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Integration of Maize Market in Indonesia

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Abstract: Maize plays a major role inserving asraw material for animal feed, especially in poultry, and is an important commodity not only in Indonesia but also worldwide. Maize production and consumption centers are spread out across several provinces in Indonesia.Additionally, differences in harvest seasons result ina disparity in supply and demand,leading to interprovincial trade. The flow of trade of maize from surplus provinces to deficit provinces indicatesthat there is market integration among provinces.An understanding of market integration is useful in determining policies related to price stabilization and market efficiency. This study aimed to analyze the spatial integration of maize markets in Indonesia. Monthlyprice data for 10 years from 13 selected provinceswere used in this study. The methods used included the Johansen cointegrationtest and error correction model. The study results proved that there is no full integration among maize markets in Indonesia. However, there is partial market integration among provinces. Provincesthat consume maize have a short- and long-term price relationship with the maize-producing provinces. However, provinces with production and consumption centers tend to integrate with other provinces in the long run. East Java, West Sumatra, Banten, and West Nusa Tenggara are the most integrated provinces, so policies aimed at stabilizing maize prices would be better if they focus on these provinces and consider the timeframe of the policies to be implemented.

Keywords: market integration, spatial integration, maize, error correction model

1. Introduction

Maize is the second most important food crop in Indonesia after paddy. However, the production of maize as human food is only 30%. The main use of maizeis animal feed,and the production of maize as animal feed is>62%. Moreover, maize can be used as seeds or for other purposes(Pusdatin Pertanian, 2018). Because of the development of the poultry industry in Indonesia,the demand and production of maize increased. In 2014–2018, maize production in Indonesia increased by 36.75%. Most of the maize crops in

Indonesia are cultivated in several provinces with production centers, and approximately84.66% of maizeproduction iscarried out by 10 provinces that are located in different islands of Indonesia (PusdatinPertanian, 2019). Except for East Nusa Tenggara, West Nusa Tenggara, and Gorontalo, someprovincesthat produce maize arealso feed factory and poultry industry centers. However, other provinces, such as Banten, West Kalimantan, and South Kalimantan,whichare centeredon poultry and feed factories,are not maize producers.

There are differences in harvest seasons in maize-producing provinces in Indonesia. Some provinces produce maize in the rainy season,whereas other provinces produce maize in the dry season. This difference in harvest seasons results in a supply difference in each province. Of note, seasonal changes that occur throughout the year affect the supply of maize. Maize-producing provinces are considered surplus provinces, whereas provinces with feed factories and poultry industriesare considered deficit provinces. However, differences in harvest seasons can result in a surplus province becoming a deficit province, especially if the province has feed factories and poultry industries. Furthermore, the demand for maize, which is mostly used for animal feed, tends to be consistent. Eventually, differencesin maize supply will leadto differences in maize prices in each province throughout the year.

The differences in maize supply and prices among provinces lead to maize trade among provinces. This interprovincial trade indicates the occurrence of integration among maize markets. The change in price in 1 market may be passed on to another market, especially if the 2 markets trade with each other. This movement of price among markets can occur if the price changes are responded to well by the market player. Takayama and Judge stated that the market is integrated if prices are determined interdependently (Munir et al. 2016). Market integration is an indicator of marketing efficiency.It is considered that its existence indicates that the difference in price between the 2 markets is close to the costs required for marketing activities.

In an integrated market, a dominant market canbecome a reference market. The reference market can influence the formation of prices in other markets and can set the national price in the long run. Rashid (2003) stated that prices formed in the long run can be influenced by market location. Therefore, government policies related to price stability will get the desired results if the policies are aimed at these markets. Knowing the conditions of maize market integration in Indonesia helpsin determining the policies related to the maize trade. Trade policies that are often a concern are related to the distribution and stability of maize prices, including decisions on maize imports. Here, we hoped that the spatial integration of the maize market in Indonesia will be known so that it can be used to provide recommendations for policymakers.

2. Data and Method

This study used secondary data of time series maize price on farmer (producer) level in the 13 selected provinces. Province selection was based on the following: the province was producing maize, the province was central to the poultry industry and feed factory, or the province was producing maize and central to the poultry industry and feed factory. The selected provinces were East Java, Gorontalo, Central Java, Banten, Lampung, South Sulawesi, West Kalimantan, West Nusa Tenggara, North Sumatra, West Java, West

Sumatra, East Nusa Tenggara, and South Kalimantan. The analysis used 10 years monthly price from January 2010 to December 2019 from the Indonesian Central Bureau of Statistics. This study examined data using the error correction model(ECM),which consists of the unit root test, determination of optimum lag, cointegration test, and vector ECM (VECM) estimation. The Eviews 10 software was used for data processing. This study aimed to determine the integration relationship among the maize markets in Indonesia based on a cointegration test.

Unit Root Test

Because time series data can be nonstationary, a stationarity test was used to determine the characteristics of the data used in the study. The data are stationary if the statistical parameter values are constant over time, or the data do not have a trend in its statistical parameters. The Augmented Dickey-Fuller (ADF) unit root test was used with the followingequation model:

$$\Delta P_t = \alpha_0 + \gamma P_{t-1} \sum_{i=1}^{p} \beta_i \Delta P_{t-i} + \varepsilon_t$$

ΔPt is the first derivative (first difference) of the tested variable (Pt-Pt-1). *t* is the time, γ and β are model coefficients, and εt is the model error. The statistical hypotheses used were as follows: H_0: $\gamma = 0$ (the data series used are nonstationary)and H_1: $\gamma \neq 0$ (the data series used are stationary). Furthermore, the differentiation of nonstationary data was carried out. This differentiation can be performed up to several times as needed until the data becomes stationary.

Determination of Optimum Lag

The optimum lag length determines how long it takes for the variableto influence other variables in the model. Additionally, determining the optimum lag avoids residual autocorrelation in the model. Therefore, the optimum lag length needs to be determined to form the vector autoregression (VAR) model. There are 5 criteria used in determining the optimum lag:likelihood ratio (LR), Hannan–Quinn information criterion (HQIC), Akaike information criterion (AIC),final prediction error (FPE), and Schwarz information criterion (SIC). The optimal lag length is obtained when the HQIC, AIC, FPE, and SIC have the smallest absolute values while the largest value for the LR criteria is used. A total of 78 pairs of maize markets were made from a combination of 13 selected provinces, and most pairs had the first or second lag based on the best criteria. The small lag is considered to fit with the model and is good considering that the small lag can also avoid the likelihood of multicollinearity.

Cointegration Test

The cointegration test is used to determine the existence of balance that occurs in time series data or a long-run equilibrium relationship. The variables in the model are cointegrated if the existing variables are integrated to the same degree. The cointegration test used in this study is based on the Johansen method or

the Johansen cointegration test. To see the existence of a long-term relationship, 2 testing methods are used, namely, the trace test (λtrace) and max eigenvalue test (λmax), which are formulated in the following equations:

$$\lambda_{trace} = -T \sum_{i=k+1}^{n} (1 - \lambda_i)$$
$$\lambda_{max}(r, r+1) = -Tln(1 - \lambda_{r+1})$$

where*k* indicates 0,1, ..., *n*-1; *T*indicates the number of observations; λi indicatesthe value estimated number-*i* lag eigenvalue from Π matrix; and *r* indicates the number of vectors from the cointegration vector on the null hypothesis.

Decision-making is performed by comparing the values of the trace and max eigenvalue statisticswith the critical value. If the values of the trace and max eigenvalue statisticsare greater than the critical value, then H_0 is rejected, which means that there is a cointegration or long-run equilibrium relationship in the system of equations. Conversely, if the values of the trace and max eigenvalue statisticsare less than the critical value, then H_0 is accepted, which means that there is no cointegration or long-run equilibrium relationship in the system of equations (Firdaus, 2011).

Vector Error Correction Model

After knowing the stationarity of the data through the stationarity test, it can be known whether the data are stationary or not. If the data are stationary, then VAR can be used at *I*(0);however, if the data are not stationary, it needs to be lowered (differences) until it is stationary. Usually, if the time series data at the level or the log level are not stationary, the first derivative (first differences) or *I*(1) will be stationary (Hills et al., 2011). When the variable is *I*(1) and cointegrated, it is necessary to change the modeling framework to allow cointegration among variables. The model in question is a VECM, which includes a cointegration relationship. Here, the ECM is used more to determine the short-term dynamics in maize prices in spatially separated markets. In this case, the speed adjustment obtained from the error correction term (ECT) is used. This analysis process is performed in2 stages. The first stage estimates the cointegration with the following equations:

$$\Delta P_t^a = \beta_1 + \beta_2 + \delta PP_{t-1}^a + \sum_{i=1}^{l} \alpha_1 \Delta P_{t-1}^a + \varepsilon_t$$
$$\Delta P_t^b = \beta_1 + \beta_2 + \delta PP_{t-1}^b + \sum_{i=1}^{l} \alpha_1 \Delta P_{t-1}^b + \varepsilon_t$$

whereP_t^a indicates the maize price in province a at time *t*; P_t^b indicatesthe maize price in province b at time *t*; *t* indicates the trend of time; *l* indicatesthe optimum lag; Δ indicatesthe first differentiation operator;ε indicates theerror term; $\beta 1$ indicatesthe intercept (drift); and $\beta 2$ indicates thetrend.
Furthermore, the ECM can be estimated using the following equations:

$$\widehat{\Delta P_t^a} = \alpha_0 + \alpha_1 \Delta P_{t-1}^b + \alpha_2 \hat{u}_{t-1} + \varepsilon_t$$

$$\hat{u}_{t-1} = \widehat{\Delta P_t^a} - \alpha_0 - \alpha_1 \Delta P_{t-1}^b - \alpha_2$$

where α1 describes the short-term effect and α2 describes the speed of error correction. In this case, α2 becomes a matter of concern in the ECM because it can describe the dynamics in the system that explains the level of the variable's ability to adjust to equilibrium conditions. Short-term system dynamics analysis will explain the speed of price transmission, thereby knowing the time it takes for prices in 1 market to be transmitted to other places (Jubaedah, 2013).

3. Findings

Unit Root Test

The ADF unit root test results on each provinceare shown in Table 1. The test resultsshowed that at level I(0), all the ADF probability values were higher than the critical value at 10% confidence level, which means the test failed to reject the null hypothesis. In contrast, all priceswere not stationary in level I(0). Furthermore, the unit root test in first difference I(1) shows that all probability values were lower than the critical value (confidence level of 1%),which means that the test rejected the null hypothesis and it can be inferred that all prices were stationary in the first difference. Based on this result, the cointegration test using the Johansen cointegration test can proceed.

Table 1 Unit root test

Province	Probability		Note
	Level I(0)	First differenceI(1)	
West Java	0.0761	0	stationary on 1diff
South Kalimantan	0.8828	0	stationary on 1diff
North Sumatra	0.7330	0	stationary on 1diff
East Nusa Tenggara	0.7398	0	stationary on 1diff
West Sumatra	0.7516	0	stationary on 1diff
Banten	0.8196	0	stationary on 1diff
Central Java	0.8742	0	stationary on 1diff
West Nusa Tenggara	0.9355	0	stationary on 1diff
Gorontalo	0.9319	0	stationary on 1diff
Lampung	0.9416	0	stationary on 1diff
East Java	0.9535	0	stationary on 1diff
West Kalimantan	0.9773	0	stationary on 1diff
South Sulawesi	0.9892	0	stationary on 1diff

Source: Author Calculation

Long-Term Dynamics of the Maize Market in Indonesia

The Johansen cointegration test was used to examine the long-termdynamics in the Indonesian maize market. The test result from 78 pairs of maize markets showed that 55 market pairs (70.51%) were not cointegrated and 23 market pairs (29.49%) were cointegrated. This indicated that most prices in the paired markets did not move together in the long run or that there is no full cointegration present among the maize markets in Indonesia. Table 2 shows the integration relationship among the maize markets in Indonesia based on the Johansen cointegration test.

Table 2 Long-run integration relationship among the maize markets in Indonesia

Province	Relationship
Banten	Integrated with West Nusa Tenggara, Gorontalo, East Java, West Sumatra, Central Java, Lampung,South Sulawesi, and West Kalimantan
Gorontalo	Integrated with West Nusa Tenggara and Banten
West Java	Integrated with West Sumatra
West Nusa Tenggara	Integrated with East Java, West Kalimantan, Gorontalo, South Kalimantan, Banten, West Sumatra, and South Sulawesi
Central java	Integrated with West Sumatra and Banten
West Kalimantan	Integrated with West Nusa Tenggara Banten and East Java
East Java	Integrated with Banten, West Kalimantan, West Sumatra, West Nusa Tenggara, and South Kalimantan
South Kalimantan	Integrated with East Java, East Nusa Tenggara, and West Nusa Tenggara
Lampung	Integrated with Banten
East Nusa Tenggara	Integrated with South Kalimantan, and North Sumatra
South Sulawesi	Integrated with West Sumatra, Banten, and West Nusa Tenggara
West Sumatra	Integrated with South Sulawesi, Banten, West Java, North Sumatra, East Java, West Nusa Tenggara, and Central Java
North Sumatra	Integrated with West Sumatra, and East Nusa Tenggara

Source: Author Calculation

The Provinceof Bantenhas the highest number ofcointegration relationships among the other provinces. As Banten iscenteredon the poultry industry and feed factory, its maize market has integratedwith 8 markets. Most were maize-producing provinces except for West Kalimantan. Banten was the second province with the highest number of poultry industries after West Java.However, Banten was not the center of maize production. Furthermore,the maize used in this province were imported from outside, which explains the integration relationship between Banten and other provinces. The results aligned withSrofenyoh(2020),indicating that most maize consumer markets have long-term relationships with maize-producing markets.

Along with West Sumatra, West Nusa Tenggara, the center of maize production but not centered onthe poultry industry and feed factory, is the second province with the highest number of cointegration relationships(7 integration relationships). The Province of West Nusa Tenggara has the opposite scenario to

the Province of Banten, where the maize produced in West Nusa Tenggara was exported to another province. This explainsthe province's maize market integration relationship with other markets. In contrast, despite West Sumatra being the maize-producing province that is the center of the poultry industry and feed factory, the province only had a small number of poultry industries and feed factories. Thisindicated that maize produced in this province was exported to other provinces. Furthermore, this explains why West Sumatra has morecointegration relationshipsthan West Nusa Tenggara.

East Java is the largest maize-producing province and hasan integration relationship with Banten, West Kalimantan, West Sumatra, South Kalimantan, and West Nusa Tenggara. The first 3 provinces are not producingmaize, indicating that the maize used in these provinces were imported from East Java. As West Nusa Tenggara is close to East Java,West Nusa Tenggaracould have traded maize with East Java before distributing the maize to otherprovinces. As East Java is also a province with the highest number of feed factories, this province may have imported maize from other provinces. The provinces of West Kalimantan, South Kalimantan, and South Sulawesi each have 3 integration relationships. Apart from Banten, West Kalimantan and South Kalimantan are centered onthe poultry industry and feed factory and are not producing maize. In contrast, Gorontalo, the maize-producing province that was not centered on the poultry industry and feed factory, has 2 integration relationships. It is the same for Central Java, East Nusa Tenggara, and North Sumatra. Lampung and West Java became the least integrated markets with only 2 integration relationships. Thisindicated that most maize produced in these provinces were not traded to the outside.

The cointegration analysis result in this study found that the long-run integration of the maize market in Indonesia tends to be affected by the characteristics of maize usage in that province. The maize-producing provinces have the propensity to be integrated with provincescentered on the poultry industry and feed factory. Provinces only producing maize are considered surplus provinces,whereas provinces with only feed factories and poultry industriesare considered deficit provinces.As such, the maize trade will be from the surplus provinces to the deficit provinces. Furthermore, the maize-producing province that is also centeredon the poultry industry and feed factory tends to trade maize mostly inside the province, making the province have less integration provinces,regardless of the differences in harvest seasons that increase the probability of interprovince trading. Nevertheless, the result of the cointegration analysis in this study could not describe the maize trade in Indonesia because the analysis only saw how the price in the paired market moves together in the longrun.

The Johansen cointegration test examined the long-run equilibrium relationship (long-run dynamic) between the maize market pair. The situation may be different in the short run because there is a possibility that the equilibrium may not be achieved in the short run,even though there is a balance in the long run (Rahmawati et al., 2018). The short-run equilibrium tends to be more dynamic, and there areadjustmentsperformed by economic actors involved in maize trade. Theseadjustmentsare made to cope with the differences between the actual and desired conditions. In the end, a market pair that was not integrated into the long run may be integrated in a shorter period.

Short-Run Dynamics of the Maize Market in Indonesia

The short-run dynamics were observed using the ECT coefficient in the VECM. According to Wimanda, to facilitate the description of short-run dynamics, the provinces can be divided into 3 groups based on the ECT coefficient (speed adjustment) value (Jubaedah, 2013):the high group with less than −0.200 speed adjustment, the moderate group with−0.100 to −0.200 speed adjustment, and the low group with greater than −0.100 speed adjustment. Rahmawati et al. (2018)noted that the coefficient must be significant and have a negative sign to match the requirement. The significant negative coefficient shows how quickly the system comes to equilibrium. Conversely, the positive sign indicates that the system would not return to equilibrium but move further away.

The West Java and South Sulawesi pair has the slowest speed adjustment with a coefficient value of −0.0015 ECT. In contrast, the pair with the fastest speed adjustment belongs to the Banten and West Sumatra pair with a coefficient value of −0.2160 ECT. The short-run relationship between Banten and West Sumatra was the only pair with a high-speed adjustment that met the requirement (ECT coefficient was significant and had a negative sign). More than 42 pairs (53.85%) have low-speed adjustment;furthermore, 14 pairs (17.95%) have moderate-speed adjustment, and 21 pairs (26.92%) did not have a short-run integration relationship. The pairs with ECT coefficientsthat did not indicate significance or had positive signs were not integrated. Table 3 shows the summary of the ECT coefficient or speed adjustment in the analysis of the short-run dynamics.

A total of 57 pairs (73.08%) had a short-run integration relationship, although most had a low-speed adjustment. This number was higher than the integration in the long run, where only 23 pairs of provinces (29.49%) were integrated. As such, the maize markets in Indonesia are more integrated in the short run, and these integration relationships do not always last in the long term. For example, Banten has short-run integration relationships with North Sumatra and East Nusa Tenggara, but these relationships do not happen in the long run. On the contrary, some pairs were integrated in the long run but not in the short run, just like the long-run integration relationship between Banten and Lampung that did not exist in the short run.

Based on the ECT coefficient value, West Sumatra has the greatest number ofshort-run integration relationships with high- and moderate-speed adjustments followed by Banten. In contrast, East Java, the largest maize-producing province in Indonesia, only has a short-run integration relationship with low-speed adjustment. However, in the long run, East Java was integrated with 5 other provinces. This condition can happen because East Java isa province that has the highest number of feed factories. In the short run, most of the maize produced in East Java were used inside the province, and the long-run relationships occurred because of the differences in maize harvesting season that affected the maize supply and increased the chance for interprovincial trade.

Provinces have a higher probability of becoming production and consumer centers in long-run interprovincial maize trade than in short-run interprovincial maize trade. The maize-producing provinces that have feed factories and are centered on the poultry industry tend to trade maize within the province rather than outside in the short run. However, provinces that consume maize, such as Banten, will trade with other provinces even if it is in the short run or long run;therefore, this province tends to be more integrated. In West Sumatra, although this province is a center of production and consumption, there are

only a few feed factories and poultry industries compared with others;therefore, this province is still in a state of surplus production in the short term.

Table 3 Short-run dynamics among the maize markets in Indonesia

Province	Speed Adjustment Between Province
Banten	Moderate-speed adjustment with Central Java, East Nusa Tenggara, and North Sumatra;high-speed adjustment with West Sumatra
Gorontalo	Moderate-speed adjustment with Central Java and East Nusa Tenggara
East Java	—
West Kalimantan	Moderate-speed adjustment with East Nusa Tenggara
Central java	Moderate-speed adjustment with Banten and Gorontalo
South Kalimantan	Moderate-speed adjustment with West Sumatra and East Nusa Tenggara
West Java	Moderate-speed adjustment with West Sumatra
Lampung	Moderate-speed adjustment with East Nusa Tenggara
West Sumatra	Moderate-speed adjustment with West Java, East Nusa Tenggara, South Kalimantan, and West Nusa Tenggara;high-speed adjustment with Banten
West Nusa Tenggara	Moderate-speed adjustment with North Sumatra and West Sumatra
East Nusa Tenggara	Moderate-speed adjustment with Banten, Gorontalo, and West Sumatra
North Sumatra	Moderate-speed adjustment with Banten, West Nusa Tenggara, and South Sulawesi
South Sulawesi	Moderate-speed adjustment with North Sumatra

Source: Author Calculation

The maize market in Indonesia tends to integrate in the short run;however, because most of the pairs' speed adjustmentswere low, it will take longer to correct the short-run balance fluctuation to the long-run equilibrium.The Banten and West Sumatra pair, the fastest speed adjustment, only had a coefficient value of −0.2160 ECT, which is still on the lower limit of high-speed adjustment. This ECT coefficient value indicated that approximately 21.60% of the adjustment process of error correction occurred in the first month, and the rest of the adjustments occurred in the following months.Low-speed adjustment can indicate that the price transmission process that occurs is not running perfectly.

The low degree of market integration can be caused by several factors, such as province remoteness, poor infrastructure conditions, and lack of ability of producers and marketers to capture price information (Zant, 2010;Varela et al., 2013). The maize market needs to be integrated because poorly integrated markets will make the price mechanism not work properly and price signals not be transmitted across spatial markets. The government's role in infrastructure development is not only to carry out direct development but also to increase private interests through the development of a good investment climate. Besides physical capital,

human capital is also adeterminant of market integration because increases in human capital will increase the speed and accuracy of the flow of information (González-Rivera and Helfand, 2001).

Managerial Implication

Based on the short- and long-run dynamics of the maize market in Indonesia, Banten, East Java, West Nusa Tenggara, and West Sumatra have more integration relationships than other provinces. Banten, West Nusa Tenggara, and West Sumatera tend to integratein the short run and long run,whereas East Java tends to integrate in the long run. The changes that occur in maize prices in these 4 provinces will affect the maize price in other provinces. Thus, the policies taken to stabilize maize prices should be focused on the 4 provinces to influence other provinces.As such, the policies taken should have desired results. The types of policies taken depend on the policies' goal, whether it aims to stabilize price in a short period (affects more quickly) or has a long-term goal.

Most maize-producing provinces tend to integrate in the long run, whereas provinces that consume maize tend to integrate in the short run and long run. Therefore, if the government aims to restore the stability of fluctuating maize prices immediately, the policies taken will be inappropriate if applied to maize-producing provinces. Policies to quickly stabilize maize prices need to be aimed at provinces that are centers of consumption rather than centers of production. Thus, the stability of maize prices can be obtained faster and spread well. In contrast, the government can apply policies with long-term goals to maize-producing provinces. Thus, the policies adopted are expected to meet the needs of producers and consumers of maize in Indonesia.

4. Conclusion and Recommendation

Conclusion

This study found that maize markets in Indonesia are not fully integrated because only 23 market pairs (29.49%) were cointegrated and 55 market pairs (70.51%) were not cointegrated. There is a tendency for low-speed adjustment to make price movements move slowly. The maize market tends to be more integrated in the short run, especially in provinces that consume maize. Furthermore, there is evidence that provincesthat consume maize have a price relationship with maize-producing provinces in the short run and long run. In contrast, provinces with both production and consumption centers tend to only integrate with other provinces in the long run.

Recommendation

This study described the integration of the maize market in Indonesia. However, several study limitations need to be improved to have excellent results in the future. Based on the result, some suggestions are provided as follows:

Banten, East Java, West Sumatra, and West Nusa Tenggarawere the most integrated provinces; thus, price changes that occur in these 4 provinces are immediately transmitted to other provinces. Therefore, policies

aiming to stabilize maize prices in Indonesia would be better if focused on these provinces. However, it is necessary to look at the timeframe for the policies to be implemented. Policies with short-term goals are more suitable for consumption centers, whereas policies with long-term goals are more suitablefor production centers.

The government can use policies that stabilize maize prices to increase the integration of the maize market in Indonesia, which is relatively low. Infrastructure development, such as roads and postharvest warehouses,and planning and increasing maize production to improve the quality of human resources involved in maize production and marketing activities are examples of long-term policies that the government can apply.

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