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Government intervention and market integration in Indonesian rice markets

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Abstract

Long-run spatial price relationships in Indonesian rice markets and factors affecting the degree of market integration are evaluated using multivariate cointegration tests with weekly price data for the 1982–1993 period. The analysis includes evaluation of pre-self-sufficiency and post-self-sufficiency periods as well as for the entire period. The cointegration tests for entire Indonesian rice market, represented by the nine most relevant price series, indicate that relative to the pre-self-sufficiency period, the post-self-sufficiency period has a smaller degree of market integration. The change of the degree of market integration over time indicates that rationalizing of the Indonesian rice price policy beyond 1984 rice self-sufficiency has resulted in a less integrated market. This suggests that the policy shift has allowed the government to decrease its intervention without significantly decreasing market integration, indicating that the private sector is responding to price signals appropriately. It is possible that further reduction in intervention through widening the band between the floor and ceiling price could be accomplished without greatly affecting market integration. Regression results show that government intervention in terms of rice procurement significantly influenced market integration during the period of post-self-sufficiency (1985–1993) and the entire period of 1982–1993. This indicates that this aspect of government intervention has had positive influences on market integration, in contrast to distribution efforts, which were not found to be statistically significant. Procurement prices may be high, and could perhaps be lowered, reducing program costs. Regional per capita income is also found to be positively related to higher levels of market integration, suggesting that in periods of economic growth, government intervention may be decreased, thereby reducing program costs. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: Cointegration; Indonesian rice prices; Government rice price policy

1. Introduction

Given the central importance of rice in the Indonesian economy as well as the ongoing debate concerning government intervention in domestic markets, it is necessary to evaluate the rice price stabilization program. This program is an important component of the overall Indonesian food and agricultural development plan since price supports may be socially beneficial through a reduction of uncertainty. Timmer (1996) suggests that the social benefits of the policies

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have historically outweighed the associated costs, though the consensus is less clear following self-sufficiency in the mid-1980s and into the 1990s.

Overall market performance may be indicated by spatial price behavior in regional markets and spatial market performance may be evaluated in terms of its price relationships. Cointegration tests can be used to examine the long-run strength and stability of rice price relationships since these tests provide information about the long-term stability of price relationships in the Indonesian rice markets.

The Johansen and Juselius (1990) cointegration tests are used to evaluate the integration of Indonesian rice markets and factors associated with market integration, including government procurement and distribution programs. Specifically, this study assesses and compares the spatial price relationships of the Indonesian rice markets before and after the attainment of rice self-sufficiency in 1985 using weekly time series consumer rice price data from each region in Indonesia between 1982–1993, and analyzes factors affecting the rice market integration such as government intervention, as well as infrastructure and development variables. The goal is to evaluate government rice price policy and factors which have influenced market integration during a period of policy change, recognizing the continuing goal of rice price stabilization by the government in an era of reduced government expenditures.

2. Background and related literature

Rice is the most important crop in Indonesia accounting for over 60% of the total food crop production and providing an estimated 50% of both calories and proteins (Food and Agriculture Organization, 1991). The area of harvested rice is roughly three times the area of corn acreage and eight times the area devoted to soybeans. Indonesia is geographically dispersed, constituting many islands and consisting of both rice surplus and deficit regions. In Java, the substitutes for rice production, corn and soybeans, are much less profitable than rice. Rice has seasonally higher output prices and higher yields which lead to higher financial returns than those of competing crops.

There are two aspects of rice price stabilization in Indonesia: inter-seasonal stabilization and inter-year stabilization. Seasonally, rice prices tend to fluctuate because the harvest does not occur evenly through the year. The main harvest in the February–May period accounts for about 60% of annual production; the second season harvest in the June–September period accounts for 30%; and the remainder is harvested during the period of October–January, during the latter part of the dry season. In the absence of intervention, prices drop steeply during the main harvests, level off during the second season harvest and rise during the lean season.

The price of rice is an important component of the retail price structure in Indonesia because of the large weight of rice in the representative consumption basket. Based on 1981 National Socio-Economic Survey (Susenas) data (BPS, 1982), van de Walle (1989) estimated that rice accounted for nearly one-third of the total food expenditures for the total population, though Timmer (1996) notes that rice has declined in importance, representing only 7.2% of the consumer price index in 1995.

In the late 1960s, the Indonesian new-order government initiated a series of measures to increase the production of rice to achieve food security and adequate stability in rice prices in a manner that would safeguard both producer and consumer interests. The government established the national food logistics agency (BULOG) to manage the rice price policy. It began to control the consumer prices of rice intensively in 1968 because of the political importance of consumer rice price stability. However, it has attempted to maintain a balance between producer and consumer interests.

Government interventions in the rice market, which are administered by BULOG, are intended to avoid a sharp decrease in price during the harvest seasons as well as to maintain the acceleration of a sufficient rice supply over times and places at a reasonable price. This parastatal agency operates as a classic buffer stock authority in the rice market (Ismet, 1988). BULOG implements a procurement program in rural areas to stabilize farm prices as well as distribution programs, particularly in urban areas, to stabilize consumer prices.

For many years, rice production lagged behind actual consumption. Until the early 1980s, Indonesia consistently imported rice and was the world's largest importer in the periods 1959–1964 and 1973–1980. As the growth of rice production accelerated from roughly 3% in 1970–1977 to 7% thereafter, rice imports declined significantly. By 1985, Indonesia achieved self-sufficiency in rice. However, drought and other factors in recent years have resulted in the government importing significant quantities of rice, leading Jones (1995) to conclude that self-sufficiency on trend may not be attainable or desirable.

In terms of price policies, each year the government sets and defends a floor price for *gabah* (unmilled rice). The floor price is maintained by increasing the demand for gabah and milled rice. Operationally, BULOG purchases this surplus from village cooperatives (KUDs) and from private traders at a specified procurement price, and stores the purchased grain in government warehouses. The floor and procurement prices are announced by the government each year at the beginning of planting season.

In the urban market, BULOG releases its stock in the late months of the crop year when the wholesale price approaches the ceiling price. The agency also controls international trade which completely insulates the domestic price from any international price uncertainty. This rice price stabilization policy has meant that at times domestic rice prices have been below world prices and at other times above them. BULOG's own operations account for only about 7% of rice production in a typical year. The food agency has never procured more than 12% of the total rice harvest or perhaps 20% of total rice traded domestically. Most of the rice sold by farmers is traded through private channels.

The World Bank (1987) and Food and Agriculture Organization (1991) noted that BULOG has been quite successful in stabilizing prices, keeping actual prices between the announced 'floor–ceiling' band in most years. Domestic prices show much less variation around the trend than the world prices. Seasonal rural and urban prices variability has also been significantly reduced over time.

Stable rice prices in Indonesia have significantly improved incentives to farmers during the period of 1968–1984 where Timmer (1985) estimated that as much as one-half of the growth in rice production was attributed to stable prices and fertilizer subsidy. The reduction in price variations indicates some success in decreasing the price risks which are of special concern to rice farmers. Timmer (1996) also concludes that continued price stabilization policies into the 1990s have contributed to significant social gains. These have been offset to some extent, however, by increasing operating costs.

During the surplus in 1986, following the attainment of rice self-sufficiency in 1985, BULOG's rice operation created a massive accumulation of stocks resulting in large storage and carrying costs. A huge marketed surplus existed because intertemporal marketing margins were narrow which caused a declining role for the private sector in rice stocking (BULOG operations tended to be directly proportional to the extent the operations squeezed the private marketing sector). Consequently, the financial burden rose as well. The government procured the marketed surplus to secure the floor price as a consequence of the stabilization program. Meanwhile, the government had already begun to feel budgetary pressures after the drop in world petroleum prices in 1983.

This financial burden called into question the cost-effectiveness of the price stabilization program. The policy to accelerate growth in rice production by keeping annual production above the consumption level, which allows absolute self-sufficiency, created serious problems for Indonesia's rice economy. Furthermore, rice deficits in 1987 and 1988, following the surplus period, strengthened the government's resolve to maintain Indonesia's capacity to sustain self-sufficiency.

Following this period, the government employed an intermediate strategy that would target production growth roughly equal to consumption growth (at about 2.5% per year). BULOG also relaxed its price policy, widening the gap between the floor and ceiling price, reducing the necessity of government intervention. During the 1970s and early 1980s, the floor/ceiling price disparity ranged between Rp. 40 and Rp. 110 per kilogram. In 1983, just prior to self-sufficiency, the difference was Rp. 140, but increased to over Rp. 200 in the late 1980s. During the 1990s, the difference between the floor and ceiling price has averaged Rp. 320 per kilogram. This rice strategy (occasional imports and/or exports) is less costly, requiring lower government expenditures on subsidized storage and trade and also facilitates private market development by creating conducive market structures for private sector initiative.

Thus, it seems economically beneficial for Indonesia to pursue a policy directed toward maintaining rice's status as a non-tradable, at least on trend (Heytens and Pearson, 1990). The basic strategy is to attempt to equilibrate production and demand growth at long run international prices. Nevertheless, this rationalization strategy has impacts on the level and stability of rice prices. Price stabilization continues to be the government policy objective, but at a feasible cost.

This change in policy is reflected in the economic literature on price stabilization programs. Generally, most economists find government stabilization of staple food prices to be less than desirable. Much of the literature has found price stabilization programs to be difficult to operate, often not worth the costs, and liable to be captured by special interests (Timmer, 1996). This has led to many countries decreasing intervention in the markets. The Philippine experience with price stabilization programs is similar to that of Indonesia, though with less success generally. Baulch (1997) found that when transport costs are included, the Philippine rice market was integrated nearly 100% of the time, indicating that government intervention could be further reduced.

Little has been done in the way of empirically evaluating actual rice market performance in Indonesia, though several descriptive studies are available (Timmer, 1974; World Bank, 1987; Food and Agriculture Organization, 1991; Pearson et al., 1991; Tabor, 1992). A pioneering study by Mears (1961), conducted prior to the Green Revolution, found that rice markets in Indonesia were not operating efficiently, and were often the subject of political considerations. Timmer (1974) evaluated marketing margins in the Indonesian rice market. This analysis was conducted following the policies introduced by the New Order government and the effects of the high-yielding varieties. Petzel and Monke (1979) included Indonesia in their analysis of international rice market integration in 1979. Indonesia at this point was the world's largest importer of rice and thus had a large influence on the international market. Squires and Tabor (1987) econometrically tested for rice market integration in Java using Granger (1981) causality tests, finding the Javanese rice market to be integrated. Other regions were not evaluated.

Alexander and Wyeth (1994) used cointegration tests developed by Engle and Granger (1987) to evaluate integration in Indonesian rice markets and found that the market was integrated. However, they used monthly rather than weekly data and medium rice price data rather than a continuous data source. In addition, only seven regions were included in the analysis, with the deficit eastern regions of Indonesia excluded. Nor did they evaluate variables associated with market integration.

This study, using the multivariate Johansen and Juselius (1990) cointegration tests, explores the dynamics of the price determination process which involves all spatially linked locations simultaneously in the geographically dispersed Indonesian rice markets. This study is conducted in order to test the hypothesis that all regional markets are linked together into a single economic market. If the separate economic markets are linked spatially in the long-run (i.e. the price series are cointegrated and exhibit strong dynamics), this may imply a form of spatial efficiency for regional linkages. The process is an important indicator of overall market performance. In order to gain additional insight into the consequences of the price policy shift, dynamic analysis of pricing relationship will be performed annually and in two different periods: pre- and post-rice self-sufficiency.

3. Cointegration and spatial market performance

Two markets are said to be spatially integrated if, when there is trade between them, the price in the exporting market together with transport costs and other transfer costs is equal to the price in the importing market. Market integration by itself, however, does not imply that the markets are competitive (Baulch, 1997).

There are two general approaches to testing market integration. The first, often referred to as the 'Law of One Price,' tests for perfect co-movement of prices and assumes that if markets are integrated, price changes will be transmitted on a one-for-one basis to other markets. The weaknesses inherent in this approach are that trade flows must occur in every period, non-random changes in transfer costs may cause the model to reject market integration when spatial arbitrage actually holds, and a choice must be made between absolute and proportional marketing margins as a maintained hypothesis. It is also assumed that prices in one market are exogenously determined using this approach.

To deal with some of these problems, cointegration tests are used to test for more general equilibrium. These tests allow price comovement to be less than perfect, allow for prices to be determined endogenously, and permit seasonal variations in transfer costs. The weaknesses of this approach include ignoring transfer costs and assuming a linear relationship between market prices. In addition, cointegration tests are unable to distinguish integrated from independent markets when both are subject to a common, exogenous inflationary process. Despite these weaknesses, this approach is more suitable than the Law of One Price in evaluating Indonesian rice markets.

Using the Johansen and Juselius (1990) approach, the following likelihood functions for Y_t conditional on any β are estimated by ordinary least squares using the SAS statistical package:

$$\Delta Y_t = \mu_{0t} + \sum_{i=t}^{k-1} \theta_{0i} \Delta Y_{t-i} + V_{0t} \tag{1}$$

$$Y_{t-k} = \sum_{i=1}^{k-1} \theta_{1i} \Delta Y_{t-1} + V_{1t} \tag{2}$$

where Y is a vector of the price series being investigated. Following the procedure of Goodwin (1992), and Brester and Goodwin (1993) who cite Dickey and Rossana (1990) in doing so, an intercept μ was included in Eq. (1). This approach uses canonical correlation techniques to identify the cointegrating relations.

To determine the number of cointegrating vectors in the vector of a time series Y_t, Johansen and Juselius (1990) use two likelihood ratio test statistics by using the residual vectors v_{0t} and v_{1t} of Eq. (1) and Eq. (2), respectively. Canonical correlation techniques were employed by using SAS CANCORR procedure (SAS Institute Inc., 1990).

The first-test statistic, known as the trace test, is given by:

$$\tau_{\text{trace}} = -N \sum_{i=r+1}^{p} \ln\left(1 - \Pi_i^2\right) \tag{3}$$

where N is the number of time periods available in the data, $\pi_{k+1} \ldots \pi_n$ are the $n-k$ smallest canonical correlations of v_{0t} with respect to v_{1t}. The trace test evaluates the null hypothesis; that is, there are k or less cointegrating vectors.

The second-test statistic, which uses the $k+1$th largest squared canonical correlation or eigenvalue, known as the maximal eigenvalue test, is given by:

$$\tau_{\max} = -N \ln\left(1 - \Pi_{k+1}^2\right) \tag{4}$$

The second-test evaluates the null hypothesis that there are exactly k cointegrating vectors in Y_t. The test statistic should be compared to the critical values in Osterwald-Lenum (1992) who recalculated and extended the tables of critical values in Johansen (1988) as well as Johansen and Juselius (1990) to cover a test sequence from full rank ($r=p$; implying Y_t is stationary) to zero rank ($r=0$) implying all linear combinations are $I(1)$ for at most 11 series. If both test statistics are greater than the values, the null hypothesis is rejected.

As suggested by Engle and Granger (1987), before applying the cointegration tests, Augmented Dickey–Fuller (ADF) unit root tests are applied to each price series and their first differences to determine the stationarity of each individual price series. The minimum of the Akaike information criteria (AIC), is used to determine the appropriate lag length (value of p) in the ADF test (Brester and Goodwin, 1993).

The null hypothesis of the unit root test is that the variable under consideration has a unit root. The ADF test is derived, respectively, from the following regression (Engle and Granger, 1987):

$$\Delta P_t = \rho P_{t-1} + \sum_{i=1}^{p} \delta_i \Delta P_{t-i} + e_t \tag{5}$$

The ADF test statistics are the ratio of estimated ρ to their standard errors. The null hypothesis is rejected for values of estimated δ which are negative and significantly different from zero by comparing them with their critical values. If the results show that each individual time series in the data set is integrated of order one, $I(1)$, which means that they are non-stationary in levels but stationary in first differences, it allows the researcher to apply the Johansen and Juselius (1990) multivariate cointegration tests.

The number of cointegrating vectors supported by the multivariate test is an important indicator of the extent of integration among variables in the price system and is directly related to the number of common stochastic trends (unit roots) in the system. The cointegrating vectors represent the constraints an economic system imposes on the system's long-run variable movements. An increase (decrease) in such vectors is viewed as an increase (decrease) in the strength and stability of price linkages (Dickey et al., 1991).

4. Bootstrapped regression analysis

Variation in rice market integration over time may be influenced by both economic and non-economic factors. A regression analysis of the following equation is undertaken to analyze the effects of government interventions in the rice market on market integration, with rice production, kilometers of roads, and a dummy variable representing the period of rice self-sufficiency:

$$\mathrm{CS}^j_{it} = \beta_0 + \beta_1\,\mathrm{PROC}^j_{it} + \beta_2\,\mathrm{DISTR}^j_{it} + \beta_3\,\mathrm{ROAD}^j_{it} + B_4\,\mathrm{PCI}^j_{it} + \beta_5\,\mathrm{DUM}_t + e^j_{it} \tag{6}$$

where CS^j_{it} represents the jth cointegration test statistic in market I at period t. PROC^j_{it} is the government procurement performed by DOLOG^j_{it} (BULOG's provincial office) normalized by rice production during the procurement period in regional market I at period t. DISTR^j_{it} is the government market injection by DOLOG^j_{it} normalized by rice production during the distribution period in market I at period t. ROAD^j_{it} is kilometers of roads in market I normalized by squared kilometers of the market at period t. PCI^j_{it} is real per capita income in market I at period t, which represents economic development other than length of roads. DUM_t represents the rice self-sufficiency period, equals 1 for the period beyond 1984, otherwise it equals 0. The parameters of Eq. (6) are hypothesized to have the following signs: $\beta_1>0$, $\beta_2>0$, and $\beta_3>0$. It is anticipated that $\beta_4<0$ since it is expected that levels of price integration declined after BULOG widened the gap between the floor and ceiling prices.

Intervention variables (PROC and DISTR) represent the presence of BULOG in rice markets which sets a limit to seasonal and interspatial price margins. BULOG procures some of marketed supplies to safeguard the floor price during the harvest period in which almost 60% of the annual rice harvest occurs in the 4-month period. Rice producers market their harvest which is nearly 40% of annual consumption in this period. During the off-harvest period, BULOG releases some of its buffer stock to secure the ceiling price.

Indonesia is geographically dispersed and its many regional economies are poorly integrated. Interprovincial price variations occur due to economic diversity and geographical conditions. Regional price differentials might be correlated with indicators of transport infrastructure. Distance between markets is used as a proxy for transport costs. It is also associated with the risk of interprovincial trade. Transport costs will be directly related to the road distance between rice markets. In the last two decades, there have been remarkable improvements in Indonesia's transportation networks. The construction of the trans-Sumatra, trans-Kalimantan and trans-Sulawesi Highways might have significant positive impacts on market integration.

Other infrastructure developments such as milling facilities, rice storage capacity, number of trucks and boats, and numbers of rural banks and rural cooperatives are represented by the per capita income variable. There has been a dramatic growth in the infrastructure during the last two decades, both physical and institutional (Tabor, 1992). It is anticipated that regional per capita income functions as a proxy for these variables better than a simple trend variable, since income would capture variations in growth over the time period. In addition, a dummy variable is used to capture the impacts of price policy shifts occurring after 1984 on market integration.

The above factors which may influence spatial market integration can however, be formally assessed, since the test statistic of cointegration is a generated regress and which follows a non-standard (non-normal) distribution, the OLS estimator is not normally distributed. Thus, OLS cannot directly be utilized (Goodwin and Schroeder, 1990; Brester and Goodwin, 1993). Alternatively, bootstrapping, a distribution-free method introduced by Efron (1979), can be used to deal with violations of normality and obtain useful parameter estimates. The bootstrap distribution converges to the true distribution of the OLS estimator as both sample size and the number of bootstrap samples increase. Freedman (1981) found that the bootstrap approximation to the distribution of the least square estimates is valid.

The bootstrapping technique draws random samples from the available sample, with replacement, to estimate population variance. The technique requires only that residual errors be independently and identically distributed regardless of their distribution (Prescott and Stengos, 1987).

Bootstrapping is done by running the OLS regression which results in parameter estimates b and residual vector e. A residual vector e_j^* is formed by randomly selecting n residual from vector e, where j=1 is the first random selection. A new model can be established using the estimated coefficient b and residual vector e_j^* as follows:

$$Y_j^* = a + Xb + e_j^* \tag{7}$$

where j=1,...,N and where N is number of replications in the bootstrapping procedure. The artificial dependent variable y_j^* depends on the parameter estimate b which was obtained from the original data (y, X). Then the parameter vector β is re-estimated N times to obtain b_j^* which can be used to set the joint probability distribution of b, the OLS estimator. Bootstrapped estimates were obtained from 1000 replications in this study.

5. Scope and source of data

The cointegration tests described above are applied to weekly provincial level data on retail rice prices for Java and off-Java rice markets during the period of 1982–1993 (624-week series, from January 1982 to December 1993). Weekly data provide certain advantages over longer period (monthly or quarterly) data since weekly data may allow greater detail in the modeling of causal relationships and may also show more price dynamics.

There are 27 provinces in Indonesia, however, since the number of variables in the tests is limited; only price series in nine relevant provinces are chosen for the overall Indonesian rice market analysis by considering the division of the Indonesian rice market based on the rice market characteristics as was done by Sapuan (1991). Sapuan divided the Indonesian rice market based on several factors, such as ratio between rice production and consumption, the volume of private rice trade, and government intervention. The nine regions selected for the study are Medan and Palembang (representing Sumatra), Jakarta and Surabaya (representing Java), Banjarmasin (representing Kalimantan), Ujung Pandang and Menado (representing Sulawesi), Mataram (representing Nusa–Tenggara), and Jayapura (representing the province of Irian Jaya). Medan and Palembang are the largest deficit markets in Sumatra. In Java, Jakarta is the largest deficit market while Surabaya is the largest surplus market. Ujung Pandang and Mataram are important surplus markets outside Java. In Jayapura, rice markets are small with sago, instead of rice, the most important staple food.

The data used in this study are from the Indonesian central bureau of statistics (BPS). These price data were collected weekly by the consumer price evaluation team (THE) in each province. Thus, lagged and feedback effects as a price shock transmitted through the entire spatial market that occur in less than a week will be masked. Consumer rice price data used in this study were recorded by Provincial BPS offices. BPS is the source of officially published rice price series. Since the analyses require a homogeneous product across regional markets, one price was chosen for each provincial capital rice price data based on its similarities in variety and availability of continuous time series. All rice prices were quoted in Indonesian monetary terms, rupiah per kilogram.

There are a great many rice varieties in Indonesia. The chosen variety of rice used in this study is the IR variety, even though its market name may be different. The IR variety is chosen to reflect national statistics in which it occupied more than 80% of all harvested rice acreage (Hadiwigeno et al., 1992). It is expected that by choosing the IR variety, the likelihood of grain quality variability is reduced. For the purpose of this study, by choosing a similar variety of rice across regions, it is assumed that price variability is due to spatial and seasonal effects and not to the presence of physical quality and variety differences in the data.

Alexander and Wyeth (1994) did cointegration tests by using monthly *medium* rice prices of seven cities published by BULOG. Medium rice is the largest marketed rice-type at a certain period of time and is monitored for the purpose of inflation rate calculations. However, these medium price data may not be consistent and thus, not comparable, since the medium rice-type may be different across provincial capital cities and also, the variety of the medium rice may change over time, contributing to spatial, temporal and discontinuity problems. The changes in the type of medium rice over time may be mistakenly interpreted as a structural change in the demand for rice. Thus, the medium price may not provide an accurate indicator of rice prices. Studies which use the medium price generally assume homogeneity of the medium rice across regions.

6. Analysis and results

The price data are analyzed before and after rice self-sufficiency of 1985. The period of 1982–1993 is divided into two periods (1982:1–1984:52 and 1985:1–1993:52). In the post-1985 period, BULOG rationalized its price stabilization activities by lowering the costs of its rice operations after realizing that an absolute self-sufficiency strategy was very costly. It is expected that there are differences in market integration levels between periods due to the shift in the rice price policy, measured by cointegration analysis.

Augmented Dickey–Fuller (ADF) unit root tests are used to determine whether each time series is non-stationary or not. Lagged differences of the augmented Dickey–Fuller test were determined by using minimum Akaike's information criteria. The null hypothesis is that the variable observed has a unit root, against the alternative that it does not. If the price data being analyzed are integrated for at least order one, then it is possible to do cointegration tests. After determining that the series contain one unit root, the trace test and the maximum eigenvalue test are used to determine the number of cointegrating vectors observed in the system.

Table 1 reports results for the ADF tests both on levels and first differences of the variables for Indonesian rice markets during the periods of 1982–1984, 1985–1993, and the entire period of 1982–1993. Critical values were taken from Fuller (1976). The results of the ADF tests for all series during the three periods

Table 1
Augmented Dickey–Fuller unit root tests results for Indonesian rice markets

Price series	1982–1984		1985–1993		1982–1993	
	ADF test statistic[a]	Lag order[b]	ADF test statistic order	Lag order[b]	ADF test statistic order	Lag order[b]
Levels						
Medan	−0.02	5	−1.29	2	−1.00	2
Palembang	−0.30	2	−1.39	3	−1.24	3
Jakarta	−0.97	2	−0.96	3	−0.61	3
Surabaya	−1.12	3	−1.19	4	−0.87	2
Banjarmasin	−0.59	2	−1.02	3	−0.83	3
Ujung Padang	−0.64	4	−0.96	2	−0.75	2
Menado	−0.42	2	−0.74	8	−0.86	8
Mataram	−0.22	2	−1.18	2	−0.93	2
Jayapura	−0.11	2	−0.61	2	−1.64	6
First differences						
Medan	−4.17***	5	−3.45**	2	−4.00***	2
Palembang	−2.99**	2	−2.97**	3	−3.51***	3
Jakarta	−2.97**	2	−3.03**	3	−3.16**	3
Surabaya	−9.28***	3	−2.99**	4	−3.40**	2
Banjarmasin	−2.61*	2	−3.27**	3	−3.19**	3
Ujung Padang	−2.89**	4	−5.90***	2	−6.11***	2
Menado	−4.37***	2	−2.98**	8	−2.94**	8
Mataram	−3.33**	2	−6.00***	2	−6.54***	2
Jayapura	−4.57***	2	−3.09**	2	−3.90**	6

[a]Critical values are −2.58 (α=0.10), −2.89 (α=0.05), and −3.51 (α=0.01) for 100<N<250 (Fuller, 1976).
[b]Lag ordered dteremined for ADF test using Akaike's information criteria (AIC).
***,** and * indicate rejection of the null hypothesis of a unit root at α=0.01, α=0.05 and α=0.10, respectively.

Table 2
Johansen and Juselius cointegration test results for Indonesian rice markets

Null hypothesis[a]	Cointegration test statistics			Critical value[b] (5%)	Critical value[b] (1%)
	1982–1984	1985–1993	1982–1993		
Trace test					
r=0	380.96**	255.02**	251.65**	202.92	215.74
r≤1	279.18**	189.20**	189.11**	165.58	177.20
r≤2	194.85**	133.18*	134.42*	131.70	143.09
r≤3	134.03**	84.87	95.61	102.14	111.01
r≤4	84.53**	56.38	70.06	76.07	84.45
r≤5	54.84*	36.97	45.93	53.12	60.16
r≤6	30.28	18.09	22.70	34.91	41.07
r≤7	11.53	6.13	5.53	19.96	24.60
r≤8	0.38	1.01	0.59	9.24	12.97
Maximal eigenvalue test					
r=0	101.78**	65.92**	62.54*	57.42	63.71
r=1	84.33**	56.02*	54.69*	52.00	57.95
r=2	60.82**	48.31*	38.81	46.45	51.91
r=3	49.50**	28.49	25.55	40.30	46.82
r=4	29.69	19.41	24.13	34.40	39.79
r=5	24.56	18.88	23.23	28.14	33.24
r=6	18.75	11.96	17.17	22.00	26.81
r=7	11.15	5.12	4.94	15.67	20.20
r=8	0.38	1.01	0.59	9.24	12.97

[a]Both tests have as their alternative, $r>k$.
[b]Critical values are from Table 1 in (Osterwald-Lenum, 1992, p. 467).
*Indicates rejection of the null hypothesis at α=0.05.
**Indicates rejection of the null hypothesis at α=0.01.

indicate that each of the nine series for each of the three periods contains a single unit root and they are each integrated to order one. The null hypothesis of a unit root each series is rejected using differenced data. They are individually stationary in first differences or $I(1)$. Thus, it is possible to test for dynamic price relationships using concepts of cointegration.

Test results for cointegration of nine rice price series of the three periods and the critical values are presented in Table 2. The critical values are derived by Osterwald-Lenum (1992). The results of the trace tests show that during the 1982–1984 period (prior to 1984 self-sufficiency) there were six cointegrating vectors and three common trends but the maximal eigenvalue test indicates that there exist only four cointegrating vectors and five common trends. The number of common trends is determined by subtracting the number of cointegrating vectors from the dimension of the impact matrix (in this case the dimension of the matrix is nine). The trace test results suggest that during the pre-self-sufficiency period, these nine price series are strongly cointegrated and converge to a long-run equilibrium in the sense that the Indonesian rice market system is stationary in six directions and non-stationary in three directions. In other words, six prices can be expressed in terms of the other three prices.

During post-self-sufficiency, the results of both the trace and maximal eigenvalue tests indicate the existence of three cointegrating vectors and six common trends. The trace tests for the entire period (1982–1993) reveal that there are three cointegrating vectors. These results of the three period tests provide support for the view that the Indonesian rice market is spatially linked in the long run. It suggests that even though the regional markets are geographically dispersed, and therefore, spatially segmented, spatial pricing relationships reveal that the prices are linked together indicating that all the exchange locations are in the same economic market. A finding of fewer cointegrating vectors in the second period (1985–1993) suggests that relative to the earlier period, prices in the second period were spatially less tightly tied together indicating that the long-run stability of the rice price relationships is larger in the 1982–1984 period than that of 1985–1993 period. Following self-sufficiency, the Indonesian government employed an intermediate strategy involving less intervention and allowing more influence from local factors to affect prices. This policy is less costly and facilitates private market development. The shift in the rice policy has likely contributed to the less highly integrated rice market though the market is still spatially integrated despite the lower levels of government intervention, indicating that the private sector is responding appropriately to price signals in dealing with disparities across regions.

Regression analysis of factors influencing rice market integration in Indonesia is conducted using bootstrapping techniques. For this purpose, cointegration tests were performed annually for the period 1982–1993 for each major region, including Sumatra, Java, Kalimantan, Sulawesi, and Bali–Nusa Tenggara. Since a different number of local markets exists within each region, the four major markets in each region are chosen. These are listed in Table 3. The test statistics for H_0: r=0 using the maximum eigenvalue test were selected from each annual test result for each region. These statistics can be considered as the measure of market integration over time, in which the larger the statistic, the stronger the degree of market integration.

Table 3 presents the cointegration statistics used in the regression analysis for each region, including the mean and standard deviation for each region. Sulawesi shows the highest average cointegration among its local markets during the entire period, followed by

Table 3
Annual cointegration test results for regional Indonesian rice markets using test statistic H_0: r=0 for the maximal eigenvalue test

Year	Sumatra[a]	Java[b]	Kalimantan[c]	Sulawesi[d]	Bali/Nusa Tenggara[e]
1982	42.07**	23.87	58.84**	53.19**	49.91**
1983	44.21**	41.95**	72.21**	82.33**	33.89*
1984	39.68**	46.94**	23.96	60.14**	79.44**
1985	43.29**	19.05	29.81*	22.92	27.67
1986	75.59**	27.46	43.55**	22.93	47.97**
1987	34.13*	25.09	91.48**	96.40**	75.59**
1988	32.98*	53.86**	30.39*	143.18**	24.42
1989	30.78*	44.69**	14.46	51.31**	18.33
1990	22.41	44.08**	26.16	130.85**	40.57**
1991	50.73**	28.45*	39.78**	180.92**	58.16**
1992	41.93**	200.01**	11.20	–	53.37**
1993	42.54**	61.98**	16.39	78.54**	–
1982–1993					
Mean	41.70	51.45	38.19	83.88	46.30
SD	13.03	48.62	24.68	50.32	19.89
1982–1984					
Mean	41.99	37.59	51.67	65.62	54.41
SD	2.27	12.14	24.91	15.22	23.11
1985–1993					
Mean	41.60	56.07	33.69	90.88	43.26
SD	15.24	55.84	24.32	57.85	19.34

[a]The four weekly price series used are Banda Aceh, Medan, Padang, and Palembang.
[b]The four weekly price series used are Jakarta, Bandung, Semarang, and Surabaya.
[c]The four weekly price series used are Pontianak, Banjarmasin, Samarinda, and Palangkaraya.
[d]The four weekly price series used are Ujung Pandang, Kendari, Palu, and Menado.
[e]The four weekly price series used are Denpasar, Mataram, Kupang, and Dili.
*Indicates rejection of the null hypothesis at α=0.05.
**Indicates rejection of the null hypothesis at α=0.01

Table 4
Bootstrap regression parameter estimates of factors influencing rice market cointegration in Indonesia, 1982–1993

Variable	1982–1993	1982–1984	1985–1993
Intercept	54.31	40.26	8.96
	(1.58)	(1.14)	(0.21)
Procurement	2.01*	0.80	7.10**
	(2.45)	(0.38)	(2.74)
Distribution	−1.85	1.79	−2.70
	(−0.69)	(0.70)	(−0.74)
Roads	17.65	−16.91	−66.95
	(0.37)	(−0.21)	(−1.12)
Per capita income	0.03	−0.02	0.07*
	(0.70)	(−0.86)	(2.02)
Self-sufficiency dummy	6.31	–	–
	(0.55)		
R^2	0.25	0.18	0.31
N	57	15	42

*Indicates statistical significance at α=0.05.
**Indicates statistical significance at α=0.01.
Note: The regressand is the annual time period test statistics for H_0: r=0. Pooled regional market data were used to obtain more efficient parameter estimates. Number of replications is 1000. T-ratios are in parentheses.

Java. The highest variation in cointegration is also found in Sulawesi, again followed by Java. The lowest level of market cointegration is found in Kalimantan.

The results of the regression analysis are shown in Table 4. During the 1985–1993 time period as well as the entire period, 1982–1993, the degree of market integration is positively and significantly associated with the level of rice procurement, implying that the larger the procurement, the higher the degree of market integration. These results suggest that procurement operations, where BULOG purchases rice from village cooperatives, may be more effective in influencing rice prices than market distribution by BULOG. In addition, the per capita income variable is positive and significant for the latter period, following self-sufficiency. Other variables such as distribution and roads are not statistically significant, nor is the dummy variable statistically significant.

7. Summary and conclusions

Long-run spatial price relationships in Indonesian rice markets and factors affecting the degree of market integration are evaluated. Multivariate Johansen and Juselius (1990) cointegration tests are used with weekly price data for the 1982–1993 period. The analysis is divided into two separate periods: pre-self-sufficiency and post-self-sufficiency periods to capture the changes in spatial price interrelationships as Indonesia approached and then surpassed self-sufficiency in rice, as well as for the entire period.

The cointegration tests were conducted for all of Indonesia. To observe the factors influencing the degree of market integration, bootstrapped regression analysis was used. The analysis evaluates the effects of government rice procurement and distribution, length of roads, and per capita income on cointegration relationships.

The cointegration tests for entire Indonesian rice market, represented by the nine most relevant price series, indicate that relative to the pre-self-sufficiency period, the post-self-sufficiency period has a smaller degree of market integration. These results support the view that even though geographically dispersed and therefore spatially segmented, the Indonesian rice market has a stable long-run relationship between spatial price series and exhibits strong price dynamics, indicating that all of the exchange locations are in the same economic market. Furthermore, the change of the degree of market integration over time indicates that rationalizing of the Indonesian rice price policy beyond 1984 rice self-sufficiency has resulted in a less integrated market suggesting that the policy shift has led to significant structural impacts on spatial market performance. By limiting intervention, the government has been able to reduce operating costs without significantly hurting market performance. It is possible that further reduction in intervention through widening the band between the floor and ceiling price could be accomplished without dramatically affecting market integration.

Regression results show that government intervention in terms of rice procurement significantly influenced market integration during the period of post-self-sufficiency (1985–1993) and the entire period of 1982–1993. The results indicate that the larger the rice procurement, the higher the degree of market integration, suggesting that the procurement program has significantly affected dynamic price adjustments. It may indicate that market intervention has been effective in neutralizing the price shocks that occurred during the observed periods, particularly in times of surplus. Market operations involving distribution seem to have been less effective in bringing about market integration, though these have been shown in other studies to have stabilized prices (Timmer, 1996). It is possible that the larger influence from procurement shows that procurement prices are relatively high and could perhaps be lowered, reducing program costs.

In the latter period, following self-sufficiency, a time when national income grew at rapid rates, generally between 5–8% annually, per capita income is found to be positively and significantly associated with integration. This indicates that overall economic development encourages market integration and seems to reduce the need for government intervention during times of economic expansion, again resulting in fewer program costs. During drought periods or economic downturns, the role of BULOG in the rice market may be more important.

In highly integrated markets where there exists interdependence of price changes across spatially separated locations in the long-run, the government may limit its market interventions. The results of the cointegration tests support the view that the government intervention in rice markets can be rationalized in these well-established and integrated markets without significantly decreasing market integration. Rationalizing price stabilization activities which lead to lower costs of operations can be applied in these integrated markets to avoid duplications of interventions since the impacts of market injections or rice procurement on price formations will be well transmitted instantaneously throughout the entire market. If the markets are highly integrated, by managing relatively small amounts of easily controlled rice bufferstocks in just a few well-chosen sites, the government could control the price structure within the system. By letting the private sector contribute as much as possible in the integrated regions, the government will achieve its food security objectives without experiencing high costs.

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