Spatial market integration for food price stabilization during the Covid 19 pandemic in West Nusa Tenggara, Indonesia: A case study of the cayenne pepper

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Spatial market integration for food price stabilization during the Covid 19 pandemic in West Nusa Tenggara, Indonesia: A case study of the cayenne pepper

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Abstract. The Covid-19 pandemic can affect the movement and prices of agricultural commodities, including red chili peppers as a result of restrictions on community activities or lock-down. This study aims to empirically examine the spatial integration of the four main markets for cayenne pepper in West Nusa Tenggara, namely Mandalika (Mataram City), Aikmel (East Lombok), Seketeng (Sumbawa), and Amahami (Bima City).The analysis was carried out using the Johansen Cointegration Model and the Vector Error Correction Model (VECM) using weekly time series data. The results of the study concluded that the four markets studied are spatially integrated. The role of the Aikmel market is very dominant for the occurrence of price volatility compared to the other three markets.

1. Introduction

Although not as much as in the financial sector, empirical studies on spatial marketintegration in the agricultural sector have recently been carried out [1–3]. In general, the purpose of these studies is to evaluate the extent to which commodity price fluctuations in one market are transmitted spatially to other markets. This is based on the consideration that the degree of market integration has important implications for the formation of commodity prices that can affect the profits of traders [4]. Initially, the study of spatial cointegration was carried out by testing the degree of correlationand estimating its regression coefficient [5]. This analysis technique that uses time series economic data then raises problems in drawing conclusions.This is because the economic data used are generally non-stationary. The use of correlationand regression on non-stationary data can give inaccurate or misleading results.

It is increasingly important to conduct spatial market integration studies at a time when theworld is facing the Covid 19 pandemic [6,7]. In this condition, almost all countries restrict the movement of goods and people through lockdown,social distancing, and community movement restrictions [8]. As aresult of these various restrictions, the formation of commodity prices was disrupted and business risk increased both due to fluctuations on the supply side and on the demand side [9]. One of the agricultural commodities whose prices are volatile is cayenne pepper [10,11].This is commensurate with thepotential income generated by these plants where high price risk is followed by high profit potential (high risk but high return). Research by Zaini et al. and shows that even when the economic conditions of West Nusa Tenggara are normal, the volatility of chili prices on average is above one standard deviation, even in 2011 exceeds two standard deviations [12,13]. This shows that the study of spatial market integration as a transmission mechanism for the formation of cayenne pepper prices has a high urgency.

2. Material and methods

2.1. Data

The study was conducted using secondary data obtained from the website of the Strategic Food Price Information Center (PIHPS) where the data collection was carried out by Bank Indonesia.The data is in the form of time series on weekly retail prices of cayenne peppers in the four main markets of each district/city in West Nusa Tenggara Province. The four markets are Mandalika Market (Mataram City), Aikmel Market (East Lombok Regency), Seketeng Market (Sumbawa Regency), and Amahami Market (Bima City).

2.2. Analysis

2.2.1. Unit root test. Modeling begins with testing whether the price data used contains a unit root or not. If data contains a unit root (non stationery), the variance is no longer homoscedastic but heteroscedastic. Stationarity test is undertaken using Augmented Dickey-Fuller by including the time trend and autoregressive changes of Xt, as follow:

$$\Delta Xt = \alpha + \beta 1Xt - 1 + \beta 2t + \sum_{j=1}^{p} \gamma j + \Delta X_{t-j} + \varepsilon_t \quad (1)$$

with the amount of autoregressive lag p determined based on the AIC (Akaike Information Criterion). AIC is calculated based on the following formula (Serra, and Zilberman, 2009):

$$AIC = -2\ln(L) + 2k \quad (2)$$

where L represents the likelihood function value on the number of estimated parametersand k on the number of estimated parameters.

Hypothesis:

H0:β1 = 0 (there is a unit root),

Ha:β1 < 0 (no unit root).

The unit root statistical test was carried out by finding the value ($\hat{r}_C$)

$$r_{C=}\frac{\beta_1}{\beta_1} \quad (3)$$

If ($\hat{r}_C$) is greater than the critical value as contained in the -table (Dickey-Fuller) then reject H0 or P-value < 0.05 then H0 is rejected, otherwise H0 is accepted [14,15].

2.3. Optimal lag determination

Determination of the optimal lag length in the VAR/VECM model is very crucial to be able to determine the impact of one variable on other variables in the model. The use ofoptimal lag length allows the residuals between variables in the model to avoid the problems of normality and autocorrelation. Some of the criteria used to determine the optimal lag length are Swartz Information Criteria (SIC), Akaike Information Criteria (AIC), Likelihood Ratio (LR), Hanna-Quinn Criteria (HQ), and Final Pediction Error (FPE). In this study, all criteria were used and the determination of the optimal lag length was based on the lag length that met the most criteria.

2.4. Cointegration test

If there are two or more variables that are not stationary at the level but are stationary when being differentiated, it is reasonable to suspect that there is cointegration between these variables. The cointegration degree test is carried out with the Johansen Cointegration test to determine the number of cointegration equations that occur betweenvariables. The test is done by looking at the results of the Trace Test and the maximumEigen value (Maximum Eigen-Value). Johansen's equation formulation is:

$$\Delta P_t = \sum_{j=1}^{p-1} \Gamma i + \Delta P_{t-1} + \Pi P_{t-k} + \beta X_t + e_t \quad (4)$$

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The target variable in this study is the price of cayenne pepper in East Lombok Regencywhere about 80 harvested areas and 87% of production occur in this district. Another model variable is the price of cayenne pepper in the cities of Mataram, Sumbawa, and Bima. In the unrestricted VAR model, each variable has the same opportunity to becomean endogenous variable or an exogenous variable. However, if there is one or more cointegration between variables, the restricted VAR or VECM (Vector Error Correction Model) model is used [2].

2.5. VECM models

The equation for the restricted VAR or VECM model is expressed as follows:

$$\Delta P_t = \gamma_o + \sum_{i=1}^{m} \gamma_1 \, \Delta P_{t-i} + \sum_{i=1}^{m} \delta_1 \, \Delta X_{t-i} + e_{it}$$
$$ECT_{t-1} = P_{t-t} - \gamma_0 + \gamma_1 X_{t-1} \quad (5)$$

ECT_{t-1} =*error correction term*at time t-1

The ECT parameter indicates the adjustment speed towards long-term equilibrium whenthere is a short-term dynamic of the relationship between variables.

2.6. For cast Error Variance Decomposition (FEVD)

Decomposition of variance is a technique to obtain the relationship between the value ofthe variability of the target variable with the lag variable and other independent variables.Through this technique, it is known which independent variable has the greatest influence on the target variable over time. In other words, FEVD can provide information on how much turmoil caused by the uncertainty of a variable in the future affects other variables, especially target variables contained in the system.

2.7. Impulse Respond Function (IRF)

IRF describes how to estimate the impact of a shock of 1 standard deviation of one variable on other variables in the model and find out how long the effect of the shock orshock on the target variable. In addition, IRF can also provide shock information on which variable will give the greatest response to the target variable.

3. Results and discussion

3.1. Data identification

The data used in this study is weekly time series price data starting from the first week of March 2020, when the government officially announced the discovery of Covid 19 cases inIndonesia, until the third week of August 2021. In that time span the price development of red cayenne pepper in four regencies/cities show the same pattern of movement, namely thehighest price occurred in March. This is consistent with the results found by Zaini (2014) that the peak price of cayenne pepper in West Nusa Tenggara always occurs in March every year [13].

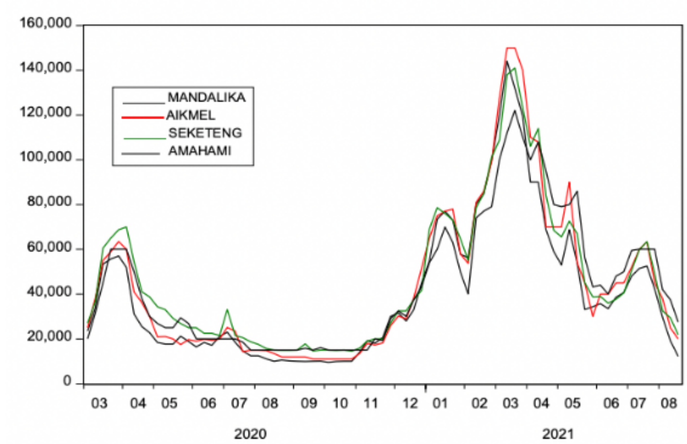

Figure 1. Cayenne pepper price movement during early period of Covid-19.

3.2. Unit root test

The unit root test is intended to determine whether the data from each research variable is stationary, because regression on non-stationary data will give inaccurate results. In addition, it is also used to determine the order of integration of each research variable. The test was carried out using the Augmented Dickey Fuller (ADF) test procedure and the test results are presented in the following Table 1.

Table 1. Unit root test and degree of integration using augmented dickey-fuller test.

Notation	Definition	*I(0)*	*I(1)*	*lag*	*P-value*
Variable					
MANDALIKA	Retail price at the Mandalika market	-1.9175	-5.6885	0	0.0001
AIKMEL	Retail price at Aikmel market	-1.7982	-6.6131	0	0.0000
SEKETENG	Retail price at Seketeng market	-1.8753	-6.0969	0	0.0000
AMAHAMI	Retail price at Amahami market	-1.4268	-6.5648	0	0.0000

From table 1 it can be seen that price data of cayenne pepper is not stationary at level but isintegrated on the order of one, I(1).

3.3. Johansen cointegration

Because the four variables have been integrated to the same order, I(1), the cointegration test is then carried out to find the most suitable model, whether the model is Vector Autoregression (VAR) or Vector Error Correction Model (VECM). Taking the logaritmic form, the test is carried out using the Johansen cointegrating test method by looking at the probability values from the Trace and Maximum Eigen statistics. The results of the estimatedcoefficients are presented in Table 2.

Table 2. Johansen cointegrating test results.

Date: 10/09/21 Time: 08:18
Sample (adjusted): 3/15/2020
8/15/2021 Included observations: 75
after adjustments Trend assumption:
Linear deterministic trend
Series: LAIKMEL LMANDALIKA LSEKETENG LAMAHAMI
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None *	0.346509	59.41921	47.85613	0.0029
At most 1	0.192212	27.51217	29.79707	0.0897
At most 2	0.105408	11.50295	15.49471	0.1824
At most 3	0.041116	3.148883	3.841466	0.0760

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

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Hypothesized No. of CE(s)	Max-Eigen Statistics	0.05 Critical Value	Prob.**
None *	0.346509	31.90704	27.58434	0.0130
At most 1	0.192212	16.00921	21.13162	0.2243
At most 2	0.105408	8.354071	14.26460	0.3439
At most 3	0.041116	3.148883	3.841466	0.0760

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

The results of the Trace test and Maximum Eigen statistics indicate that there is one cointegration equation in the model. This means that there is a long-term relationship between cayenne pepper prices in the Aikmel market and the Mandalika, Seketeng, and Amahami markets. For this reason, the normalized cointegrating coefficients were tested toobtain more complete information on the long-term relationship between these variables as seen in the table 3.

Table 3. Normalized cointegration coefficient.

LAIKMEL	LMANDALIKA	LSEKETENG	LAMAHAMI
1.0000000	-0.626741	-0.122980	-0.290293
	(0.09932)	(0.11849)	(0.09288)
t-statistics	6.0607*	1.0696	3.1248

3.4. Normalized cointegrating coefficients (standard error in parentheses)
The sign on the normalized cointegration coefficient should be read the other way around, namely that

there is a positive influence from the Mandalika, Seketeng, and Amahami markets on the price of cayenne pepper in the Aikmel market. This means that a 10% increase in the price of cayenne pepper in the Mandalika market causes a 6.27% increase inthe price in the Aikmel market.

3.5. Vector Error Correction Model (VECM)

Since there is cointegration between variables, the Vector Error Correction model (VECM) is the most suitable alternative model to be used in the analysis. VECM, also known as restricted VAR (Vector Autoregression), is a very useful model for explaining short-term price dynamics between markets without losing information about long-term relationships.In addition, VECM provides information about the speed of adjustment in the event of a shock in one of the variables to reach its long-term equilibrium. However, this model is onlysuitable if the data for each variable is not stationary in level, integrated on the order 1, I(1)and there is cointegration between variables as in this study.

In this study, VECM is used primarily to obtain an explanation of the short-term dynamics of cayenne pepper prices in four markets with the Aikmel market as the target variable. Theparameter estimation results are presented in the following equation:

$$\Delta LAIKMEL_t = -0.8066\, ECT_{t-1} + 0.1386\, \Delta LAIKMEL_{t-1} + 0.3242\, \Delta LMANDALIKA_{t-1} + 0.0987\, \Delta LSEKETENG_{t-1} - 0.1222\, \Delta LAMAHAMI_{t-1} - 0.0067$$

$$ECT_{t-1} = 1.000\, LAIKMEL_{t-1} - 0.6267\, LMANDALIKA_{t-1} - 0.1230\, LSEKETENG_{t-1} - 0.2903\, LAMAHAMI_{t-1} + 0.3815$$

The estimation results show that the main parameters of ECT, error correction term, are in accordance with the theory. To ensure a long-term equilibrium price relationship between markets, the γ_1 coefficient has negative sign and is less than 1. The ECT coefficient of 0.8066 ($-0.8066\ ECT_{t-1}$) means that deviations from the long-term equilibrium of the previous period are corrected in the current period with an adjustment speed of 80.66%. In the short term this week's cayenne pepper prices in Aikmel were positively influenced by cayenne pepper prices in the Aikmel, Mandalika, and Seketeng markets in the previous weekand negatively by Amahami markets. However, in the long run, these market prices have a positive effect on prices in the Aikmel market, with the Mandalika market the biggest influence.

3.6. Forcast Error Variance Decomposition (FEVD)

Further interpretation of VECM is easier to do through the decomposition of the variance. Decomposition of variance is one technique to obtain information about the relationship between price variations on the target variable with the variance of the variable itself in theprevious period and the variance of other explanatory variables. The variance decompositionvalue of the target variable for the next 4 weeks is presented in the following Table 4.

Table 4. Decomposition of variance using VECM.

Variance Decomposition of LAIKMEL:					
Periode	SE	LAIKMEL	LMANDALIKA	LSEKETENG	LAMAHAMI
1	0.172407	100.0000	0.000000	0.000000	0.000000
2	0.289832	88.85413	10.50746	0.492705	0.145699
3	0.405076	81.91964	17.59506	0.273949	0.211351
4	0.506053	77.07494	22.42945	0.231428	0.264177

In period 1 the forecast error variance of cayenne pepper prices in the Aikmel market 100%came from the error variance of the variable itself, while the contribution of the error variance of other variables did not exist. However, with the passage of time, the role of the error variance of other variables, especially the Mandalika market, is getting bigger while the contribution of the Aikmel market's own error variance is decreasing. In week 4, the contribution of the Mandalika market increased by 22.4% in explaining the variation of pricevariance in the Aikmel market. The total contribution of each market in each period is 100%. More complete information about the contribution of each error variance to the error variance of each market for the next 10 periods is graphically presented in Figure 2.

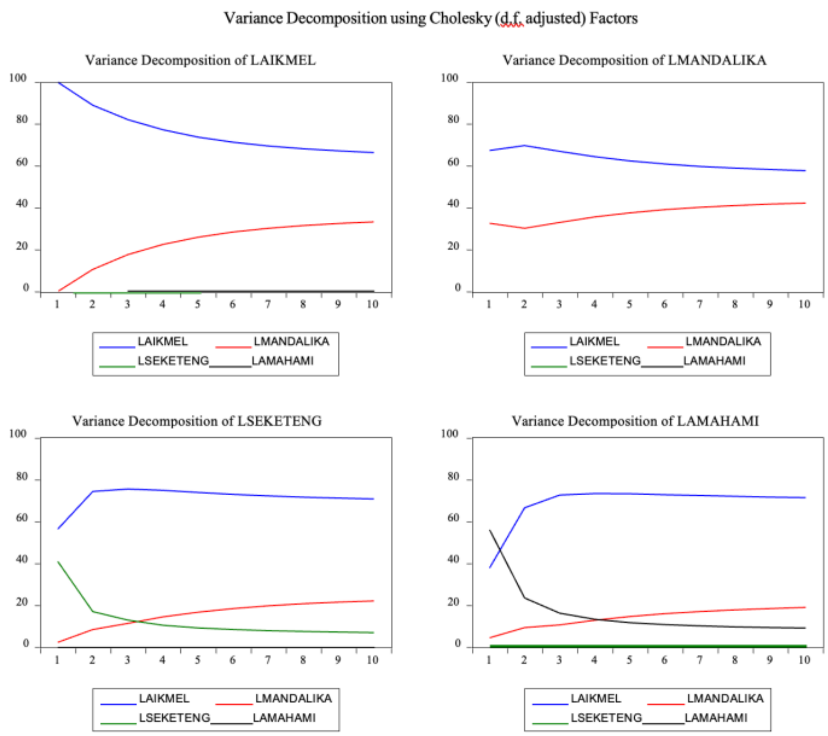

Figure 2. Decomposition of variance in the four main markets

From the graph, it can be seen that for all markets, the contribution of the cayenne pepper price error variance in the Aikmel market is very large to other market error variants. In other words, the contribution of chili price fluctuations that occurred in the Aikmel market was very strong, exceeding the fluctuations originating from markets in other districts/citiesthemselves. The implication is to stabilize chili prices in West Nusa Tenggara, starting withprice stabilization in the Aikmel market, East Lombok Regency, where around 80 harvestedareas and 87% of production occur in this district.

3.7. Impulse Respond Function (IRF)

IRF describes how to estimate the impact of a shock of 1 standard deviation of one variableon other variables in the model and find out how long the effect of the shock or shock on thetarget variable. In addition, IRF can also provide shock information on which variable will give the greatest response to the target variable as shown in the following picture.

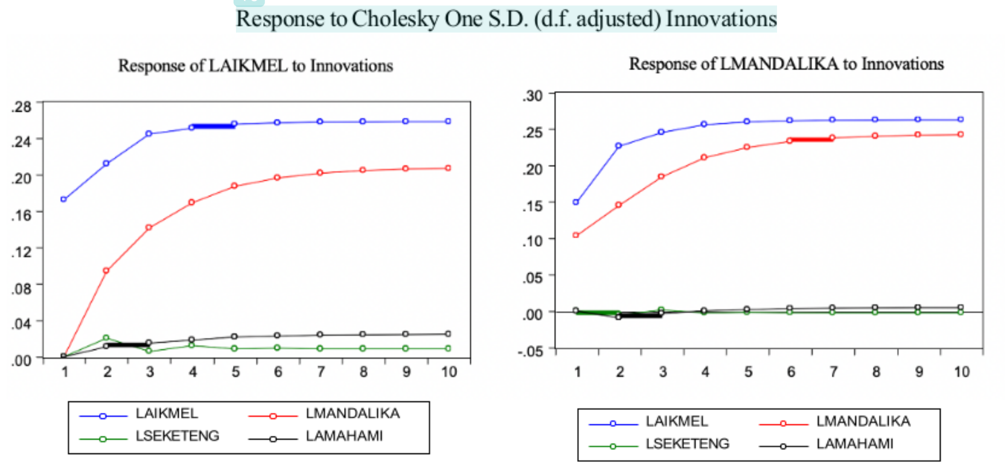

Figure 3. Responses of the two main markets to price shocks in four markets.

IRF analysis was conducted on two main markets, namely Aikmel and Mandalika which showed the largest contribution to price fluctuations. The analysis emphasizes the evolutionof the response because the data used has been transformed in logarithmic form. If there is a positive shock of 1 standard deviation in the Aikmel market in the current period, the pricein the Aikmel market will increase sharply for the next 3 weeks and then slope down. However, if the shock occurs in the Mandalika market, the impact on the increase in the price of cayenne pepper in the Aikmel market is also relatively large until the 5th week. After that, the impact of the shock begins to slow towards a steady state until the 10th week.However, if the shock occurs in the Seketeng market and understand the impact on the increase in chili prices in Aikmel is relatively very small, not even impact on the Mandalikamarket. The following figure presents the responses of the two main variables in the event of a shock of 1 standard deviation.

4. Conclusion

Based on the results and the previous discussion, it can be concluded that the four markets studied, namely Mandalika, Aikmel, Seketeng and Amahami are spatially integrated. This means that there is a long-run equilibrium relationship between the four markets. Furthermore, if there is a price shock in one of the markets studied, the adjustment in the Aikmel market is the fastest as indicated by the adjustment speed value of 80.6 percent. Finally, the role of the Aikmel market is very dominant for the occurrence of price volatility compared to other markets.

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