for price stabilisation, thereby enabling the prompt mitigation of price changes existing at specific trading tiers that might adversely affect certain economic actors. Analysing market integration and rice price transmission in Indonesia is the goal of this study. Apart from that, this research also examines in more depth the relationship between price transmission and the welfare of Indonesian farmers. Consequently, in addition to supplying the most recent information about transmitting changes in grain and rice prices utilising the latest data, this study also provides valuable insights into the speed at which changes in grain prices are conveyed from the producer level to modifications in rice prices across various tiers.

## 2 Methodology

This research employed secondary data encompassing monthly time series data from January 2018 to August 2023 sourced from BPS-Statistics Indonesia. This dataset comprises three distinct categories of price data: first, data concerning the prices of harvested dry grain; second, rice prices at the wholesale trade level; and third, rice price data at the consumer level. This study employed the Vector Error Correction Model (VECM) method to examine market integration and price transmission. Conversely, it utilises the qualitative descriptive analysis method to examine the connection between farmers' welfare and price transmission. Concentrating especially on market integration and research of price transmission, the research follows the stages outlined in VECM modelling:

a. Stationarity test

   Time series data are typically characterised by non-stationarity, a characteristic that can result in spurious regression parameters. Consequently, it is essential to have stationary data to reduce errors within the model [17]. To assess stationarity, the Augmented Dickey-Fuller (ADF) unit root test is performed, and the following hypothesis is tested:

   reject H0 = if ADF statistics > ADFcritical, the time-series data exhibit the absence of a unit root, signifying its stationarity.

   accept H0 = if ADF statistics ≤ ADFcritical

   There is a unit root in the time-series data, which suggests that it is not yet stationary.

b. Optimum lag test

Selecting the optimal lag in the model is crucial to avoid issues related to autocorrelation. The determination of the optimal lag is accomplished through the Akaike Information Criterion (AIC) to identify the lag with the smallest value.

c. Cointegration test

A cointegration test was run to determine whether there was long-term integration. The Johansen cointegration test was employed for this purpose, and hypothesis testing was performed using both trace statistics and maximum eigenvalue tests. The likelihood ratio (LR) test was used to determine long-term cointegration. The LR value indicates the presence of cointegration among several variables if it exceeds the crucial threshold; however, if it falls below the threshold, cointegration is not present.

d. Granger causality test

The Granger causality test was applied to determine whether there is a bidirectional relationship between the two variables. It seeks to establish whether one variable has a causal effect on another. The Granger causality test also enables us to determine whether an exogenous or endogenous variable may be regarded in the context of the proven cause-and-effect connection.

e. VECM test

VECM analysis is used in this paper due to the fact that the data lacks stationarity at this particular level. The VECM model used in this study is as follows:

$$HP_t=\alpha_0+\sum_{i=1}^{p}\alpha_1 HP_{t-1}+\sum_{i=1}^{p}\beta_i HPB_{t-1}+\sum_{i=1}^{p}\gamma_i HK_{t-1}+\varepsilon_{1t} \quad (1)$$

$$HPB_t=\delta_0+\sum_{i=1}^{p}\delta_1 HP_{t-1}+\sum_{i=1}^{p}\sigma_i HPB_{t-1}+\sum_{i=1}^{p}\emptyset_i HK_{t-1}+\varepsilon_{1t} \quad (2)$$

$$HK_t=\theta_0+\sum_{i=1}^{p}\theta_1 HP_{t-1}+\sum_{i=1}^{p}\omega_i HPB_{t-1}+\sum_{i=1}^{p}\varphi_i HK_{t-1}+\varepsilon_{1t} \quad (3)$$

where:

$HP_t$ : the price of grain at the producer level in the t-period (IDR/kg)
$HP_{t-1}$ : lag of grain prices at the producer level in the t-th period (IDR/kg)
$HPB_t$ : the price of rice at the wholesale trading level in the t-period (IDR/kg)
$HPB_{t-1}$ : rice price lag at wholesale trade level in t-period (IDR/kg)
$HK_t$ : rice price at the consumer level in period t (IDR/kg)
$HK_{t-1}$ : lag of rice prices at the consumer level in the t-th period (IDR/kg)

# 3 Results and discussion

## 3.1. Market integration analysis and rice market price transmission

### *3.1.1 Root unit test results*

The unit root test is used to evaluate the stationarity of the data for each price variable at the producer, consumer, and wholesale trade levels. The results of the Augmented Dickey-Fuller test, which looks at the stationarity of the data, are shown in Table 1.

The outcomes of the unit root test reveal that the data for consumer and producer prices attain stationarity at the first difference, with a probability value lower than 0.05. In contrast, the producer price variable reaches stationarity at the second difference, with a probability value of 0.0000, falling below the 5% significance threshold. Achieving stationarity involves applying different levels of differencing (d=1 and d=2). Consequently, the Vector Error

Correction Model (VECM) is the most appropriate analytical method for investigating price transmission in this context.

**Table 1.** Stationarity test results of Indonesian rice price data in several markets in 2018 – 2023.

| Variable | Critical value 5% | t-stat | Prob. |
|---|---|---|---|
| Producer price | -2.917650 | -7.136994 | 0.0000 |
| Wholesale price | -2.907660 | -7.085971 | 0.0000 |
| Consumer price | -2.907660 | -4.251494 | 0.0012 |

### *3.1.2 Optimal lag test results*

In VECM modelling, choosing the best lag is crucial since it serves as an exogenous variable for the endogenous variables in the equation. Finding the AIC value with the lowest value after using the AIC yields the determination of the ideal lag. The outcomes of the optimal lag test are presented in Table 2.

**Table 2.** Optimal lag test results.

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 430.2681 | NA | 1.03e-10 | -14.48366 | -14.37803 | -14.44243 |
| 1 | 459.9016 | 55.24884* | 5.12e-11* | -15.18310* | -14.76055* | -15.01816* |
| 2 | 465.3018 | 9.519101 | 5.80e-11 | -15.06108 | -14.32162 | -14.77242 |
| 3 | 467.4893 | 3.633462 | 7.35e-11 | -14.83015 | -13.77377 | -14.41778 |
| 4 | 477.4383 | 15.51368 | 7.20e-11 | -14.86232 | -13.48903 | -14.32624 |
| 5 | 485.5403 | 11.80967 | 7.57e-11 | -14.83187 | -13.14167 | -14.17209 |
| 6 | 493.3293 | 10.56140 | 8.13e-11 | -14.79082 | -12.78371 | -14.00733 |

The optimal lag test results indicate that the smallest AIC value is observed at lag 1, with a value of -15,183. Therefore, the optimal lag to be employed in the VECM equation is lag 1. This finding suggests that the relationship between the variables is linked to both the current month and the preceding month.

### *3.1.3 Cointegration test results*

According to the cointegration test results (Table 3) utilising the Johansen cointegration test method, a long-term integration relationship is established between producer and consumer prices, as well as between producer prices and wholesale prices. This long-term relationship is evident through the trace statistics and max-eigenvalue values, both of which have probability values lower than the 5% critical threshold. Consequently, the two equations can effectively describe the cointegration among the variables included in the model.

**Table 3.** Cointegration test results.

| Price variable | No. of CE(s) | Max. Eigenvalue | Trace stat. | Prob. |
|---|---|---|---|---|
| HP → HK | None | 23.16406 | 23.50287 | 0.0005* |
| | At most 1 | 0.338810 | 0.338810 | 0.6231 |
| HP → HPB | None | 13.72324 | 13.72327 | 0.0289* |
| | At most 1 | 2.71E-05 | 2.71E-05 | 0.9967 |
| HK → HPB | None | 3.492798 | 3.559604 | 0.7733 |
| | At most 1 | 0.066806 | 0.066806 | 0.8321 |

Note: (*) = Reject H0

### *3.1.4 Granger causality test results*

The Granger causality test results (Table 4) show that producer prices significantly affect consumer prices, with a probability value lower than the 0.05 significance level. However, the reverse relationship, where consumer prices affect producer prices, is not statistically significant, with a probability value of 0.259, exceeding the 0.05 threshold. Therefore, a one-specifically, a producer price to consumer price causal relationship can be used to determine the cause of the difference in producer and consumer prices. This suggests that the dissemination of information regarding price changes could be more efficient because only information regarding price changes from farmers appears to impact the consumer market.

**Table 4.** Granger causality test results.

| Null hypothesis: | Obs | F-statistic | Prob. |
|---|---|---|---|
| HP does not Granger Cause HK | 65 | 24.0563 | 7.E-06* |
| HK does not Granger Cause HP | | 1.29410 | 0.2597 |
| HPB does not Granger Cause HK | 65 | 2.45750 | 0.1221 |
| HK does not Granger Cause HPB | | 3.89451 | 0.0529 |
| HPB does not Granger because HP | 65 | 0.28716 | 0.5940 |
| HP does not Granger Cause HPB | | 6.76233 | 0.0116* |

With a probability value of 0.0116, which is below the 5% level of significance, the producer price variable significantly affects wholesale trade prices. However, there is no statistically significant correlation between wholesale and producer prices. Thus, we can infer a one-way causal relationship between producer and wholesale prices.

It is thrilling to see that the price of rice at the consumer level also affects the movement of grain prices at the farmer level, based on the findings above and when contrasted with the findings of a previous [19]. This circumstance shows how the price of rice at the producer level affects the price at the consumer level, according to research findings. In contrast, grain must be supplied by farmers to rice producers.

### *3.1.5 VECM estimation results*

The VECM analysis comprises an examination of cointegration among variables in both the long and short term. The outcomes of the VECM analysis regarding long-term cointegration are provided in Table 5.

**Table 5**. Results of rice market cointegration between consumer prices and producer prices.

| Cointegration equation | Rice price variable | | |
|---|---|---|---|
| | HK | HP | C |
| Cointegration 1 | 1.000000 | -1.248802 | -0.639819 |
| | | (0.11526) | |
| | | [-10.8346] | |

Note: The numbers in [ ] are t-statistics with a t-table value of 1.99

Additionally, the outcomes of the second long-term analysis of rice market integration show that consumer and wholesale trade levels of integration are present. The t-statistic value (|-10.8346|), which is more significant than the essential t-table value (1.99), supports the integration of the rice market.

From the findings of the VECM analysis in cointegration equation 1, it is evident that the price of rice at the producer level significantly and negatively impacts the price of rice at the consumer level by -1,248. This result suggests unidirectional price transmission from producer prices to consumer prices. Specifically, for every 1% increase in producer prices, consumer prices decrease by 1.24%. This aligns with previous research findings that concluded the significant influence of producer-level rice prices [18,19]. However, this relationship is not bidirectional, indicating that the transmission direction between producer and consumer prices is asymmetrical.

This phenomenon is quite common because rice is considered a strategic and politically sensitive commodity. Consequently, government intervention is essential to uphold rice price stability at the consumer level. In certain situations, such as when the price of dry unhusked grain (GKP) rises due to factors such as adverse weather conditions leading to crop failure or pest infestations, GKP prices also increase. The government typically enforces a policy known as the highest retail price (HET) for rice to safeguard consumers from surging prices.

In a different scenario, when prices surge at the consumer level, it necessitates a swift response with an increase in prices at the producer level, often because of the heightened demand for rice. This signifies that the government's price policy primarily emphasises maintaining stability at the consumer level [19]. Situations in which long-term two-way cointegration does not occur are indicative of price asymmetry, a common phenomenon in the realm of food commodities. However, it is important to note that prices transmitted asymmetrically tend to have adverse effects on producer-level welfare. This means that a decline in farmers' income from selling grain is coupled with an increase in their expenditure on purchasing rice [20].

**Table 6.** Results of rice market cointegration between consumer and wholesale prices.

| Cointegration equation | Rice price variable | | |
|---|---|---|---|
| | HK | HPB | C |
| Cointegration 2 | 1.000000 | 0.222021 | -0.639819 |
| | | (0.09933) | |
| | | [ 2.23524] | |

Note: The numbers in [ ] are t-statistics with a t-table value of 1.99

The findings of the cointegration analysis between wholesale and retail prices (Table 6) further show that the rice market is integrated over time at both retail and wholesale trading levels. The t-statistic value (2.2352), which is higher than the essential t-table value (1.99), indicates the presence of cointegration.

In cointegration equation 2, it can be deduced that the price of rice at the wholesale trade level has a favourable and important effect on consumer prices, with a coefficient of 0.22. This finding implies a unidirectional or positive direction of price transmission. In other words, it can be concluded that a 1% price increase at the wholesale price level will result in a 0.22% price increase at the consumer level.

The impact of price fluctuations at the wholesale level on prices at the producer level is relatively minor, primarily because changes in consumer-level prices are less responsive to wholesale-level adjustments (price changes show inelasticity). This can be attributed to government interventions aimed at stabilising rice prices to preserve consumers' purchasing power in essential food commodities, such as rice.

In the context of short-term VECM analysis in the rice market, finding short-term correlations between rice prices at the producer level is the goal, rice prices at the wholesale level, and rice prices at the consumer level. The results of the short-term VECM test are elaborated in Table 7.

The error correction term (ECT) figure in Table 7 for the producer price variable is 0.373, signifying an adjustment from the short term to the long term every month of 0.373. A notable observation is that the ECT coefficient for producer prices is higher than the ECT coefficient for consumer and wholesale prices. This difference shows that producer-level pricing changes occur more quickly than consumer- and wholesale-level price changes.

**Table 7.** Short-run cointegration results between producer, consumer, and wholesale prices.

| Error correction | D(HK) | D(HP) | D(HPB) |
|---|---|---|---|
| ECT1 | -0.046043 | 0.373380 | -0.084719 |
| | (0.05015) | (0.11629) | (0.07841) |
| | [-0.91816] | [ 3.21067] | [-1.08045] |
| D(HK(-1)) | 0.010965 | -0.195263 | 0.120691 |
| | (0.15451) | (0.35833) | (0.24160) |
| | [ 0.07097] | [-0.54493] | [ 0.49955] |
| D(HP(-1)) | 0.301610 | 0.796142 | -0.008389 |
| | (0.05967) | (0.13838) | (0.09330) |
| | [ 5.05465]* | [ 5.75340]* | [-0.08991] |
| D(HPB(-1)) | 0.100748 | 0.261490 | 0.040823 |
| | (0.08584) | (0.19906) | (0.13422) |
| | [ 1.17370] | [ 1.31360] | [ 0.30415] |

The estimation results of the VECM also reveal short-term market integration among several variables in the model. According to the outcomes of the VECM test, there are two short-term integrations: one between producer and consumer prices, and the other between producer and producer prices, both occurring in lag 1. The first relationship can be explained by the significance of the t-statistic for the consumer price variable, which is |5.05|, surpassing the t-table threshold (1.99). Additionally, it had a coefficient value of 0.30. This coefficient indicates that if there is a 1 rupiah change in price at the producer level in the previous month, it will lead to a price increase of 0.30 rupiah at the consumer level in the current month. The conclusions of this interpretation suggest that changes in producer-level prices are passed on to consumer-level prices. However, the reverse does not apply when price changes at the consumer level are not transmitted to producer prices. The results of this analysis are also in line with those of a previous study [21], which shows that price increases at the consumer level continue slowly and do not occur ideally.

The second short-term relationship is evident from the t-statistic value of the producer price variable, which exceeds the t-table value (5.75 > 1.99). A coefficient value of 0.79 confirms the existence of this link. These findings imply that if there was a 1% change in producer prices one month ago, producer prices in the current month would increase by 0.79%. Therefore, short-term price transmission also occurs from producer prices in the previous month to those in the current month. These test results concur with those of a study [22] that found a brief correlation between the retail rice price for the current period and the retail rice price for the previous period.

### 3.2. Market integration and welfare of rice farmers in Indonesia

Numerous buyers and sellers, perfect information availability, uniform goods, and the capacity of players to enter or depart the market are all characteristics of a perfectly competitive market. However, the producer-level rice market in Indonesia does not meet the criteria for a perfectly competitive market. Instead, it exhibits characteristics that resemble an oligopoly, where the number of buyers is fewer than that of sellers. In such circumstances, buyers hold greater influence and can drive grain prices down, given the relatively larger number of farmers compared to grain buyers [23,24]. This situation can result in buyers pushing grain prices to be as low as possible.

Assistance is required for rice farmers in various aspects of their farming endeavours. For instance, they face challenges in negotiating grain prices due to limitations in grain storage capacity and high liquidity demands. GKP is the most common form of grain sold by rice farmers. The quality of GKP is greatly influenced by weather and pest activity, which causes variations in GKP production.

Furthermore, findings from a prior study [25] indicate that the supply of grain in Indonesia is characterised as inelastic, both in the short and long term, with elasticity values of 0.088 and 0.153, respectively. This suggests that the supply shift is less significant than the price change in terms of percentage. In practical terms, a 1% increase in grain prices will result in a supply increase of only 0.088% in the short term and 0.153% in the long term. The combination of inelastic grain supply, fluctuating GKP production, and oligopsony and monopolistic grain market structures in some regions causes grain prices to fluctuate, and an imbalance between supply and demand causes grain price fluctuations at the farm level to be higher than those at other levels [21,23].

Given that patterns in producer demand are suggestive of patterns in consumer demand, price fluctuations at the consumer level should resemble those observed at the producer level. In essence, this signifies a degree of integration in the rice market between consumers and farmers, facilitating the transmission of both grain and rice prices across various trade levels. The analysis's VECM findings, both in the short and long terms, confirm the integration of the rice market into both the ranks of producers and consumers. In the long term, two cointegrations were observed. The first cointegration involves prices at the producer level, represented by GKP prices, and prices at the consumer level, represented by rice prices. It can be deduced that rice prices at the producer level have a negative and significant impact on rice prices at the consumer level. This suggests that whenever GKP prices rise, rice prices at the consumer level also rise during the lockstep.

Numerous studies have yielded results similar to those found in the research mentioned in reference [19]. In these studies, long-term VECM tests demonstrated cointegration between prices at the producer and consumer levels. This suggests that changes in grain prices are swiftly transmitted to consumer-level prices, thereby influencing rice prices. Conversely, when there is an uptick in consumer-level prices due to heightened rice demand, this upward movement does not significantly impact prices at the producer level. This unidirectional price transmission pattern is commonly referred to as asymmetric price transmission.

The asymmetric price transmission phenomenon has negative effects on farmers' welfare. The decrease in prices at the farmer level, coupled with the rise in rice prices at the consumer level, results in a decline in farmers' incomes and an increase in their expenditure on purchasing rice. Given that a significant proportion of Indonesian farmers are smallholders who allocate a substantial portion of their income to meet their food needs, these conditions lead to a reduction in their overall welfare.

In this context, an increase in rice costs, without a corresponding increase in the price of GKP, continues to erode farmers' income and diminish their welfare levels in Indonesia. These challenges underscore the importance of government intervention through policies that address pricing at both the farmer and consumer levels as well as policies related to agricultural inputs. A more comprehensive and in-depth examination of these policy aspects is warranted, as highlighted in previous research [23,26,27,28].

# 4 Conclusions and policy recommendations

## 4.1 Conclusions

Asymmetric price transmission has negative effects on consumers' and farmers' well-being. This asymmetry, marked by a decrease in prices at the farmer level, along with an increase in consumer-level rice prices, results in a drop in farmers' income and an escalation in their expenses for purchasing rice. In such circumstances, the welfare of farmers declines, particularly when considering that a significant portion of Indonesian farmers are smallholders who allocate the majority of their earnings to fulfil their food requirements.

If the government does not intervene with policies addressing pricing at both the farmer and consumer levels, and further investigates policies related to agricultural inputs, the situation remains precarious. An increase in rice prices, unaccompanied by a corresponding increase in GKP prices, continues to erode income and reduce the welfare of farmers in Indonesia. These pressing issues underscore the need for a comprehensive and in-depth examination of policy interventions, as highlighted in previous studies [23,26,27,28]. The combined effect of falling producer prices and rising consumer prices for rice has a synergistic negative impact on farmers, as it reduces their income while increasing their expenses. In such circumstances, the overall welfare of farmers diminishes, particularly given that the majority of farmers in Indonesia are small-scale operators who allocate a substantial portion of their earnings to fulfil their food requirements.

## 4.2 Policy recommendations

Several policy suggestions that can be implemented regarding rice price stabilisation include the following. (1) Improve and build a rice storage infrastructure system so that farmers can store some of their rice during the main harvest; therefore, when demand increases, such as during holidays, farmers can still sell spare rice from the main harvest. (2) Considering the oligopsonous nature of the market structure, the government needs to increase access to price information for farmers so that they have a high bargaining position for GKP. (3) Flexibility in government purchasing price policies is necessary, especially during harvest and rainy seasons when the water content in the GKP is high. This is aimed at reducing farmers' losses due to low GKP prices when faced with high farming costs. (4) It is necessary to study the regulations governing the setting of price levels in each marketing agency, considering the high price disparity between producer and consumer prices. (5) Research on superior varieties that are resistant to weather changes and pests is necessary so that seed adaptation to climate change can maintain rice productivity levels, even in bad weather. (6) Increase access to capital with low interest rates and accessible conditions for farmers to increase rice planting area and production. (7) Equal distribution of fertiliser subsidies and machinery to reduce production costs to maintain farmers' income.

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