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Exploring the pattern of price interdependence in rice market in Indonesia in the presence of quality differential

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Exploring the pattern of price interdependence in rice market in Indonesia in the presence of quality differential

Anisa Dwi Utami¹*, Harianto Harianto¹ and Bayu Krisnamurthi¹

Abstract: Being the main food commodity, the dynamics of rice prices is one of the most important issues for Indonesian economy. The prices at the retail level and at the farm level are influenced not only by the demand and supply in each of these markets but also by price behavior at the wholesale market. This study aims to analyse the dynamics of the relationship and behaviour of the prices of various varieties and qualities of rice in the wholesale market. The dynamics of rice prices are investigated by employing multivariate vector error correction model (VECM) and using daily price series at wholesale level during the period of 1 October 2014 until 12 February 2018. The results show a strong price relationship between premium-quality rice and medium-quality rice and between medium-quality rice and low-quality rice. Changes in the price of premium-quality rice and changes in the price of low-quality rice will have a large influence on the price of medium quality rice, but not vice versa. Furthermore, regarding the price stabilization policy, the results suggested that the policies aimed at regulating medium-guality rice prices are estimated to have relatively weak effects on the prices of premium-quality rice and low-quality rice.

Subjects: Microeconomics; Econometrics; Industry & Industrial Studies

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PUBLIC INTEREST STATEMENT

As the strategic food commodity for Indonesian economy, the rice market has been commonly assumed to be homogeneous in terms of product and quality. However, along with the changing socioeconomic condition, the situation may require to be further clarified. This paper aims to explore the interdependence of prices among the different quality of rice products. To this end, this paper used wholesale prices in a specific market in Indonesia with the period of 1 October 2014 until 12 February 2018. The findings generally suggested that different quality and characteristics of the rice products in Indonesia have different price behaviour. Furthermore, it can be concluded that the substitution relationship between the premium-quality rice and the lowquality rice is lower than the substitution relationship between the premium-quality rice and the medium-quality rice as well as lower compared to the substitution relationships of lowquality rice with medium-quality rice.

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Keywords: Food price; Price transmission; Rice; Wholesale market; VECM

JEL Classification: Q110; Q130; C320

1. Introduction

The dynamics of rice prices has been widely discussed within the existing economics literatures around the world. As one of the most consumed food products globally, rice is a strategic commodity which attracts much attention from many developing countries, especially in Asia. In several rice-producing countries, rice generally accounts for half of farmers' income, though with declining trend of its share due to nonfarm economy that has overtaken rural economies (Bandumula, 2018). Meanwhile, at the consumer side, rice accounts for 25–40% of households' expenditure (Dawe & Timmer, 2012; Timmer, 2010). Therefore, changes in rice prices will likely lead to large changes in purchasing power and nutrition of the poor (Akhter, 2017; Bekkers et al., 2017; Block et al., 2004; Dawe & Timmer, 2012; Elleby & Jensen, 2019; Haile et al., 2016; Hasan, 2016).

The global rice market has been generally found to be thin and volatile during some recent periods. This relates to the situation in which nearly one-half of the world population has consumed rice as their staple food, but only 7 percent are traded across the borders (Gibson & Kim, 2013). Furthermore, after global food price spikes in 2007–2008, people are more aware of the existence of food price instability and thus, some governments revise their policy to maintain their food security. During this period, within 4 months in the early of 2008, the world's largest rice exporters, i.e., Vietnam and India (the second and the third world largest exporters), banned rice export, followed by panic buying by the Philippines as the largest rice importer. This export bans by Vietnam and India, which have driven to the increasing world rice prices, reflected political goals of protecting domestic consumers from the rice price inflation, but the situation was contradictory. The local rice prices were reported to being doubled in Ho Chi Min City as rice disappeared from the city market for over 2 days (Slayton, 2009). Volatile market has discouraged governments to rely on the global market for maintaining their domestic consumption, thus making the thinner world market become more unstable (Timmer, 2010).

Being the fourth most populous country in the world, Indonesia has played a strategic role in the global rice market, considering rice as the staple food of the people. Playing as consumer and producer at the same time, Indonesian economy heavily relies on the dynamics of rice prices. Many studies have emphasized this situation. Grabowski and Self (2016) found that rice price stability was one of the main drivers of structural change in Indonesia. The shifting labor from agriculture sector to manufacturing sector is critically dependent on the existence of food price stability. Therefore, rice is considered not only as an economic commodity but also as a political commodity. For decades, Indonesian government has maintained many policies regularizing the rice market. Rice price stabilization, for example, is one of the most highlighting political issues especially during the political momentum such as presidential and general election in the country. In addition, the rice self-sufficiency has become the main agenda for every president. The government of Indonesia has claimed achieving rice self-sufficiency in some periods, i.e., 2005, 2010, and 2014. However, there are still growing debates on the validity of the data regarding whether the rice production is sufficient while at the same time, the rice prices tend to increase over time. Following this issue, the debates are more complex when the government conducts import for rice.

Studies of price transmission between market levels along the marketing chain have been widely conducted (Aguiar & Santana, 2002; Çamoğlu et al., 2015; Cao & Mohiuddin, 2019; Chavas & Mehta, 2004; Deb et al., 2020; Fousekis et al., 2016; Kinnucan & & [With reply from Tim Lloyd], 2019; Ngango & Hong, 2020; Zanin et al., 2020). Those studies also assume that the quality of products traded at each level along the marketing chain is the same. However, studies of the price relationship of similar but different quality of agricultural products or varieties in one market are relatively rare. This study attempts to fill this gap. This study aims to analyze the behavior of rice

prices at the wholesale market in Indonesia by investigating the interdependence among rice products and learning whether there are differences among rice products in the market. Furthermore, the price interdependency was investigated by estimating the cross price elasticity for the varieties of rice products. The next session explains the literature review and methods of analysis. Then, it is followed by the empirical results and discussion. Finally, the last session will be the conclusion as well as the policy implications.

2. Literature Review

Within the existing economics literature, rice is usually treated as one single commodity (Anggraeni et al., 2019; Chaudhary et al., 2019; Onumah et al., 2022; Putra et al., 2021; Rahman et al., 2020; Śmiech et al., 2019). (Shively & Thapa, 2017); (Korale Gedara et al., 2016); (Valera & Lee, 2016); (Keho & Camara, 2012). In the estimation technique, mainly because of data availability issue, most of the studies have not accounted for the type and quality differences in the price analysis. This empirical way to some extent may lead to the unclear conclusion in explaining the real market behavior and the price dynamics and in explaining the policy implication. In the case of Indonesian rice industry, for instance, as studied by Rachmat et al. (2016), along with the variation of consumer preferences, the consumers of rice in Indonesia are becoming more discriminating on the rice quality. In addition, following the changing of socioeconomic condition, especially among the people from upper- and middle- income classes, the correlation between price and quality difference is becoming more important in the consumption behavior (Cuevas et al., 2016; Mottaleb et al., 2017).

Price behavior in the wholesale rice market needs to be analyzed so that any policy intended to influence the price level in retailers or the price at the farmer level can be formulated appropriately. The wholesale market connects the market at the farm level with the retail market. Price movement behavior at the retail level and at the farm level will be largely determined by the role of every trader in the wholesale market in setting the price. Therefore, the wholesaler's behavior will determine whether or not the changes in the retail price level will be transmitted perfectly to the market at the farm level, or vice versa.

Traders or wholesalers in the wholesale rice market can be classified as multi-product firms which sell more than one quality grades of rice products. Rice sold in the wholesale market is categorized as premium-quality, medium-quality, and low-quality rice. Quality differences between rice occur because of differences in varieties and differences in rice characteristics, such as levels of broken rice, off color, chalkiness, and the absence or presence of dirt (Cuevas et al., 2016). Medium-quality rice can be further processed to become premium-quality rice. Similarly, low-quality rice can be improved to have medium-quality rice characteristics. This process of changing characteristics certainly requires additional costs.

The quality differences of rice products reflect the condition of both production and consumption sides, which can be different from each other. Consequently, according to this assumption, how strong the price relationships among the rice products of different qualities will depend on the interaction of both supply and demand side characteristics? On the demand side, rice with different quality or characteristics has a relationship to substitute one another. Consumers determine the choice of the quality of rice they like based on preferences. Consumers' willingness to pay for each unit of rice they buy depends on the characteristics of rice. Hedonic price function theory has shown that consumers provide certain implicit prices for each change in the characteristics of a product (Lancaster, 1966; Rosen, 1974; Hendler, 1975; Lancaster, 1966). Several studies of the characteristics of agricultural products and their implicit prices have been done (Ahmad & Anders, 2011; Chang et al., 2010; Espinosa & Goodwin, 1991; Misra & Bondurant, 2000).

Following Midrigan (2011) and Alvarez and Lippi (2012) who examined pricing in multi-product companies, this study assumed that trader or firm in the wholesale rice market can be categorized as not fully acting as the price taker. The sales amount of each firm in the wholesale market is

relatively large compared to the volume of rice sold in one day on the market. Accordingly, it was assumed that there is one firm in the wholesaler rice market, which can represent the behavior of all wholesalers in the rice market. This firm sells different quality of rice. The firm was assumed to employ technology that is linear with the use of labor $(l_{i,t})$ to produce output of rice with quality *i* $(q_{i,t})$ in period *t* as follows: $q_{i,t} = \alpha l_{i,t}$. Assuming the firm as a price taker in the labor market and given technology, the marginal cost of firm for rice *i* is $MC_{i,t} = W_t$ where W_t is nominal wage.

The firm faces the demand for every variety of rice (i) it produced as follows:

$$q_{i,t} = f(p_{1,t}, p_{2,t}, \dots, p_{n,t}), i = 1, 2 \dots, n$$
 (1)

$$Q_t = q_1 + q_2 + \ldots + q_n \tag{2}$$

where $p_{i,t}$ is the price of rice *i* and Q_t is the aggregate rice demand that is faced by firm. Therefore, marginal revenue of firm for each additional unit of rice of quality *i* is

$$MR_{i,t} = q_{i,t} \left(\frac{\partial p_{i,t}}{\partial q_i} + \sum_{i \neq j} \frac{\partial p_{j,t}}{\partial q_{j,t}} \frac{\partial q_{j,t}}{\partial q_{i,t}}\right).$$
(3)

The marginal revenue of each additional one-unit sale of rice *i* will be determined not only by the value of the own price elasticity of rice of quality *i* but also by the magnitude of cross price elasticity of rice with quality *i* and that of rice with quality *j*, where $i \neq j$. The lower the value of own price elasticity of demand for rice of quality *i* is, the higher the marginal revenue for each additional one unit of rice of quality *i* becomes. The lower the substitution relationship between rice of quality *i* and rice of quality *j* is, or the smaller the magnitude of cross price elasticity of rice of these two qualities is, the higher the marginal return obtained for each additional one unit of rice of quality *j* is obtained by the firm in a certain period are as follows:

$$\pi_t = \sum_{i=1}^n \pi_{i,t} = \sum_{i=1}^n TR_{i,t} - TC_{i,t}.$$
(4)

The problem faced by the firm is to determine the price of rice of each quality to obtain maximum profits in each period t. The maximum profit of the firm will be obtained if the marginal cost of rice of quality *i* will be equal to its marginal revenue, i.e., $MC_{i,t} = MR_{i,t}$ or $W_t = MR_{i,t}$. In the equilibrium condition, the total amount of rice $(q_{1,t}+q_{2,t}+...+q_{n,t})$ sold is the same as the aggregate demand for rice received by the firm (Q_t) . The optimal determination of price of rice of quality *i* will affect the determination of the price of rice of other quality *j*. With constant quantity of total demand for rice (Q_t) , each price increase in one quality of rice *i* will be followed by a decrease in the price of the other quality of rice (j), so that the total of all variety of rice sold is the same as the total demand. The closer the substitution relationship between two qualities of rice is, the greater the effect of changes in rice price of one quality (i) on the rice prices of other quality (j).

3. Research Methodology

3.1. Data

This study used daily price series obtained from Cipinang Wholesale Rice Market in Jakarta during the period of 1 October 2014 until 12 February 2018 (n = 1225 observations). Cipinang Wholesale Market (PIC) is the main wholesale rice market located in Jakarta that distributes most of rice

Table 1. Descr	iption of investi	gated rice prices	s in IDR		
Rice variety	Quality category	Mean	Standard deviation	Minimum	Maximum
Cianjur Kepala (CK)	Premium	13,366	496.6	12,000	15,600
Cianjur Slyp (CS)	Premium	12,171	486.7	11,000	14,925
Setra (SE)	Premium	12,219	583.3	10,900	13,825
Saigon (SA)	Medium	11,117	602.7	9900	13,200
Muncul 1 (M1)	Medium	10,465	734.6	9000	13,675
Muncul 2 (M2)	Low	9656.8	719.9	8200	12,400
Muncul 3 (M3)	Low	8938.3	704.1	7500	11,825
IR 641	Medium	9990.3	649.1	8800	12,650
IR 642	Low	9091.8	713.2	8100	12,075
IR 643	Low	8198.2	488.16	7200	10,300
IR 42	Medium	10,486	730.4	9000	12,600

Source: Cipinang Market

products from several producing areas in Java Island and supplies rice products to several regions outside Java Island. This study covered 11 rice products that are mostly traded in Cipinang Market based on the type and quality, as summarized in Table 1. All price series were then transformed into the logarithmic form.

3.2. Methods of Analysis

The dynamics of rice prices were investigated by employing a multivariate vector error correction model (VECM). A VECM can give information about how the reactions among investigated prices are both in the long run and in the short run. We first presumably asked whether the investigated rice prices in PIC shared the same long-run information. According to this assumption, we tested the existence of one common cointegrating factor. Suppose that we have n x 1 vector of nonstationary price series, i.e., I(1) $P_t = P_1, P_2, ..., P_{nt}$ at time t for the i rice product. This P_t can be written as:

$$\mathsf{Pt} = \mathsf{A}_{\mathsf{nxs}}\mathsf{f}_{\mathsf{t}} + \sim \mathsf{P}_{\mathsf{t}} \tag{5}$$

where Pt is an s x 1 vector of s (s < n) common unit root vectors and ~P_t is an 1 x n nonstationary components. This equation implies the common factor representation if and only if there are n-s cointegrating vectors among the elements of the vector of Pt as depicted in the Engel-Granger representation theorem. Based on this theorem, a cointegrated system can be explained by a vector of error correction model as follows:

$$\Delta Pt = \mu + nPt - 1 + T1\Delta Pt - 1 + T2\Delta Pt - 2 + \dots + Tp - 12\Delta Pt - p + 1 + \varepsilon t,$$
(6)

where π and T are the coefficient of matrices of n x n and π has reduced ranks of n-s. The matrix of π can also be written as $\pi = \alpha\beta'$, where α is an n x n (n < s) cointegrated vector. Accordingly, we have Π Pt- 1 = $\alpha\beta'$ Pt-1 = α Zt-1. The interest point here is the error correction term as Zt-1 = β' Pt-1 with α called as adjustment coefficient from the long-run disequilibrium. With this framework, the market integration was held when s = 1 since we searched for markets which share the same long-run information. Therefore, searching the common factor representation as in Equation 15 is equivalent with the searching for n-1 cointegrating vectors. The search for n-1 cointegrating vectors was conducted in a multivariate framework proposed by Johansen (1998), i.e., the reduced rank of VAR cointegration testing.

In addition, to capture the effect of policy during the period of investigation, which was between 2014 and 2017, we augmented the long-run equation with the dummy variables representing the implementation of rice policy. Therefore, for this purpose, the normalized cointegrating vector for each pair is defined as follows:

$$P_{1t} = \beta_0 + \beta_1 P_{2t} + \beta_3 POL2016 + \beta_4 POL2017 + u_t$$
(7)

where P_{1t} and P_{2t} are the price pairs of the respective rice products, while POL 2016 is the dummy variable with value of 1 representing the implementation of the price reference policy in 2016 and POL 2017 represents the implementation of the ceiling price policy in 2017. According to these results, the estimation of cross price elasticities of rice products is calculated by referring to the magnitude of β_1 for each pair of rice product prices.

Subsequently, the investigation of interdependency among the rice prices is conducted by referring to the magnitude of error correction coefficients, i.e., α resulted from the MVECM. The VEC in Equation 6 contains the short-run dynamics of the vector Pt as a function of α past disequilibrium and the lags of P_{t-1} for every Δ Pt. The matrix of speed of adjustments provides information about the structure of the market, which can be observed by referring to which coefficient is statistically significant. For instance, if all α are found to be statistically significant, it implies the reactions of one rice product to every disequilibrium of any other rice products. In addition, an investigation of the presence of exogenous rice product that dominate the long-run behavior of the system was conducted. Furthermore, to capture the structure of interdependency among the rice prices, the estimated half-life time adjustments were then calculated to picture the reactions among the rice prices. The estimated half-life time adjustments provide the information about the time required for the effect of 50% of price shocks to stop gradually.

In brief, our empirical technique is summarized as follows: 1) We checked the time-series properties by testing the stationary of the price variables using augmented Dickey-Fuller (ADF) unit root test; 2) For the price variables which have the same order of integration at the first difference, i.e. I(1), we tested the existence of cointegration relationships by employing Johansen multivariate cointegration test; 3) After finding the number of cointegration rank, we employed multivariate error correction model (MVECM) with several modifications in normalizing the cointegrating vector for each rice product; and 4) Finally, the robustness of the estimation was tested to evaluate the possibility of model misspecification by employing Lagrange Multiplier test for serial correlation, the RESET test for functional form, White test for heteroscedasticity, and Chow test for the model stability.

4. Results

As common procedure in the time-series analysis, first we checked the time-series properties to investigate whether or not the investigated variables were stationary. To do this, we employed ADF unit root test with both constant and trend in the test specification. According to the results of ADF test as summarized in Table 2, most price variables were stationary at the first difference, i.e. I(1), except IR 643, which was stationary at the level. This finding has confirmed the unique behavior of IR 643, which has the lowest price among the other rice products. The Indonesian government uses IR 643 as rice aid for the poor, which is called *beras miskin* (*raskin*) or rice for the poor. The government subsidizes this rice product and, therefore, IR 643 has different market than other rice products.

Furthermore, after finding that all price variables have the same order of integration at the first difference (excluding IR 643), the cointegration test was conducted by employing the Johansen cointegration test. The results suggested the existence of nine cointegration ranks for the ten price variables being investigated, as shown in Table 3.

Table 2. Correspo	nding p-value of A	DF unit root test		
Price variables	L	evel	First di	fference
	Constant	Constant and trend	Constant	Constant and trend
СК	0.9066	0.9254	0.0000	0.0000
CS	0.9660	0.9668	0.0000	0.0000
SE	0.2139	0.2489	0.0000	0.0000
SA	0.7147	0.4243	0.0000	0.0000
M1	0.5061	0.6154	0.0000	0.0000
M2	0.2484	0.2964	0.0000	0.0000
M3	0.3257	0.4363	0.0000	0.0000
IR 641	0.4352	0.1142	0.0000	0.0000
IR 642	0.6897	0.6641	0.0000	0.0000
IR 643	0.0025	0.0147	0.0000	0.0000
IR 42	0.6144	0.7241	0.0000	0.0000

Annotation: The lag selection in the unit root test is based on the AIC. Null hypothesis is the existence of unit root. (Source: Author's conception)

Table 3. Results o	of Johansen Cointeg	ration Test		
Rank of	Cons	stant	Constant	and trend
cointegration	Trace-test	P-value	Trace-test	P-value
0	314.11	0.0000	382.70	0.0000
1	235.57	0.0001	268.53	0.0001
2	165.92	0.0218	192.40	0.0282
3	111.98	0.2588	137.10	0.2315
4	78.770	0.4156	103.03	0.2988
5	48.965	0.6870	72.907	0.4047
6	29.367	0.7563	43.131	0.7334
7	13.154	0.8815	23.712	0.8478
8	4.6736	0.8394	8.2297	0.9724
9	0.14233	0.7067	2.1733	0.9430

Annotation: Number of lags was selected by AIC. (Source: Author's conception)

After finding the existence of cointegrating relationships among the 10 investigated price products, we employed multivariate VECM using normalized Johansen cointegrating methods to estimate the cross price elasticity of rice products. To explore the pattern of interdependence among rice products, we conducted several modifications in normalizing the cointegrating vector for each rice product. The results of estimated cross product price elasticity are presented in Table 4. When we normalize the cointegrating vector by CK rice product, for instance, we will have nine cointegrating vectors: 1) CS = -3.5CK + 0.05 POL 2016-0.38 POL 2017 + u_t , 2) SE = -2.11CK + 0.02 POL 2016 + 0.2 POL 2017 + u_t , 3) SA = -3.31CK + 0.01 POL 2016 + 0.37 POL 2017 + u_t , 4) M1 = -8.05CK + 0.18 POL 2016 + 1.08 POL 2017 + u_t , 5) M2 = -6.33 CK + 0.13POL 2016 + 0.83 POL 2017 + u_t , 6) M3 = -1.12 CK + 0.02POL 2016 + 0.02 POL 2017 + u_t , 7) IR 641 = -4.40 CK + 0.06 POL 2016 + 0.52 POL 2017 + u_t , 8) IR 642 = 3.59 CK—0.10 POL 2016-0.75 POL 2017 + u_t , and 9) IR 42 = 14.88 CK + 0.29 POL 2016 + 2.23 POL 2017 + u_t .

Table 4. Estin	nated cross pri	ce elasticity of	rice product							
Normalization					Depender	ıt variable				
(Independent)	СĶ	S	SE	SA	M1	M2	M3	IR 641	IR 642	IR 42
CK	1.00	-3.50	-2.11	-3.31	-8.05	-6.33	-1.12	-4.40	3.59	-14.88
CS	-0.28	1.00	-0.60	-0.95	-2.30	-1.81	-0.32	-1.26	1.03	-4.25
SE	-0.47	-1.65	1.00	-1.56	-3.81	-2.99	-0.53	-2.08	1.70	-7.04
SA	-0.30	-1.05	-0.64	1.00	-2.43	-1.91	-0.34	-1.33	1.08	-4.49
M1	-0.12	-0.43	-0.26	-0.41	1.00	-0.78	-0.14	-0.54	0.45	-1.85
M2	-0.16	-0.55	-0.33	-0.52	-1.27	1.00	-0.18	-0.69	0.57	-2.35
M3	-0.89	-3.11	-1.88	-2.95	-7.17	-5.63	1.00	-3.92	3.19	-13.25
IR 641	-0.22	-0.79	-0.48	-0.75	-1.83	-1.44	-0.25	1.00	0.82	-3.38
IR 642	0.28	0.97	0.59	0.92	2.24	1.76	0.31	1.22	1.00	4.14
IR 42	-0.06	-0.23	-0.14	-0.22	-0.54	-0.42	-0.07	-0.29	0.24	1.00
Annotation: The significance. The conception)	estimated elastici cointegrating vect	ty was calculated or was also specif.	based on the norr ied by including co	malized cointegrat	ting vectors by Jo y variables repres	hansen methods. enting the impler	All parameters we nented price policy	re found to be sto during the period	atistically significar s of investigation.	t at 5% level of Source: Author's

station. The estimated electricity was calculated brand on the normalized contraction contact and the fractional citation of the statistical citation of the
מתיוסון. וווב באנווזתובת בותאנתול אתא בתובתותובת מתאבת מון נווב וומווותודבת בסווובהלותנוול אברנמו אל זמוווברוו וובנוומתי. אוו לתומווברבו אבוב ומתוח נס מב אתתאוורמוו מו 2.% ובאבו מ
ficance. The cointegrating vector was also specified by including constant and dummy variables representing the implemented price policy during the periods of investigation. (Source: Author's
eption)

5. Discussions

The pattern of rice price interdependences was investigated by calculating the cross-product price elasticities. Based on Table 5 and 6, it appears that any increase in prices in one rice variety will be accompanied by a decrease in the prices of other types of rice varieties.

Most of cross-product price elasticities were found to be negative, implying substitution relations among rice products as expected. However, the exception was found for IR 642 rice variety whose cross price elasticities were positive, implying a complementary relation. This finding may be related to the fact that the end consumers of IR 642 rice are generally not household consumers. IR 642 rice is commonly used as the raw material for rice flour in the rice processing industry. Therefore, the IR 642 rice is indeed not a substitution of other rice varieties that are intended for the retail market. The price of IR 642 rice variety tended to move in the same direction as the increase and decrease in the price of other rice varieties. Table 6 presents the results of the average cross price elasticity of rice products based on rice quality category, while the complete estimations are presented in Table 4.

The increase in the premium quality rice prices will have a greater impact on the medium-quality rice prices than it will on the prices of low-quality rice. The medium-quality rice prices will decrease by 4.66 percent for every 1 percent increase in the premium-quality rice prices. A one percent increase in the premium rice prices only lowers the price of low- quality rice by 2.18 percent. Similarly, if there is an increase in the price of the low-quality rice, a reduction in the price of medium-quality rice will be greater than the price of premium-quality rice. The substitution relationships between medium-quality rice and premium-quality rice and between medium-quality rice and low-quality rice. On the other hand, changes in the price of medium-quality rice groups had the lowest effect on prices of rice groups of other qualities, namely premium quality (-0.39) and low quality (-0.87). Therefore, it can be concluded that the effect of cross price changes between quality groups is not symmetrical for medium-quality rice groups.

The average cross price elasticity among rice varieties in the premium quality group had the lowest value compared to those in the medium-quality and low-quality rice groups. In addition, the cross-price elasticity that occurs among premium rice groups (-1.43) was lower than cross price elasticity from the impact of premium-quality rice price changes on medium-quality rice (-4.66) and low-quality rice (-2.18). Changes in the price of one of the rice varieties that occurred in the premium quality rice group had a greater relationship with the price of rice in the medium-quality and low-quality groups than with the price of other varieties of rice in the same premium-quality group.

Beside investigating the value of cross price elasticity among the rice products with different quality, the pattern of interdependence among the rice prices was also explored by calculating the half-life time adjustment to see how much time was required for each rice product to react for the shock in the market disequilibrium. Table 7 summarizes the average of half-life time adjustment based on rice quality category.

The detailed estimates of the half-life time adjustment from restricted VECM are presented in Table 5.

As presented in Table 5, if there is a shock of the price of one of the rice varieties, it becomes apparent that the premium-quality rice takes the longest time to return to its balance. Meanwhile, the prices of medium- and low-quality rice groups adjusted relatively faster to balance condition.

Prices included in the premium quality rice group needed a longer time to return to their balance condition, which is an average of half a life time vacation for more than 9 days. However, mediumquality rice and low-quality rice each has a half-life time adjustment average of 5.90 days and 5.35 days. The estimated half-life time adjustment of premium-quality rice that was relatively longer than those of medium-quality rice and low-quality rice was possibly due to the elasticity of premium-quality rice demand that is relatively lower than the demand for medium-quality rice and

					Dependen	t variable				
Normalization	СК	S	SE	SA	M1	M2	M3	IR 641	IR 642	IR 42
CK	13.86	2.89	17.33	9.90	5.77	1.77	8.66	6.93	2.57	3.54
C	11.55	3.30	16.50	9.49	5.45	1.79	8.55	7.06	2.57	4.41
SE	8.29	2.21	14.51	9.52	5.44	2.02	8.54	7.05	2.81	4.07
SA	8.28	2.05	14.51	18.21	6.75	1.78	8.54	7.05	2.79	3.61
M1	8.27	2.27	14.54	9.52	5.44	2.09	8.54	9.83	2.91	5.09
M2	12.44	2.26	53.77	9.52	8.00	3.05	8.50	18.60	3.80	5.22
M3	8.27	2.04	14.51	9.52	5.44	2.06	8.54	7.05	2.96	3.61
IR 641	8.27	2.23	14.51	14.54	8.03	1.98	14.19	7.05	3.00	4.04
IR 642	7.34	2.04	19.87	9.52	4.71	1.78	13.99	7.05	2.83	3.61
IR 42	8.26	2.04	14.51	11.08	6.52	1.92	10.85	7.81	2.56	3.61
Annotation: The es restricted VECM. (S	stimated half-life ource: Author's c	time adjustment onception)	was calculated bas	sed on the estima	ition of error corre	ction coefficients,	which were statist	ically significant a	It 5% level of signi	ficance from the

Table 5. Estimated half-life time adjustment from restricted VECM (day)

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Table 6. Average of cr	oss price elasticity of rid	e products based on ric	e quality category
Rice product	Premium	Medium	Low
Premium	-1.43	-4.66	-2.18
Medium	-0.39	-1.50	-0.66
Low	-1.15	-4.01	-2.90

Source: Author's conception

low-quality rice. Premium-quality rice is generally consumed by households that fall into the upper-middle income category. A study by Najmudinrohman (2015) using the 2013 National Socio-Economic Survey (Susenas) data showed that the price elasticity of demand for rice from households with high-income category was -0.093, which was smaller than the elasticity of demand from middle- or low-income households each of which was -0.154 and -0.277. The same finding also revealed that the half-live time adjustment of medium-quality rice was longer than that of low-quality rice.

Regarding the effect of policy intervention during the investigated period, this study suggested the variation effects of those policy for each rice product. Along with the argument of maintaining food price stabilization, the Indonesian government has initiated some food price policies for some main food commodities including rice. This price policy is mainly coordinated by the Ministry of Trade (MoT) technically by issuing Minister's regulation. During the last 5 years, the MoT has issued two regulations in 2016 and in 2017 as an amendment to the previous regulation. In 2016, through the Regulation of the Minister of Trade Number 63/M-DAG/PER/9/2016, the government published the application of purchasing price reference policy and the price reference policy for the sale. According to this regulation, the purchasing price reference is applied at the farmers' level while the price reference for the sale is set at the consumer's level. The government argues that the price reference is determined by considering the reasonable cost structure, including production costs, distribution costs, profits, and other possible costs. The purchasing price preference at the farmers' level for rice was set at IDR 7500, while the price reference for the sale at the consumers' level was set at IDR 9500.

In 2017, the government has made an amendment to the previous price reference policy by issuing the Minister of Trade's Regulation, number 57/M-DAG/PER/8/2017. According to this regulation, price ceiling policy at the retail level has been applied to rice products in the form of *Harga Eceran Tertinggi* (HET) or maximum retail price (MRP). Different from the previous regulation in 2016, the rice price is established at the retail level and applied to the medium and premium rice products. The previous regulation in 2016 did not consider the difference of the rice products quality. In addition, the MRP is also set differently for each area in Indonesia.

In the long run, the effect of the implementation of price policy on the rice price dynamics generally show variations both in the magnitudes and signs of the estimated policy variable, i.e., POL 2016 and POL 2017, as shown in Tables 8 and 9.

It implies that each price variable has different reaction to the implementation of price policy. Regarding the significance of policy variables, the findings showed that price policy in 2016 did not have significant effect on the price dynamics in most cases. The significant effect of POL 2016 was found on some rice products which are commonly characterized as medium- and low-quality rice products, i.e., SA, Murni 1, Murni 2, IR 641 and IR 642. Meanwhile, different findings were found in the significance effect of price policy in 2017. In the case of Cianjur Kepala (CK) rice, this variable did not react to the implementation of POL 2016 in most cases, but as shown in Table 9, the effect of POL 2017 on the price dynamics was generally negative. However, an exception was found when we normalized the cointegrating vectors using CK price variable. According to this model, it was suggested that the effect of POL 2017 was positive on most variables, with an exception for

Table 7. Average half-	life time adjustment (da	ays) based on rice qualit	y category
Rice quality price	Premium	Medium	Low
Premium	10.14	5.88	4.54
Medium	9.16	6.71	5.33
Low	9.69	5.12	6.20

Source: Author's conception

the response of IR 64, which was negative. Regarding the sign of the estimated coefficient, an exception was also found in the case of IR 42. It was suggested that the effect of POL 2017 was positive. Combining the empirical findings of the effect of price policy, this study suggests that rice market in Indonesia seems to become more heterogeneous. Each rice product has been found to have different reaction to the implementation of price policy. These findings have also confirmed the assumption that rice consumers have been differentiated according to the type and quality of rice products.

6. Conclusion

As the strategic food commodity for Indonesia's economy, rice has been commonly assumed to be homogeneous product in the market. However, along with the changing socioeconomic condition, the situation may require to be further clarified. Following this motivation, this study found the different behavior among different rice products. It is generally found that the rice products of different quality and characteristics in Indonesia have different price behaviors. As the price reflects the dynamics of both consumption and production sides, the study on the price at the wholesale market can provide insights on how the interactions among the markets of rice products along the supply chain, which also relates to the behavior of the traders. According to this, the study has explored the pattern of interdependence of rice prices with products of different quality and characteristics.

Generally, this study found that the prices of various variety of rice of various qualities in the wholesale market are statistically and significant related among each other. However, the results also found an exception, which proposes a unique behavior from the lowest priced rice products, i.e., IR 643. The IR 643, which were found to be stationary at level, while the remaining rice products were stationary at the first difference, and thus, this price variable was not cointegrated with all other price variables. This finding may be related to the fact that the IR 643 is commonly used by the government for the aid program for the poor people. Therefore, the price of IR 643 is strictly established to be at the low level by the government.

Based on the magnitude of cross price elasticity of product, the prices of premium-quality rice have a larger influence on the price of medium-quality rice rather than on the price of low-quality rice. Similarly, the prices of low-quality rice have a greater influence on the price of medium-quality rice than on the price of premium-quality rice. Therefore, it can be concluded that the substitution relationship between premium-quality rice and low-quality rice is lower than the substitution relationship between premium-quality rice and medium-quality rice and lower compared to the substitution relationships of low-quality rice with medium-quality rice. Furthermore, based on the half-life time adjustment indicator, the price of premium-quality rice product affected by any shock will require a longer time to return to the equilibrium condition compared to the price of mediumquality rice product and the price of low-quality rice product.

By assuming that the traders in the wholesale market behave as firms with multi-product, we propose the finding that price interdependence is related to this assumption where the trader is not fully acting as a price taker in the market. According to the sign of cross price elasticities of the rice products, which were mostly negative, the empirical findings support the existence of

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					Dependent	: variables				
Normalization	СК	cs	SE	SA	M1	M2	M3	IR 641	IR 642	IR 42
CK										
POL 2016		0.05	0.02	0.01	0.18	0.13	0.02	0.06	-0.10	0.29
CS										
POL 2016	-0.01		-0.00	-0.04	0.07	0.03	00.00	-0.01	-0.05	0.07
SE										
POL 2016	-0.01	0.01		-0.03	0.09	0.05	00.00	00.0	-0.06	0.11
SA										
POL 2016	-0.00	0.04	0.02		0.16**	0.11**	0.014	0.04**	-0.09	0.24**
M1										
POL 2016	-0.02	-0.02	-0.02	-0.06**		-0.02	-0.00	-0.04**	-0.02**	-0.05
M2										
POL 2016	-0.02	-0.02	-0.02	-0.06**	0.02**		-0.00	-0.03**	-0.03	-0.01
M3										
POL 2016	-0.02	-0.00	-0.00	-0.04	0.05	0.02		-0.01	-0.05	0.05
IR 641										
POL 2016	-0.01	0.00	-0.00	-0.03**	0.08**	0.04**	0.00		-0.05	0.09
IR 642										
POL 2016	0.78**	-0.05	-0.03	-0.08**	-0.04	-0.05	0.01	-0.07**		-0.14
IR 42										
POL 2016	-0.02	-0.01	-0.01	-0.05**	0.03	0.00	-0.00	-0.03	-0.03	
Note: Annotation	: *significant at 1()% level, ** signific	ant at 5% level, *'	** significant at 1%	level (Source: Autl	nor's conception)				

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Normalitzation	;		}		Dependen	c variables				
Normalization	СК	cs	SE	SA	M1	M2	M3	IR 641	IR 642	IR 42
CK										
POL 2017		0.38**	0.20**	0.37**	1.08**	0.83**	0.02	0.52**	-0.75**	2.23**
CS										
POL 2017	-0.11^{**}		-0.03	0.00	0.21**	0.14**	-0.10**	0.04	-0.36**	0.61**
SE										
POL 2017	-0.09**	0.04		0.05	0.32**	0.23**	-0.09**	60.0	-0.41**	0.81**
SA										
POL 2017	-0.11^{**}	-0.00	-0.03		0.19**	0.13**	-0.11**	0.03	-0.35**	0.58**
M1										
POL 2017	-0.13**	-0.09**	-0.08**	-0.08**		-0.02	-0.13**	-0.07**	-0.26**	0.22**
M2										
POL 2017	-0.13**	-0.08**	-0.07**	-0.07**	0.03		-0.13**	-0.06**	-0.28**	0.28**
M3										
POL 2017	-0.01	0.32**	0.17**	0.31**	0.95**	0.73**		0.45**	-0.69**	1.99**
IR 641										
POL 2017	-0.11^{**}	-0.03	-0.05	-0.02	0.14**	0.08**	-0.11^{**}		-0.33**	0.48**
IR 642										
POL 2017	-0.21**	-0.35**	-0.24**	-0.32**	0.32**	-0.49**	-0.21**	-0.04**		0.09**
IR 42										
POL 2017	-0.15^{**}	-0.14**	-0.11^{**}	-0.13^{**}	-0.12^{**}	-0.12**	-0.15**	-0.14**	-0.21**	
Note: Annotation:	*significant at 10	1% level, ** signific	ant at 5% level, **	* significant at 1%	level (Source: Aut	hor's conception)				

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substitution relationships among the rice products of different qualities and characteristics. This substitution relation may reflect that the trader in the market will adjust their decision on trading, and maybe pricing, depending on the dynamics of each rice product. For example, traders may decide to mix some rice products to exploit more profit due to price differences. As a consequence, it will lead to substitution relations among the different rice products. However, an exception was found in the case of the IR 642 rice price, which is categorized as the low-quality rice product. The IR 642 was found to have positive sign of cross price elasticity with the prices of all other rice products.

The results of this study have important implications for the policy formulation, especially in the food sector in Indonesia. In the context of agricultural policy in Indonesia, where rice market has been quite highly intervened, the understanding of market dynamics needs to be improved. Differentiation by considering the behavior of each rice products and the behavior of each actor along the commodity's value chain in more detail is then crucial in the policy formulation process. Furthermore, policy to stabilize rice prices in the market needs to pay attention to the linkages between prices of rice of various varieties and qualities in the market. The policies aimed at regulating medium-quality rice prices are estimated to have relatively weak effects on the prices of premium-quality rice category and low-quality rice. However, if there is a change in the price of premium-quality rice.

Despite the contribution of this study in investigating the presence of quality differentials in the market dynamics especially in rice market sector in Indonesia, this study still has limitations that we should be aware of. This study has only relied on the behavior of prices at wholesale level at a specific market in Jakarta. This may not be directly reflecting the firm's behavior specifically. Additionally, this may be insufficient to capture the whole dynamics of rice markets in Indonesia with various geographic and physical situations.

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