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Analyzing the Spatial Integration of Rice Market in South Kalimantan Province, Indonesia : using Vector Error Correction Model (VECM)

Sadik Ikhsan[1*], Djoko Santoso[2], Yuriadi Ilmi[1], Dea Etna Ananda[1]

[1] Magister of Agricultural Economics Study Program, Faculty of Agriculture ULM, Banjarbaru, 70714 South Kalimantan, Indonesia
[2] Agribusiness Study Program, Faculty of Agriculture ULM, Banjarbaru, 70714 South Kalimantan, Indonesia
*Corresponding Author: sikhsan@ulm.ac.id

Abstract Market integration plays a key role in ensuring prevailed price signal in a market is well transmitted to the other spatially connected markets. The actors in the market will get symmetrical information to prevent one party from exploiting another to get excessive arbitrage profit. This research aims to test existence of integration in rice markets in South Kalimantan Province, Indonesia. Weekly composite rice price in three market locations, namely Banjarmasin City, Tabalong, and Kotabaru from July 2020 to March 2023 was observed. The unit root test to check stationarity data and the cointegration test were carried out. The ADF unit root test results showed that data is not stationary but becomes stationary after being differencing in level one. Johansen's cointegration results showed that there is a cointegration that represents long-term equilibrium between price variables. Due to the non-stationarity of data and the presence of cointegration, the Vector Error Correction Model (VECM) is used. The estimation results showed dominant and linear influences of rice price in Banjarmasin over rice price in Kotabaru, reviewed from significant level and elasticity amount in the cointegration equation, and its consistency with the results of Granger pairwise causality test and Impulse Response Function (IRF) graphic description.

Keywords Market integration, Stationary, Cointegration, VAR, VECM

1. Introduction

In establishing prices over goods, the market individually does not only stands alone as determiner demand and supply in the market but is also affected by the power formed through buyer and seller behavior in the other connected markets. Each market develops mechanisms to transmit price signal on each market and other substitutional possibilities on a certain level to other related markets [1,2] so that those markets are integrated. Market integration is interpreted as the actual situation when price of good among markets move together to adjust so that the price difference is only because of transfer cost [3]. If goods trading occurs between two areas, the price of the importing area is as much as the price of the exporting area and added to the costs of transporting goods between those two areas. When this is happening, those two markets are considered to be spatially integrated as a single market [4,5].

Integration, according to Barrett[6] and Fackler & Goodwin[7], covers the Law of One Price (LOP) in some other forms. In that LOP framework, when trading occurs and every possible arbitrage profit is removed, the maximum price developed is as much as the cost of commerce. Dawson & Dey[8] explained LOP as the following statement: if the trade occurs between two markets, the price of the importing market should be as much as the exporting market and has additional transportation costs.

The price transmitting process from one market to another is the key to discovering whether market integration is perfectly carried out and market efficiency is developed. According to Meyer & von Cramon-Taubadel[9], in symmetric price transmission, price changes in one market will be followed by symmetric changes in other markets. In the other non-integrated markets, the price information may be inaccurate, thus distorting producers' marketing decisions and contributing to inefficient goods movement [10]. Therefore, according to Conforti[11], the extent to which price transmission takes place will provide an illustration of market efficiency, which means that the market structure is approaching a competitive model, as well as indicating that the price signals are consistently conveyed among markets.

Integration becomes an important measure of market efficiency. Its existence pushes resources to be distributed efficiently, reduces social cost, also maximizes social welfare. On the contrary, segmented markets has a negative impact on the development of market health, increase deadweight loss that occurs in society, and generally reduce economic efficiency [12]. The existence of market integration has important implications for regulations and government economic policy, especially in international trade. If the market is internationally integrated, government intervention in a country will be ineffective or over-priced [5]. Baulch[3] showed market integration as a pre-condition to ensure that the benefits of liberalization which is the common component in structural adjustment programs and marketing reformation which is generally implemented in developing countries can be realized. The outcome of this liberalization is expected to encourage the development of static allocative efficiency and long-term agricultural development. The absence of market integration drives price signals that are not transmitted properly through the marketing chain and farmers fail to specialize according to their comparative advantages. In Indonesia, Makbul & Ratnaningtyas[13] and Makbul et al[14] questioned the existence of transmission between paddy and rice prices in determining the success of food policy. If the paddy and rice markets are integrated, paddy and rice prices will influence each other both in the short term and long term. Depending on the degree of ongoing transmission, whether or not the policy to increase the rice prices on the consumer side will improve the income of rice farmers and become a stimulant to increase production, or on the other hand, on the customer side, the policy will decrease their real income and eventually elevate poverty as well as decrease food security in Indonesia.

Many instruments and models have been developed and are widely applied to test market integration —starting with bivariate correlation coefficients which are developed and then expanded using autoregressive distributed lags, cointegration, error correction model (ECM), and Granger causality [3]. Cointegration is two or more variable properties of price series that indicate the existence of long-term market integration [15].

This article was written based on the research results on the spatial integration of the rice markets in South Kalimantan Province which involves markets in Banjarmasin City, Kotabaru Regency, and Tabalong Regency which was constructed using the VAR (Vector Autoregression) model approach.

2. Materials and Methods

2.1. Research Location

This research was conducted in South Kalimantan Province, Indonesia, taking observation areas in Banjarmasin City, Tabalong Regency, and Kotabaru Regency (Figure 1). All three are spatial representations of the South Kalimantan region.

Banjarmasin City is an urban and commercial area, formerly the capital of South Kalimantan Province, before moving to Banjarbaru City which is 40 km from Banjarmasin City and located in the south part of South Kalimantan Province. Banjarmasin market areas get rice supplies from the surrounding areas which are rice production centers, namely Barito Kuala Regency and Banjar Regency. The market area in Tabalong Regency is in the northern part of South Kalimantan Province. Tabalong Regency has rice buffer stock from the surrounding areas where there are rice fields known as *Banua Enam*, consisting of Balangan Regency, Hulu Sungai Utara Regency, Hulu Sungai Tengah Regency, Hulu Sungai Selatan Regency, Tapin Regency, and Tabalong Regency. The market area in Kotabaru Regency is southeast of South Kalimantan Province, on an island called Pulau Laut which is separated from the main island of Kalimantan. The geographical position of each market gives integration patterns that are built among these three.

2.2. Data

The data used in the research is weekly time series data on average consumer prices for rice, starting from the first week of July 2020 until the 4th week of May 2023. The data was taken from the three markets which consists of 152 data for each market. The data is a composite of various types of rice traded in the markets which are averaged as an approach to rice as a homogeneous commodity. The data was obtained from the Central Bureau of Statistics (BPS) in South Kalimantan Province which periodically conducts field surveys on rice prices in three markets as a representation of the prevailing prices in South Kalimantan for compiling the Customer Price Index (CPI) and inflation statistics in South Kalimantan. The prevailing price of rice in each market is generally different. The difference is partly due to the availability and supply of the rice from the production buffer area as well as the transportation costs to bring it to the nearest market. In addition, as an urban area, the price of rice in Banjarmasin City also tends to be more expensive compared to prices in other markets.

The analyzed data was previously transformed into the ln function to accommodate the a priori assumption that generally, the relationship between economic variables is not linear. Thus, in the notation, LNPB, LNPT, LNPK are used respectively for the rice price variable (in ln) in Banjarmasin City, Tabalong Regency, and Kotabaru Regency.

2.2. Analysis Methods

Integration between markets in Banjarmasin City, Tabalong Regency, and Kotabaru Regency is constructed using the VAR (Vector Autoregressive) model, as follows.

$$LNPB_t = \alpha_{10} + \sum_{j=1}^{k} \beta_{1j} LNPB_{t-1} + \sum_{j=1}^{k} \gamma_{1j} LNPT_{t-1} + \sum_{j=1}^{k} \delta_{1j} LNPK_{t-1} + \varepsilon_{1t} \quad (1a)$$

$$LNPT_t = \alpha_{20} + \sum_{j=1}^{k} \beta_{2j} LNPT_{t-1} + \sum_{j=1}^{k} \gamma_{2j} LNPK_{t-1} + \sum_{j=1}^{k} \delta_{2j} LNPB_{t-1} + \varepsilon_{2t} \quad (1b)$$

$$LNPT_t = \alpha_{20} + \sum_{j=1}^{k} \beta_{2j} LNPT_{t-1} + \sum_{j=1}^{k} \gamma_{2j} LNPK_{t-1} + \sum_{j=1}^{k} \delta_{2j} LNPB_{t-1} + \varepsilon_{2t} \quad (1c)$$

where: ε white noise, $\varepsilon \sim IIDN(0, \sigma^2)$

Two crucial tests need to be carried out in estimating and analyzing the model, namely the unit root test and the cointegration test. Unit root test is intended to ensure that

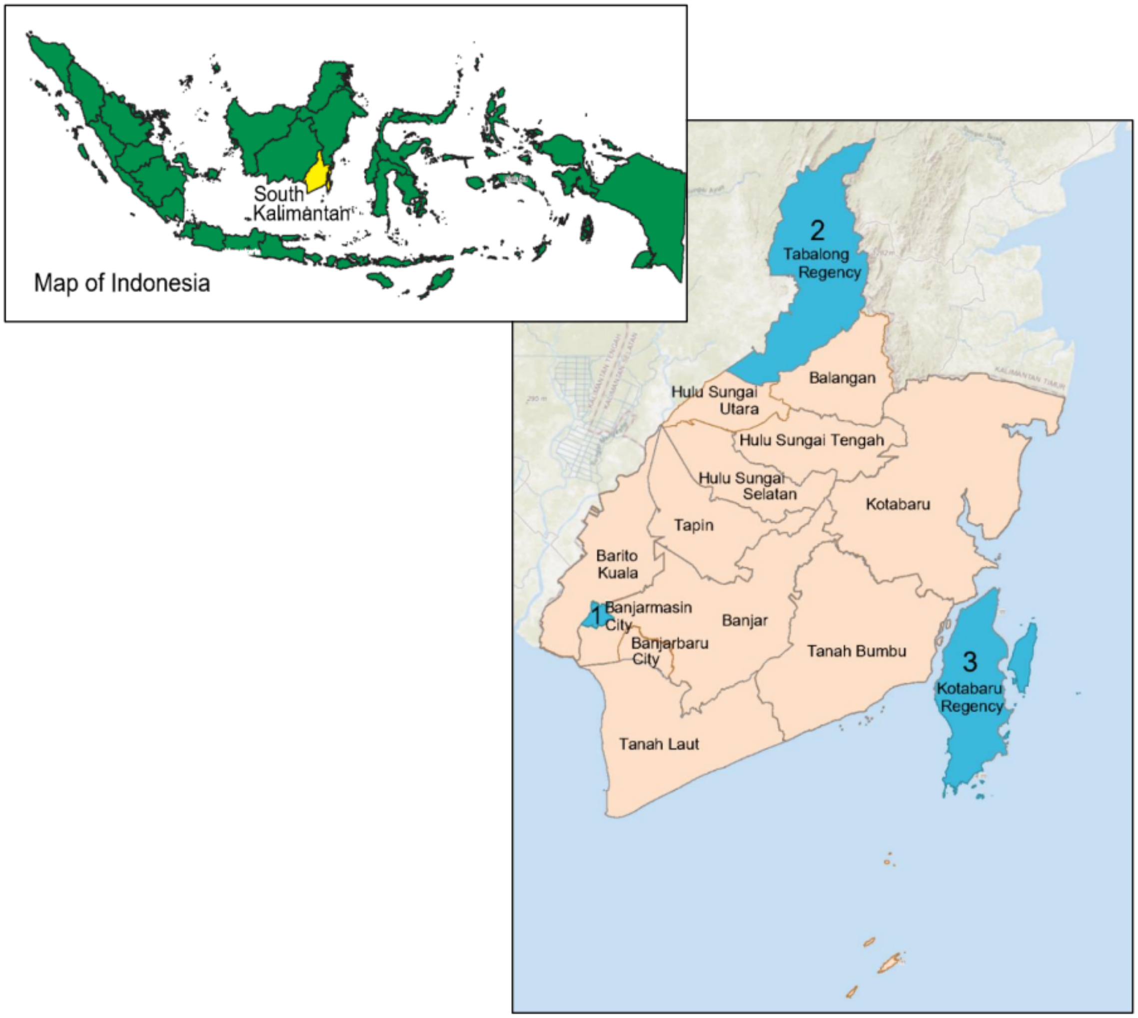

Figure 1. Map of South Kalimantan Province, Indonesia. The observation area: (1) Banjarmasin City; (2) Tabalong Regency; (3) Kotabaru Regency

data of rice price variable in the three market areas is stationary or integrated in a certain order. Testing uses the ADF (Augmented Dickey – Fuller) procedure based on the random walk model (RWM), as follows:

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-i} + \varepsilon_t \qquad (2)$$

where: δ autoregressive coefficient

m optimum lag length

for each series of rice price variables in Banjarmasin City (LNPB), Tabalong (LNPT), and Kotabaru (LNPK). The hypothesis that is being tested is H_0: $\delta = 0$ (there is a unit root problem) which means the data on the variable is not stationary) versus H_1: $\delta < 0$. Reject H_0 if the tau statistics (τ) is greater than the MacKinnon critical value. To make it stationary, an upper differencing transformation is carried out until stationarity is obtained based on the ADF test. Regarding the optimum lag length in the VAR (1) and RWM (2) models, it is determined based on several choices of information criteria procedures: Akaike, Schwarz, or Hannan-Quinn which are available in the EViews software.

The cointegration test is aimed at revealing whether there is a long-term balance between variables or not. Hence, the Johansen test is carried out, using two test statistics, namely trace and maximum eigenvalue, which are respectively written as,

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad (3)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad (4)$$

[16]

where: λ estimated value of the eigenvalue obtained from matrix Π;

T the number of observations that can be used

Matrix Π is in the equation:

$$\Delta \underline{\mathbf{x}}_t = \mathbf{A}_0 + \mathbf{\Pi}\underline{\mathbf{x}}_{t-i} + \sum_{i=1}^{k-1} \mathbf{\Gamma}_i \Delta \underline{\mathbf{x}}_{t-i} + \underline{\mathbf{e}}_t \quad (5)$$

where: $\mathbf{\Pi} = \sum_{i=1}^{p} \mathbf{A}_i - \mathbf{I}$, and $\mathbf{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{A}_j$

[17,18] which is a reparameter of the VAR model.

With variables that are not stationary and with cointegration, the VAR model (1) is restricted by carrying out a differencing transformation on these variables so that they become stationary, and inserting error correction variables into the model to produce the following Vector Error Correction Model (VECM),

$$\Delta LNPB_t = \alpha_{10} + \sum_{j=1}^{k} \beta_{1j} \Delta LNPB_{t-1} + \sum_{j=1}^{k} \gamma_{1j} \Delta LNPT_{t-1} + \sum_{j=1}^{k} \delta_{1j} \Delta LNPK_{t-1} + \lambda_1 u_{1t} + \varepsilon_{1t} \quad (6a)$$

$$\Delta LNPT_t = \alpha_{20} + \sum_{j=1}^{k} \beta_{2j} \Delta LNPT_{t-1} + \sum_{j=1}^{k} \gamma_{2j} \Delta LNPK_{t-1} + \sum_{j=1}^{k} \delta_{2j} \Delta LNPB_{t-1} + \lambda_2 u_{3t} + \varepsilon_{2t} \quad (6b)$$

$$\Delta LNPT_t = \alpha_{20} + \sum_{j=1}^{k} \beta_{2j} \Delta LNPT_{t-1} + \sum_{j=1}^{k} \gamma_{2j} \Delta LNPK_{t-1} + \sum_{j=1}^{k} \delta_{2j} \Delta LNPB_{t-1} + \lambda_3 u_{3t} + \varepsilon_{3t} \quad (6c)$$

where: Δ differencing operator

u error correction term (ECT)

Inference on the VECM estimation results can be done by referring to the t statistic and $R^2_{adjusted}$ as a measure of GoF (goodness of fit). However, according to Gujarati & Porter (2009), one of the disadvantages of VECM estimation is that it is difficult to interpret it in a practical context, among other things because the variables used are the results of difference transformations. Therefore, the Impulse Response Function (IRF) instrument was proposed as an alternative.

3. Result and Discussion

3.1. Unit Root Test

Unit roots test is aimed to test the stationary of the data, considering that generally data on economic variables is not stationary [19] and it seems that non-stationary is a natural feature in the economy [20]; while statistical applications of time series data require stationary data. Non-stationary data when regressed will produce spurious regression which can be misleading because it has a high R^2 and significant t statistics, but does not provide a meaningful economic interpretation [16]. To change non-stationary data into stationary, a difference transformation will be carried out. Generally, the economic variables will be stationary after the first difference transformation. Non-stationary data graphically shows trends and drifts. Stationary data has properties of mean value, variance, and autocovariance at various lags that remain constant at the time when the calculation begins.

The test results are provided in Table 1. The three variables are not stationary in level but become stationary after being differencing transformed in the first level or it stated as I(1) — indicated by the value of Prob. = 0.0000 (= has a very small value, not zero) and corresponds to a t-statistic (in absolute value) which is greater than the MacKinnon critical value at the real level of up to 1%.

Table 1. The results of the ADF unit root test on variable data of LNPB, LNPK, and LNPT

Series	Lag+	Max Lag	Obs.	Statistik Uji ADF++	
				t-statistics	Prob.
Variable in *level*					
LNPB	5	13	146	-1.166711	0.6879
LNPT	0	13	151	-0.796592	0.8169
LNPK	0	13	151	-0.518478	0.8832
Variable in *first difference*					
D(LNPB)	4	13	146	-6.903461	0.0000***
D(LNPT)	0	13	150	-14.25502	0.0000***
D(LNPK)	0	13	150	-14.27073	0.0000***

+lag length: determined automatically based on SIC, maxlag=13

++MacKinnon (1996) one-sided p-values.

Test critical values:	1% level	-3.473967
	5% level	-2.880591
	10% level	-2.577008

3.2. Optimum Lag Length

The lag variables in RWM and VAR/VECM are meant to capture the past effects of the variables on the response variables. The influence of these variables is responded to late due to the influence of rigidity and inertia, the influence of technology, and institutional influence [21]. Cointegration testing is sensitive to the lag length used. Enders[16] believes that determining lag length is very important: too short will result in misspecification, but too long will waste degrees of freedom.

Determining the optimum lag length uses several criteria options available in EViews. The optimum lag length is determined by taking into account the widest available lag length [13] as well as the dominant one expressed by several information criteria. Table 2 shows the optimum lag length is 6, which means that lag is shown to be the longest and dominantly stated by several criteria: LR, FPE, AIC.

Table 2. Determination of the optimal lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	505.696	NA	1.86E-07	-6.982	-6.920	-6.957
1	1163.404	1278.875	2.28E-11	-15.992	**-15.744***	**-15.8912***
2	1173.386	18.994	2.25E-11	-16.005	-15.572	-15.8294
3	1175.930	4.7353	2.46E-11	-15.916	-15.297	-15.66423
4	1183.286	13.382	2.52E-11	-15.893	-15.088	-15.5660
5	1197.072	24.510	2.36E-11	-15.959	-14.969	-15.5571
6	1210.666	**23.599***	**2.22e-11***	**-16.023***	-14.848	-15.5453
7	1219.586	15.116	2.23E-11	-16.022	-14.669	-15.4689
8	1222.397	4.645	2.43E-11	-15.936	-14.389	-15.3075

Notes: * indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

3.3. The Cointegration Test

Cointegration is defined as a statistical statement related to the long-term equilibrium interrelationship among variables. Cointegration is believed that in the long run, pairs of economic variables will not deviate too far from each other. Temporary deviations may occur or possibly follow short-term seasonal factors. However, if these deviations tend to widen in the long run, there will be forces such as market mechanisms or government interventions that will guide these variables back towards their equilibrium positions [22]. According to Gujarati & Porter (2009), when there is a long-term interrelationship or equilibrium between two variables, it is said that they are cointegrated with each other.

The Johansen cointegration test on the variables LNPB, LNPT, and LNPK in the VAR is based on the choice of the intercept model (no trend) in CE, no intercept in VAR, and the optimal lag parameter set to 6. The choice of the intercept model (no trend) in CE and no intercept in VAR is determined by referring to the summarizing results of the pre-test assumptions of cointegration in EViews using the Schwarz Criteria. The test results, considering both the trace statistic test and the maximum eigenvalue test, conclude that the VAR model has one cointegration (Table 3).

Table 3. Johansen Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No.of CE(s)	Eigenvalue	Trace Statistic	Critical Value^{+}	Prob.$^{++}$
None	0.166252	36.31511	24.27596	0.001***
At most 1	0.057801	9.95054	12.3209	0.1209
At most 2	0.009045	1.317441	4.129906	0.2934

Trace test indicates 1 cointegrating eqn(s) at the 0.01 level
+ critical value at the 0.05 level
++ MacKinnon-Haug-Michelis (1999) p-values
***denotes rejection of the hypothesis at the 0.01 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No.of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value^{+}	Prob.$^{++}$
None	0.166252	26.36458	17.7973	0.002***
At most 1	0.057801	8.633098	11.2248	0.1379
At most 2	0.009045	1.317441	4.129906	0.2934

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.01 level
+ critical value at the 0.05 level
++ MacKinnon-Haug-Michelis (1999) p-values
***denotes rejection of the hypothesis at the 0.01 level

The cointegration is expressed in the following equation,

$$LNPK_{t-1} = 1.5942 + 1.0411\ LNPB_{t-1} + 0.1118\ LNPT_{t-1} \quad (6)$$

0.11983[8.6885]*** 0.06297[1.7756]*

*** significant at the real level of testing at 0.01 level
* significant at the real level of testing at 0.1 level

In the long-term equilibrium interrelationship that is formed, it is shown that the rice prices in Banjarmasin and Tabalong markets have a significantly positive effect on the rice prices in the Kotabaru market. The price signals formed in the Banjarmasin and Tabalong markets will be transmitted positively to the Kotabaru market. In particular, the rice prices variable in the Banjarmasin market influencing the rice prices in the Kotabaru market is strengthened by the pairwise Granger causality test results. The null hypothesis H0: LNPD does not Granger Cause LNPK is rejected, and thus, it means that LNPB has a Granger causality effect on LNPK because it has Prob. = 0.0027, which can be shown to be smaller than the significant at 0.01 level or even smaller than 0.01 (Table 4).

Table 4. Pairwise Granger Causality Test Results

Null Hypothesis:	Obs	F-Statistic	Prob.
LNPK does not Granger Cause LNPB	146	1.58182	0.1572
LNPB does not Granger Cause LNPK		3.56021	**0.0027*** **
LNPT does not Granger Cause LNPB	146	0.92621	0.4784
LNPB does not Granger Cause LNPT		0.87568	0.5147
LNPT does not Granger Cause LNPK	146	0.28999	0.9408
LNPK does not Granger Cause LNPT		0.79628	0.5744

***significant at the real level of testing at 0.01 level

3.4. Impulse Response Function (IRF)

IRFs are based on a VECM (or a restricted VAR model) due to the non-stationarity of variables and existing cointegration. Using IRF, the dynamic responses of endogenous variables in each equation within the VAR system are traced for the effects of shocks on errors that occur as a result of changes in one of the examined exogenous variables (Figure 2). In this mechanism, the simulated shock that occurs is equal to one standard error.

In general, the shock effect of the variable itself is quite strong, as indicated by the relatively high spike in rice prices in each region, but the responses differ. In the Kotabaru market, after the spike, prices tend to decrease in the following weeks. In the Banjarmasin City market, after the initial spike, it is followed by subsequent spikes until the 5th week before declining in the following weeks. As an urban market with a diverse and large population, price shocks are responded to with a rush by buyers, resulting in price increases, but they are subsequently responded to by supplies from rice-producing buffer regions, causing rice prices to gradually decrease in the following weeks. Meanwhile, in the Tabalong market, the shock effect of the variable itself responded with small and stable fluctuations in the weeks ahead, but they settled at a higher price equilibrium.

The shock effects from price variables in other market regions are predominantly influenced by the rice prices in Banjarmasin City on the rice prices in the Kotabaru region. The shock is positively responded to with an increase in rice prices in the Kotabaru market. This finding is consistent with the statement in the cointegration equation (6), which specifies the influence of rice prices in Banjarmasin City as significant and elastic on the prices in the Kotabaru market.

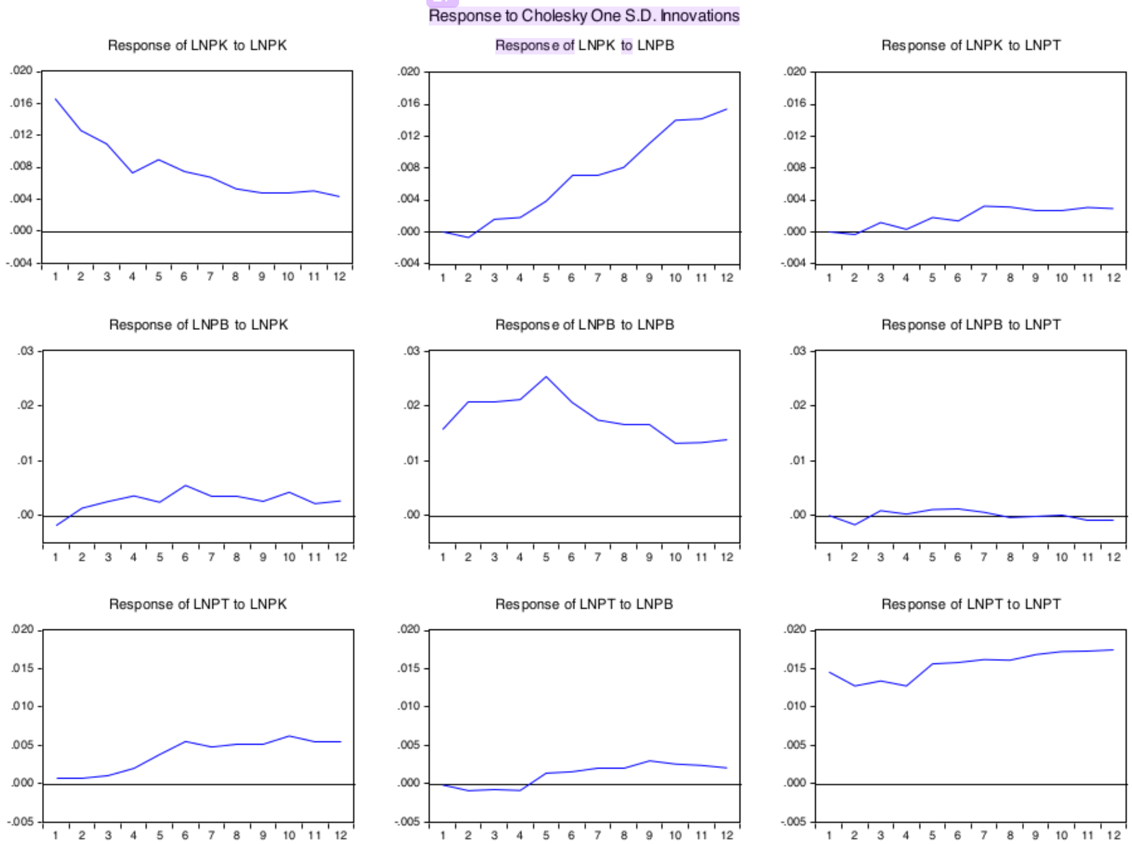

Figure 2. IRF Results: the response of endogenous variables to the effects of shocks occurring in exogenous variables

4. Conclusion

Market integration is important because it provides insights into the performance of price signal transmission between interconnected markets, which will work well when information moves symmetrically. Integration promotes the formation of market efficiency and serves as a precondition to ensure the proper implementation of market intervention policies. The findings of this study suggest that integration persists over the long term, as evidenced statistically by the cointegration equation. This equation reflects the dominance of a unidirectional and positive influence of rice prices in Banjarmasin City on rice prices in Kotabaru, with a significant level and elasticity. These results are consistent with the outcomes of Granger's paired causality test and the IRF graphic description in the Response of LNPK to the LNPB segment. The argument for the high dependence of rice prices in the Kotabaru market on the rice prices in the Banjarmasin City market refers, among other things, to the fact that, firstly, the Banjarmasin City market serves as the central market in South Kalimantan Province and can act as a reference market; and secondly, the supply of rice commodities in the Kotabaru market generally originates from the Banjarmasin City market or the surrounding regions that have traditionally been the main sources of rice supply to Banjarmasin City.

The implications of these conclusions suggest that the flow of information regarding rice price signals between the Banjarmasin and Kotabaru markets moves symmetrically, positioning the involved actors as price takers. It is crucial for the government, as a regulator, to maintain this conducive condition so that any implemented policy price interventions provide proportional benefits to all parties according to their positions. Further studies are recommended, particularly to evaluate the vertical integration between retail rice prices and producer-level paddy prices, to conclude whether the movement of rice prices at the consumer level influences and positively impacts the well-being of rice farmers.

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