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Research Article

Spatial Study on How COVID-19 Affects the Indonesian Rice Markets Integration: Period of March to July 2020

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Abstract

This study applied the co-integration tests with daily rice prices from 25th July 2016 to 2nd July 2020. The dummy variable in this study is based on the initial COVID-19 case in Indonesia, which was confirmed on 2nd March 2020. The main objective of this paper is to investigate the impact of the COVID-19 pandemic on rice prices transmission in several regions of producers (Surabaya and Semarang) and consumers (Serang, Jakarta, Bandung, and Yogyakarta) markets in Java, Indonesia. Analysis data used is the average daily price in a wholesale market and a group of traditional markets. Error correction model estimation results show an integration among the rice markets and the long-term equilibrium adjustment process, which is relatively slow. However, this study's empirical results confirm that implementing the COVID-19 control program in the short-term does not cause changes in rice prices currently in Jakarta.

Keywords
Rice Prices; COVID-19; Market Integration; Error Correction Model; Wholesale Market; Traditional Markets.

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Introduction

The first coronavirus pneumonia (COVID-19) outbreak, which was first reported to occur in Wuhan, the capital of Hubei Province, China, on December 31, 2019, has spread rapidly throughout the world and has been classified as a global epidemic. At present, all countries in the world have struggled to anticipate the influence of COVID-19 in various fields at the micro and macro level (Gong et al., 2020). COVID-19 is considered to harm the economy in the short-term. It affects the ability of economic stabilization in the long-term. Uncertainty about future epidemics and the international community's vigilance on their spread can also reduce the process of economic development. The COVID-19 outbreak has given new challenges to researchers regarding the performance of various social and economic sectors.

COVID-19 has exponentially spread in every region and has influenced various people's daily activities, production activities, business, and trade. Various preventive measures such as health protocols, social distancing, self-isolation, and travel restrictions have been implemented in each region to limit the spread of COVID-19. Besides, various countries have introduced regional quarantine to control the spread of the virus. Uncertainty and vigilance towards the spread of epidemics in the future can reduce the performance of various economic sectors such as the agricultural sector, especially in limiting access to crops so that there is an accumulation of fresh agricultural products that cannot be distributed across the region. On the other hand, during the current pandemic, the distribution of staple foods still needs to be improved to maintain a balanced market performance (Food and Agriculture Organization, 2020).

Indonesia is the fourth most populous country in the world wherein 2018, and it reached around 267.67 million people or around 3.52% of the world's population (World Bank, 2020). Based on these conditions, Indonesia is predicted to face a huge impact of COVID-19 and a longer period than other countries with a lower population. On 4th February 2020, the Ministry of Health of the Republic of Indonesia had determined a novel coronavirus infection (infection 2019-nCoV) as a disease that can cause an outbreak and its prevention efforts through KMK No. HK.01.07 / MENKES / 104/2020. Meanwhile, on 2nd March 2020, the government had confirmed the first two COVID-19 cases in Indonesia. As of 2nd April 2020, COVID-19 cases in Indonesia were confirmed to have reached 1,790, with details of 1,508 being treated, 170 dead, and 112 recovering (Ministry of Health, 2020).

The spread of COVID-19 in Indonesia from 18th March 2020 to 2nd July 2020 has been confirmed to reach 2,580,441 positive cases (Ministry of Health, 2020). Java became the region with the most significant spread of cases in Indonesia, which reached around 1,595,182 positive cases or 61.82% of Indonesia's total cases during that period. Java Island consists of 6 provinces, i.e., Banten, the Special Capital Region of Jakarta (DKI. Jakarta), West Java, Central Java, Special Region of Yogyakarta (D.I. Yogyakarta), and East Java. From 18th March 2020 to 2nd July 2020, the most significant spread of COVID-19 was in the Provinces of the Special Capital Region of Jakarta and East Java (Figure 1).

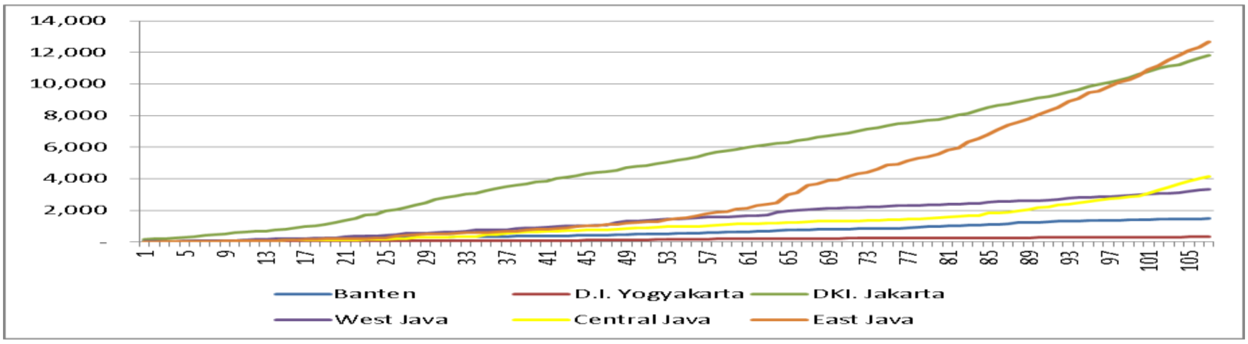

Figure 1. Confirmed COVID-19 cases in Java: 18th March – 2nd July 2020

Source: Ministry of Health, 2020

Many policies and programs associating with managing the spread of COVID-19 have affected the food system in every region in Indonesia (Nasir et al., 2021). During the pandemic, every household experienced very rapid changes in food availability, accessibility, and affordability. That is caused by implementing the regional quarantine policy that limits the mobility of various activities, including the distribution of food that is considered to be able to disrupt the balance of supply and stability of food prices between regions in Indonesia. The balance of supply and stability of food prices is a crucial issue for Indonesia due to its large population.

Rice is one of the leading staple foods for most of Indonesia's population, which is indicated by the high level of consumer participation, around 97.27% at the end of 2018. Meanwhile, in 2018 the total national rice consumption reaches around 29.57 million tons (BPS & BPPT, 2018). Through the Presidential Regulation of the Republic of Indonesia Number 71 the Year 2015 concerning Stipulation and Storage of Staples and Important Goods, the Government has determined rice as one of the staple goods for agricultural products. This determination is based on the fact that rice is an item that concerns many people's lives and influences Indonesia's inflation rate.

This paper tries to explain the consequences of managing the spread of the COVID-19 epidemic to manage the supply and stability of prices among regions through integrating the rice market in Indonesia. The study was conducted because rice production was only focused in some regions, so it needed to distribute rice from the production center to the non-production area. Java Island is one of the leading centers of national rice production. In 2018, the proportion of rice production in Java reached around 56.04% of national production, or around 18.16 million tons per year. The general distribution of national rice production is presented in Figure 2.

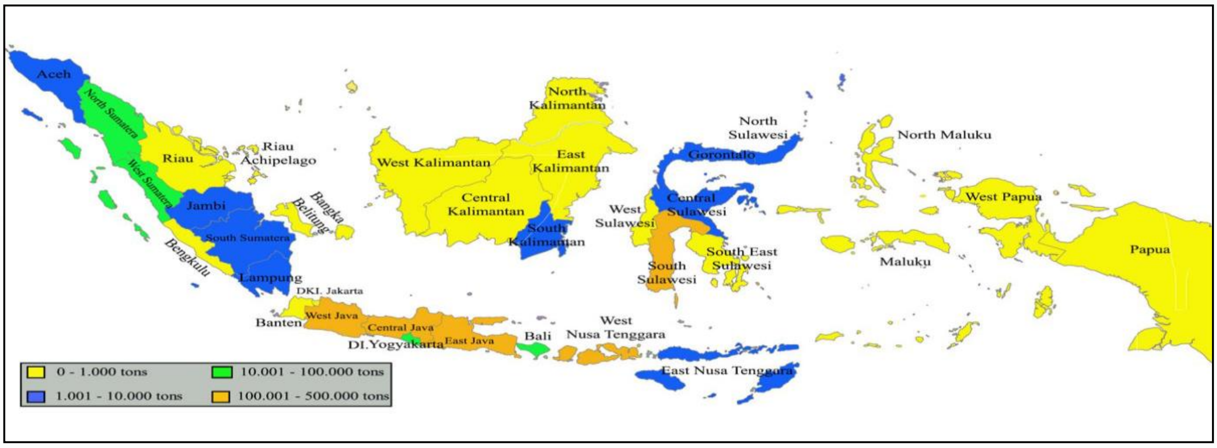

Figure 2. Distribution of Rice Production Centers in Indonesia

Source: BPS and BPPT, 2018

Market integration can provide price balances between regions of rice deficits and surpluses caused by spatial dispersion between production and rice market players' behaviour. The relationship between rice prices can be used to identify integrated market groups, so the government does not need to intervene. Besides, market integration also provides information on market functions' efficiency and the dynamics of price adjustments. In this paper, market integration is used to explain and evaluate the influence of policies associating with managing the spread of the COVID-19 on the stability of supply and prices of rice commodities to inform future policy.The idea of spatial rice markets integration also plays a vital function in sustaining economic performance within regions, mainly during uncertain conditions, such as the COVID-19 outbreak. During the current pandemic, the government needs to reduce the risk of inflation caused by rising food prices due to future uncertainty and vigilance against the spread of epidemics. On the other hand, in these conditions, the control of food needs in sufficient quantities maintained quality, and affordable prices are crucial. The integrated market conditions are still considered to optimize trade performance between regions despite a pandemic.This research applied Ravallion (1986) by integrating the inter-regional rice market between a wholesale and a group of traditional markets in Java. It is considered very important because rice prices in the wholesale market may be influenced by price variations at the traditional market level. On the other hand, some traders in traditional markets trading with traders in the wholesale market dominate traditional markets. Therefore, by estimating market integration, we can determine market efficiency and potential price adjustments in the event of fluctuating rice prices in the studied market. The rice price was chosen because rice has a crucial role in the Indonesian economy and the nature of the available data.This paper's methodologies are a vector error correction model (VECM) and engle granger causality. An exogenous variable in the form of a dummy variable is included in the vector error correction model to simulate scenarios and predict the effect of COVID-19 on the Indonesia rice market integration. This research is expected to provide policy recommendations on strategies to secure supply and price stability for rice commodities when the COVID-19 outbreak occurs again. It will eventually become valuable guidance for local government to improve the local resource community development in each region (Dumasari et al., 2020). In the second session of this paper, we reviewed the literature about the effect of COVID-19 on the food system. Then, we explained the concept of price integration in the agricultural commodity market. In the fourth and fifth sessions, the methodology and data analysis were explained. As for the sixth session, we discussed our empirical results, and in the latest session, significant conclusions were presented.

Impact of Covid-19 On the Food System

The production, trade, and food consumption sectors are some of the economic sectors severely affected by the COVID-19. From a producer perspective, the COVID-19 has harmed most vegetable farmers in India regarding production, sales, prices, and income (Harris et al., 2020). On the other hand, the fragmentation of economic activity caused by COVID-19 can be used by food retailers to increase local market power . Meanwhile, from the perspective of consumption, the COVID-19 pandemic can encourage positive changes for Tunisia consumers towards household food wastage (Jribi et al., 2020).The COVID-19 pandemic has had a devastating effect on food systems in every country. Béné (2020) suggested that one of the consequences of the COVID-19 outbreak is the implementation of lockdowns and closure of various enterprises by the national/local government, which has implications for disrupting people's food security due to loss of income and purchasing power. Elleby et al. (2020) observed that during the first semester of 2020, various developing countries experienced an increase in food insecurity due to income losses and local supply chain disruptions.Many policies and programs to control the spread of COVID-19 can influence the stability of various foodstuffs' supply and prices. During the pandemic, the food sector increased demand caused by the community's panic buying and food stockpiling . Benton (2020) stated that implementing lockdowns to overcome the spread of COVID-19 could potentially disrupt the food supply chain so that food prices, both locally and globally, would increase. Besides, Akter (2020) proved that implementing the 'stay-at-home' restriction policy can cause food inflation in 31 European countries.

Agricultural Market Integration

In this research, the co-integration concept is applied to determine the effect of COVID-19 on the rice market integration. Co-integration is one of the statistical procedures developed to determine the relationship between non-stationary variables (Granger, 1981). Co-integration has become a powerful technique for analyzing trends in bivariate time series (Engle & Yoo, 1987). The rice market integration in Indonesia is a significant issue due to the limited conditions of domestic rice production centers in several regions and many rice supply chain operators. Ismet et al. (1998) state that in 1982-1993, the rice market in Indonesia was integrated. As for 1987-2006, Indonesia's rice market was also integrated (Marks, 2010).Spatial market integration becomes an essential instrument in economic development through price stabilization between regions. Hossain et al. (2012) applied a co-integration test and VECM to recognize integration among rural markets in eight districts in northern Bangladesh by wheat commodities. Co-integration test results reveal a long-term relationship within rural markets. Meanwhile, the VECM test results indicate that most rural markets have moderate price adjustments between each market.Sahito (2017) examined the wheat market integration from 2014 to 2015 by applying the vector error correction and threshold vector error correction models. The study was applied on wheat wholesale markets in Pakistan. The ECM showed that each wheat market in Pakistan was well integrated. Ahmed et al. (2015) applied a VECM and the co-integration method to review spatial price transmission between Pakistan's wheat and rice markets. The results showed that there was an integration of prices among the wheat and rice markets.Meanwhile, the concept of co-integration is also widely applied in the integration of trade between countries for agricultural commodities. Sanogo and Maliki Amadou (2010) analyzed spatial market integration among the Jogbani wholesale market (India) and Morang market (Nepal). The results showed that price dynamics greatly influenced the price of rice in Nepal in India. Meanwhile, in 60 developing countries, urban markets have a long-term co-integration relationship to prices in world markets in the commodities of wheat, rice, corn, and sorghum (Baquedano & Liefert, 2014). Akhter (2016) applied a VECM to explain the effect of rice export restrictions policy by the Indian government on spatial rice market integration within surplus market (India) and deficit markets (Nepal and Bangladesh) during the "global food crisis" in 2007-2008. Co-integration analysis results show that domestic rice markets of India, Nepal, and Bangladesh are mutually integrated into the short- and long-term.

Methodology

In this paper, testing the rice market integration in Indonesia through the vector error correction method and causality test is conceptualized in a multivariate framework, with one wholesale market and five traditional market groups as endogenous variables. Vector error correction method and causality are performed after conducting several tests in the form of (i) unit root testing, (ii) optimal lag length, and (iii) co-integration test.In this paper, we first do unit root testing to find out the level of stationarity series. Unit root testing is one of the tests requiring that each series' condition is integrated of order 1, or written as I(1). These conditions mean that the first derivative causes the series to be stationary. On the other hand, co-integration happens when all variables are I (1). In this study, unit root testing is carried out through the Augmented Dickey-Fuller Test (ADF) method developed by (Dickey & Fuller, 1981). Tests are carried out on each time series variable individually to determine the data stationarity level at I(0) and I(1). The Augmented Dickey-Fuller equation is as follows:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

In the ADF equation, the lag value of Δyt can collect every dynamic structure in the dependent variable to prove that ε_t is uncorrelated (Brooks, 2014). In the ADF test, the statistical test is determined as follows:

$$test\ statistic = \frac{\hat{\delta}}{SE(\hat{\delta})} \quad (2)$$

The statistical test values above are then compared with the DF table's critical values with the following hypotheses:

H_0: price series contains a unit root
H_1: price series are stationary
Next, we determine the number of lags based on the lowest Schwartz Bayesian Information Criterion (SBIC) and Akaike Information Criterion (AIC). Brooks (2014) states that SBIC tends to be very consistent but inefficient. On the other hand, AIC is inconsistent but generally more efficient. Mathematically, the equation of SBIC and AIC is:

$$SBIC = ln(\hat{\sigma}^2) + \frac{k}{T} ln\, T \quad (3)$$

$$AIC = ln(\hat{\sigma}^2) + \frac{2k}{T} \quad (4)$$

where $\hat{\sigma}^2$ is the residual variance, k is the number of parameters estimated, and T is the sample size? When the unit root results show that each series is integrated of order one, I (1), then it can proceed to the multivariate co-integration tests to determine the number of cointegrated vectors in the system. In this paper, the co-integration test is carried out by the Johansen (1991) method, through the trace and maximum eigenvalue tests.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} ln(1 - \hat{\lambda}_i) \quad (5)$$

$$\lambda_{max}(r, r+1) = -T\ ln(1 - \hat{\lambda}_{r+1}) \quad (6)$$

In equations 5 and 6, r is the number of co-integration vectors in the null hypothesis, and λ ̂_i is the estimated value for the i-eigenvalue in the matrix ∏ = αβ′. The distribution of the statistical test of the trace test and the maximum eigenvalue test are non-standard, and the value of g - r greatly influences critical values (Brooks, 2014).

The error correction equation defines the co-integration relation between the wholesale market and a group of traditional markets. In the short-term, various external factors can distort rice prices in Java from a long-term equilibrium position. On the other hand, the error correction process can rebalance the deviations that occur to adjust to the equilibrium position. Measurement of the adjustment speed to the equilibrium position can be done through an error correction-term (ECT) if the short-term adjustment of each data series can correct the deviation. The existence of deviations or price deviations and the error correction process in the short-term dynamics can be explained through the VECM. The COVID-19 on the rice market integration is defined as a dummy. The error correction equation is (Kirchgässner et al., 2013).

$$\Delta y_{1,t} = \alpha_0 - \gamma_1 y_{1,t-1} + \sum_{j=2}^{k} \theta_j y_{j,t-1} + \sum_{j=1}^{k_1} \alpha_{1j} \Delta y_{1,t-j} + \ldots + \sum_{j=1}^{k_k} \alpha_{kj} \Delta y_{k,t-j} + \sum_{j=1}^{k} \Phi_j D_{j,t} + u_{1,t} \quad (7)$$

where y is the natural log of the price of rice in Jakarta, Serang, Bandung, Semarang, Yogyakarta and Surabaya. Δ as the first difference operator. α_0 is constant-terms. θ_j, α_{1j}, α_{kj}, and Φ_j describe the short-term coefficients. Meanwhile, γ outlines the error correction-term. D represents the period of implementation of the COVID-19 program and control policies in Indonesia, where 1 represents the period 2nd March to 2nd July 2020, otherwise it equals 0. Co-integration testing through the error correction framework is determined by the lag length k_1, ... k_k to prevent autocorrelation from estimating residuals û. Meanwhile, based on equation (7), the following hypothesis can be obtained,

H_0: (y_1, y_2, ... y_m) are not cointegrated, $\gamma_1 = 0$
H_1: (y_1, y_2, ... y_m) are cointegrated, $\gamma_1 > 0$
Based on the hypothesis testing above, if each variable is cointegrated, equation (7) can be used to find the long-term relationship by changing it into the form of least squares estimation, formulated as follows:

$$\Delta y_{1,t} - \alpha - \beta_2 y_{2,t-1} - \beta_3 y_{3,t-1} - \beta_4 y_{4,t-1} - \beta_5 y_{5,t-1} - \beta_6 y_{6,t-1} = z_{t-1} \quad (8)$$

where y_1 is the target variable, dan y_2, …., y_6 are endogenous variables. Δ as the first difference operator. α is constant-terms. β_2, …., β_6 represent the long-term coefficients. z_{t-1} as a stationary equilibrium error.

Data and Research Scope

The estimated period of market integration in Indonesia is done with a daily price of 5-day week of rice commodity prices between regions during 25th July 2016, to 2nd July 2020 (980 data). If there is blank data on a particular transaction day, data will be included that are consistent with prices on the previous day to ensure that all data are appropriate and to represent the complete occurrence of trade transactions on that day. Daily data is used because it tends to have more significant price dynamics and detailed information than data with a more extended period. In this paper, the dummy variable is determined based on the first COVID-19 cases confirmed in Indonesia on 2nd March 2020. Since the 2nd March 2020, the government has implemented numerous policies and programs to manage the spread of COVID-19. Indonesia's considerable scale of social restrictions can influence rice market integration in Java.

The designation of Java as a research location is because the region is the largest rice production center in Indonesia (Figure 2). Besides, the area of rice production deficits in Java is divided into two parts: the surplus region is dominated in the eastern region, and the western part is mostly a deficit region. This condition causes the deficit region to reach rice needs. It depends on imports from the surplus regions, so there will be a distribution of rice from the surplus to the deficit region in Java.

Domestic distribution channels in the eastern to central Java, have been supported with access to the Trans Java toll road (Brebes-Surabaya) and Non-Trans Java toll roads (Pandaan-Malang and Ciawi-Cigombong) with toll roads operating each reaching around 455 each, 56 km and 53.83 km. Besides, the Jabodetabek toll road infrastructure (Jakarta, Bogor, Depok, Tangerang, and Bekasi) has also operated in the western part of Java Island with a length of approximately 72.81 km (Toll Road Regulatory Agency, 2020). This condition indicates that land transportation has become the main staple in the transportation system in Java. Toll road access that-terms from the east to the western part of Java Island has been connected with secondary transport networks where consumer markets are located.

A sea distribution channel has also supported Java Island. Based on the development of sea tolls in the National Medium-Term Development Plan of 2015-2019, there are two hub ports (Tanjung Priok "Jakarta" and Tanjung Perak "Surabaya") and one feeder port (Tanjung Emas "Semarang") on Java Island to improve inter-island connectivity in Indonesia. The availability of quite a lot of domestic distribution channels in Java makes it possible to accelerate rice movement from the surplus market to the deficit market and reduce handling costs.

In this study, the research area consists of six cities, each province's capital in Java. The research areas include Central Jakarta City (JKT), Serang (SRG), Bandung (BDG), Semarang (SMR), Yogyakarta (YOG), and Surabaya (SBY). Jakarta is the largest deficit market in Indonesia, amounting to 1.24 million tons in 2018 (Table 1). This condition enables Jakarta to provide the demand that will significantly affect the formation of rice prices. Serang represents a deficit market in the western region of Java. Bandung is the capital of West Java province, with the second-largest deficit rate in Java. Yogyakarta represents a deficit area on the southern island of Java. Semarang and Surabaya are the biggest surplus markets in Java, namely the Provinces of Central Java and East Java.

Table 1.
Production and consumption rice in Java Island, 2018 (tons)

Provinces	Provincial Capitals	Production	Consumption	Prod - Cons
SCR of Jakarta*	Central Jakarta	2,340	1,242,188	(1,239,848)
Banten*	Serang	908,563	1,319,607	(411,044)
West Java*	Bandung	5,480,415	6,251,002	(770,587)
Central Java	Semarang	5,442,034	3,718,130	1,723,904
SR of Yogyakarta*	Yogyakarta	281,193	423,183	(141,990)
East Java	Surabaya	6,053,467	4,301,639	1,751,828
Total		18,168,012	17,255,749	912,263

Source: BPS and BPPT, 2018
Note: Deficit's provinces in *; SCR (Special Capital Region); SR (Special Region); Prod (Production); Cons (Consumption)

The research data are the daily average prices in the wholesale market and a group of traditional markets in Java (Table 2), transformed into natural logarithms. Price data at the wholesale market level are prices at the Cipinang Rice Wholesale Market (PIBC) obtained from <https://foodstation.co.id/>. PIBC is the largest rice wholesale market institution in Indonesia because it has a volume of in and out transactions (± 4,500 tons per day) and a sizeable daily rice stock (± 4,000 tons per day) (Food Station Tjipinang Jaya, 2020). The rice trade in the PIBC is a significant domestic supply for the deficit market in Jakarta and surrounding areas. PIBC can play a role as a center for the consolidation and distribution of rice in western Java.

Price data at the traditional market sample level is determined by the Food Price Information Centre data collection <https://hargapangan.id/>. Traditional markets are determined as a research sample based on a 2018 market survey conducted by the *Badan Pusat Statistik* (Indonesian Bureau of statistics) (BPS, 2018). The proportion of the largest trade center in Indonesia is the traditional market, which reaches around 88.52%. Market sample distribution schemes in this study are presented in Figure 3. Analysis of the rice market integration is determined by rice price with medium quality classes and IR-64 varieties. Based on the National Standardization Agency of Indonesia (SNI) No.6128/2015, rice in this study is the average price of the medium I and medium II rice. Determination of medium rice quality class: That medium rice is the type of rice with the highest marketing level in the study period. Medium rice is the dominant rice quality class consumed by the Indonesian population in the aggregate so that the rice quality class can be used as a national price reference. Medium rice is also classified as volatile food, a strategic food commodity that contributes significantly to inflation formation.

Table 2.
Distribution of markets sample

Regions	Markets Wholesale Market	Traditional Markets
Central Jakarta (JKT)	Cipinang	
Serang (SRG)		**1. Rawu** **2. Royal Lama**
Bandung (BDG)		1. Kiara Condong 2. Kosambi
Semarang (SMR)		1. Johar 2. Peterongan
Yogyakarta (YOG)		1. Beringharjo 2. Kranggan
Surabaya (SBY)		1. Tambah Rejo 2. Wonokromo

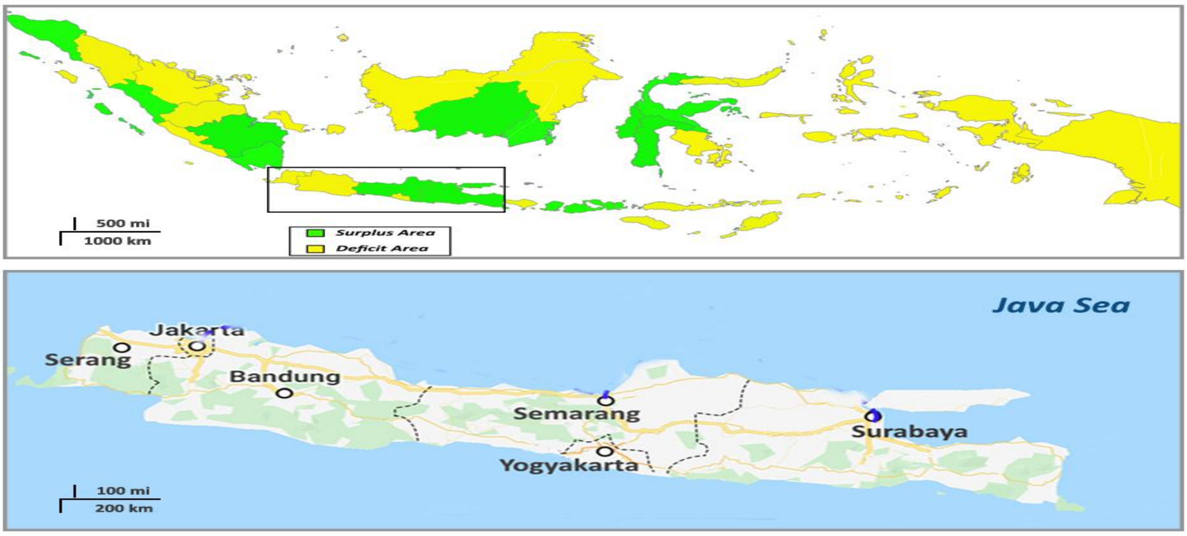

Figure 3. Market sample distribution scheme

In this study, the rice price between regions was determined based on IR-64 variety, which was intended to reduce the effect of varieties and quality differences on rice prices so that differences in rice price variability tended to be influenced by spatial factors. The determination of varieties is also carried out to minimize the translation of comprehensive information, which is considered quite challenging to do in the rice market because there are too many related parameters, especially product quality.

Results and Discussion

The results of the ADF tests are presented in Table 3. All series are nonstationary at low levels. The null hypothesis is that ln prices containing unit-roots fail to be rejected at the statistical significance of 10%, 5%, and 1%. Unit root tests are also carried out by including intercepts and trend-terms in the equation, but all series are still nonstationary. The ADF test is performed in the first difference, which results in the null hypothesis being rejected at a 1% significance level. This indicating that all series are integrated of order 1, I (1).

Table 3.
Augmented Dickey-Fuller test

Variabel	Ln levels		First difference	
	Lag length	t-value	Lag length	t-value
Jakarta	5	0.40	4	-9.48***
Serang	1	0.39	0	-28.17***
Bandung	8	0.57	7	-7.91***
Semarang	0	0.84	0	-32.87***
Yogyakarta	6	0.81	5	-9.28***
Surabaya	4	0.26	3	-12.74***

Note: Statistical significance at 10%, 5% and 1% denoted by *, ** and ***

Based on the unit root test that confirms that all price series are integrated into order 1, a co-integration analysis between rice prices in selected markets in Java can be carried out. The Johansen maximum-likelihood multivariate co-integration model is used to test the long-term relationship between price series. The lag length is determined based on various information criteria, namely Akaike information criterion (AIC) or Schwarz criterion (SC), to ensure that residuals are white noise. In this study, optimal lag is determined at two lags. The trace test results in Table 4 reveal three cointegrating equations at a significance level of 5%, indicating three long-term linear combinations of rice prices. The maximum eigenvalue test results are presented to confirm the results of the trace test. The maximum eigenvalue test indicates that at the 5% significance level, there are three co-integrating equations.

Table 4.
The Johansen co-integration test

Market	Null	Alternative	Trace	5% CV	Eigenvalue	5% CV
All rice markets	r = 0	r ≥ 1	195.37**	95.75	81.69**	40.08
	r ≤ 1	r ≥ 2	113.68**	69.82	58.60**	33.88
	r ≤ 2	r ≥ 3	55.09**	47.86	28.45**	27.58
	r ≤ 3	r ≥ 4	26.63	29.80	12.93	21.13
	r ≤ 4	r ≥ 5	13.70	15.49	10.19	14.26
	r ≤ 5	r ≥ 6	3.51	3.84	3.51	3.84

Note: ** Indicates rejection of the null hypothesis at 5% level of significance

Co-integration tests between rice markets in Java in the ECM are presented in Table 5. The determination of lag is based on the SC results, suggesting a lag of order of one as a period to reach new equilibrium conditions after the price shock. A short-term co-integration relationship among rice markets in Java occurs when the estimated coefficient of ECT (-1) is significantly.
The VECM reveals that the long-term coefficient is statistically significant at the 1% significance level only in Yogyakarta and Surabaya. The price flexibility sign is positive, indicating that the rise in prices of those regions will increase prices in Jakarta and vice versa. The long-term coefficient is between 0.63 to 0.88, which means that around 63% to 88% of rice prices changes in Yogyakarta and Surabaya will be transmitted to Jakarta. These results confirm that in the long-term, price behaviour in Jakarta is influenced by regions that are geographically far separated from Jakarta. Surabaya is the largest rice surplus-producing region in Java, so it tends to dominate the rice supply to Jakarta. On the other hand, Yogyakarta is a rice deficit-producing region, but some traders in Yogyakarta export rice to Jakarta due to higher profits. The result shows that price changes in Serang, Bandung and Semarang do not affect price formation in Jakarta in the long-term. This concludes that Jakarta and those regions are not in the same economic market. Serang and Bandung are rice deficit-producing regions, so they cannot directly influence price behaviour in Jakarta in the long-term. It might be that Serang and Bandung get supplies from Semarang and Surabaya, so they are not directly involved in the rice trade with Jakarta. Meanwhile, Semarang is the second-largest rice surplus-producing region in Java. However, in the long-term, it does not have a rice price relationship with Jakarta. This might be that traders in Semarang are more

dominant in supplying rice to deficit regions that are spatially closer, such as Bandung and Yogyakarta, compared to Jakarta. The result reveals that the speed of adjustment coefficient is 0.01 and is statistically significant at a significance level of 10%. This indicates an adjustment of about 1% of any deviation to equilibrium conditions every day. This suggests that spatially, Jakarta is far separated from the rice surplus-producing region, so that the rice supply to Jakarta requires a long distribution time. In addition, several regions in eastern Java have limited transportation infrastructure, so that the implications for the efficiency of the rice supply chain are not optimal.

Table 5.
Vector error correction model estimates

Dependent Variable	Long-term coefficients		Short-term coefficients	
	Ln (Jakarta)	t-statistic	D (Ln (Jakarta))	t-statistic
Intercept	-0.84	-	0.00	1.16
ECT	-	-	0.01	1.89*
Ln (Serang (-1))	-0.11	0.68	-	-
Ln (Bandung (-1))	-0.01	0.06	-	-
Ln (Semarang (-1))	-0.31	0.94	-	-
Ln (Yogyakarta (-1))	0.88	3.53***	-	-
Ln (Surabaya (-1))	0.63	3.29***	-	-
D (Ln (Jakarta (-1)))	-	-	0.02	0.67
D (Ln (Serang (-1)))	-	-	0.06	1.71*
D (Ln (Bandung (-1)))	-	-	0.07	1.90*
D (Ln (Semarang (-1)))	-	-	-0.01	-0.21
D (Ln (Yogyakarta (-1)))	-	-	0.09	1.87*
D (Ln (Surabaya (-1)))	-	-	-0.04	-0.84
COVID-19	-	-	0.00	-1.62

Note: the t-values of 10%, 5% and 1% significant levels are1.65, 1.96 and 2.58.

Furthermore, price transmission in the short-term shows that Jakarta is integrated with Serang, Bandung, and Yogyakarta. This indicates that in the short-term, Jakarta is only integrated with rice deficit-producing regions. In the short-term, an increase in prices in those regions will increase prices in Jakarta and vice versa. The price rise in deficit regions has influenced surplus regions to supply more rice, which has implications for a decrease in rice supply to Jakarta, which increases rice prices. The result may also explain that the spatial distance between regions strongly influences integration in the short-term. This might be that price changes in a region may be transmitted more quickly in the short-term at closer distances. A quite good land transportation infrastructure supports the relationship between Jakarta and those rice deficit-producing regions. The signal of price changes in those regions will be well transmitted to Jakarta.
The results show that various programs in restrictions on various businesses and travel to reduce the spread of COVID-19 starting at the end of March 2020 have no impact on integrating the rice market in Indonesia. It might be that these restrictions have no impact on the agricultural sector, which is considered an essential sector so that it will continue to operate during the pandemic. However, the occurrence of COVID-19 causes direct and indirect disruption to the integration of the rice market. It will have long-term implications for the sector after COVID-19 ends. In the short-term, physical distancing restrictions will significantly reduce food demand with the closure of restaurants, hotels, schools, and associated institutions.

Conclusion

Issues related to various domestic distribution channels and the COVID-19 pandemic were empirically investigated to determine their effects on the integration between the surplus and deficit markets. This study's primary focus is to discover the effect of performing many policies and programs associated with managing the spread of COVID-19 from 2nd March to 2nd July 2020 on the rice markets integration in Java. By the result, VECM estimates show that there is a short-term integration between rice markets in Java. The error correction coefficient is close to zero, meaning a slow adjustment towards a long-term equilibrium caused by slow transportation and trade rigidity. Nevertheless, the empirical results confirm that the implementation of the COVID-19 control program in the short-term does not affect price formation in Jakarta as the most extensive rice deficit region in Indonesia. However, there is co-integration between Jakarta with Yogyakarta and Surabaya in the long-term equilibrium. Jakarta's status as the most significant deficit market allows rice supply from the surplus market to be crucial in determining domestic rice prices. Besides, the Tanjung Priok port, toll road infrastructure, and the Cipinang Rice Wholesale Market enable Jakarta to become a center for the consolidation and distribution of rice in western Java. We recognize that many limitations to this study. We cannot guarantee the recurrence of currently controlling rice price relations in the future. Additional uncertainties overflow: climate changes, farming models, new players in the supply chain, also other economic disturbances reveal new uncertainties in the markets. The study considers the price data of only six regions in Java. Further study should include other agricultural regions from other islands in Indonesia as the sample and examine price transmission and volatility.

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