Determinants of Market Integration and Price Transmission in Indonesia

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Abstract

This paper investigates the determinants of price differences and market integration among Indonesian provinces, using data from retail cooking oil, rice and sugar markets during the period 1993–2007, and from wholesale maize and soybean markets during the period 1992–2006. The authors measure the degree of integration using co-integration techniques, and calculate average price differences. They use regression analysis to understand the drivers of price differences and market integration. For rice and sugar, they find wide market

integration and low price differences, in the range of 5–12 percent. For maize, soybeans and cooking oil, they find less integration and higher price differences (16–22 percent). Integration across provinces is explained by the remoteness and quality of transport infrastructure of a province. Price differences across provinces respond to differences in provincial characteristics such as remoteness, transport infrastructure, output of the commodity, land productivity and income per capita.

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Determinants of market integration and price transmission in Indonesia

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A. INTRODUCTION

The recent wave of high international commodity prices has increased interest in understanding spatial market integration of domestic markets both with international and also with other domestic ones. The sharp increase in prices constitutes at the same time an important opportunity as well as a challenge for natural-resource abundant economies like Indonesia. The degree to which Indonesian producers can profit from this opportunity depends, firstly, on how integrated domestic markets are with world markets. In other words, on how closely domestic prices move with world prices. Secondly, on how integrated the different provincial markets are with each other. Weak integration implies weak domestic supply responses to higher commodity prices. A non-integrated market is “blind”. Producers that are not able to “see” what is highly appreciated in world markets and what is not are unable to make the best possible decision, which leads to an inefficient outcome.¹

As important as understanding the degree of integration within Indonesia, given its peculiar geographical characteristics, is understanding what are the factors that explain why some provinces are strongly spatially integrated, while others are weakly, or not integrated at all. Surprisingly, the analysis of determinants of market integration has generally been neglected in the literature, and not much is known about it. In addition and to the best of our knowledge, there has been no systematic analysis of the determinants of food commodity price differentials.

This paper contributes to the literature by providing new evidence on two separate but related issues: the determinants of market integration across provinces in Indonesia, and the

¹ The outcome of market integration will generate net welfare gains for the society; however, different groups may either gain or lose. This potentially raises a political economy dimension to question about determinants of market integration. That dimension is out of the scope of this paper.

determinants of price differentials across provinces, looking at five commodity markets: rice, soybeans, maize, sugar and cooking oil.

To analyze market integration determinants, it starts by assessing the degree of integration of these markets among provinces in a geographically heterogeneous country like Indonesia. It does so by testing for a common stochastic long run trend between pairs of provinces using Johansen co-integration techniques. Then, it explores what are the determinants of price differences across provinces and of market integration.

In particular, it attempts to answer the following questions:

Spatial Integration: Are Indonesian provincial commodity markets spatially integrated? Is there a significant degree of co-movement between provincial commodity prices?

Determinants of Price Differences and Spatial Integration: What are the factors that explain price differences across provinces? What are the factors that explain spatial integration? In particular, what is the role of logistic costs? Does more output produced imply less integration with world markets?

This paper is organized as follows: section B summarizes the literature on determinants of spatial integration in commodity markets. Section C describes the dataset. Section D presents the methodology for testing market integration among Indonesian provinces and the main findings for the five commodities considered. Section E presents the methodology and main findings of the analysis of determinants of price differences, and of market integration across Indonesian provinces. Section F concludes and draws policy implications.

B. LITERATURE REVIEW

This paper builds upon the question of market integration by examining the factors that influence this issue, i.e. the determinants of integration. Though inferences related to the

drivers of revealed patterns of integration are very informative, these are generally lacking in the literature.

There is a vast literature on the measurement of spatial market integration. Table 1 summarizes the key elements of some of the most frequently cited papers in this literature. An excellent review on methodological issues related to the analysis of spatial market integration can be found in Fackler and Goodwin (2001). The rest of the section reviews the limited literature on the analysis of determinants.

Distance between markets has been acknowledged as an important factor affecting market integration. It is common to find in the literature measures of market integration tabulated against markets' distances. However, in most of the cases, no formal empirical analysis of the links is carried out (for these types of informal analyses, see: Ravallion (1986), Goodwin and Piggott (2001), Rashid (2004), and Van Campenhout (2007)).

The exceptions to this are the work done by Goodwin and Schroeder (1991), Goletti, Raisuddin, and Farid (1995) and Ismet, Barkley, and Llewelyn (1998). These three papers address the question of the determinants of integration. Their common methodological feature is that they proceed in two stages. They first measure spatial market integration in their relevant geographical setting. Then, they regress the measure of market integration on a number of explanatory variables.

Goodwin and Schroeder (1991) use five different co-integration tests to measure integration in livestock markets in the US, over four different periods (from 1980 to 1987). They obtain one test statistic for each pair of markets analyzed, and for each period considered. These test statistics are then used as a dependent variable in the second stage. They consider four factors affecting integration: the costs and risks associated with trade between markets (distance between markets), the amount of market information reflected in prices at a particular market (whether the market is a 'terminal' market or not), the market volume, and the degree of

concentration in the packing market. Their results reveal that distance, as expected, is a significant deterrent of market integration. In addition, they found that concentration in the meat packing market increased the degree of market integration. This result is interesting, as the exercise of market power (through, say, the ability of carry out price discrimination) is sometimes argued to decrease the degree of integration of markets. Instead, the authors claim that when firms operate plants in spatially separated markets, transaction costs and uncertainty about market outlets for cattle shipped from one region to another is reduced and it could also facilitate price behavior coordination among meatpackers across regions.

Goletti, Raisuddin, and Farid (1995) examine rice market integration and its determinants in Bangladesh in the period 1989–1992, for 64 districts. To measure market integration, the authors combine correlation coefficients on the price series, with co-integration coefficients, dynamic multipliers (which measure how much of a shock in market i is transmitted to market j in k periods) and measures of the speed of adjustment (how many periods it takes for a shock in market i to be fully transmitted to market j). Then, they regress these measures of market integration on the hypothesized determinants. Three broad structural determinants of market integration are considered: marketing infrastructure (road distance between markets, density of paved roads, railway infrastructure, number of strikes in the areas, telephones per capita, and density of bank branches), volatility of policy (variation coefficient of the stocks that the government agency keeps in each district at the end of the month) and dissimilarity of production (absolute value of the percentage difference in production per capita). The author's findings revealed that distance between markets, telephone density and labor strikes affected integration negatively. Instead integration was positively affected by more dissimilarity in production and road density (as both factors encourage trade).

The last study to be considered is that of Ismet, Barkley, and Llewelyn (1998). These authors focus on the effects of government intervention on rice market integration in different regions of Indonesia during the period 1982-1993. In the first stage, they measure the degree of

spatial integration using the multivariate Johansen approach to test for co-integration of the regional price series and explore the dynamics of the price transmission process. Then, they extract the trace statistic (the test statistic for the null of no co-integration) obtained from that first stage procedure and use it as a measure of market integration. The larger the value of that statistic, the stronger is the evidence for market integration. In the second stage, the authors regress the trace on measures of government intervention (purchases and sales of rice carried out by Bulog in each market), infrastructure (road density), market development (income per capita of the region) and a dummy that controls for the periods of self-sufficiency in rice production. The results for the whole period suggest that only the purchases of rice by Bulog had a significant effect on market integration. The rest of the variables do not significantly explain it. For the self-sufficiency period, sales of rice by Bulog also has a significantly positive effect, as well as per capita income.

Summarizing, there is scarce literature exploring determinants of market integration. Probably the most robust lesson that has been learnt is that spatial integration is weaker in distant provinces, and stronger in central ones. This paper attempts to contribute to this scarce literature by tackling the question of what are the factors that determine market integration in the context of Indonesian commodity markets.

C. DATASET: REVIEW AND DESCRIPTIVE STATISTICS

In this paper we use consumer price time series for the period January 1993 – December 2007 for rice, sugar and cooking oil, and producer price time series for the period January 1992 – December 2006 for soybeans and maize. All price series were obtained from the National Bureau of Statistics of Indonesia (BPS). Data were also obtained from CEIC (CEIC Data Company Ltd) and BPS.

Table 2 presents mean, standard deviation, maximum and minimum of each of the variables used in this analysis, across provinces. ‘Distance’ is the minimum distance in kilometers to

one of the main five cities in the country (Jakarta, Surabaya, Medan, Makasar or Batam). This measure needs to be complemented. Take, for example, the case of Banda Aceh. It is relatively close to one of the largest cities in the country, which is Medan. Still, Banda Aceh cannot be considered as a “central” city. For a given distance to one of the main five cities, centrality depends on the size of the city you are close to. Thus, in this paper, the notion of centrality is captured by weighting the distance in kilometers by the inverse of the population of the closest city. This weighted variable is called *Remoteness*². Infrastructure measures quality of roads, as the proportion of asphalted roads in total roads. *Population* is the number of inhabitants by province while *PCI* is real per capita income expressed in Indonesian rupiah at constant prices of 1993. Turning to the commodity-specific variables, *Output PC* is the annual average output of the commodity (in kilograms) divided by the population of the province, while *Productivity* is the average yield per hectare (in tons) over the period. ³*Trace Stat* is the trace statistic, which is a measure of the degree of market integration (this measure will be described in more detail in Section C). The larger the trace statistic between provinces *i* and *j*, the “stronger” is the market integration between them. Here the average for province *i* over all possible *j* is reported. *Price Diff* is the average price difference over the period, of one province averaged against all the others, and *Price* is the average price of the commodity over the period of analysis. Both are expressed in rupiah per kilo.

One of the striking patterns in Table 2 is the provincial heterogeneity. This is clear when one looks at the difference between the maximum and the minimum for any given variable. Take infrastructure, for example: in one province almost all roads are asphalted, while in others only 15% are. Given provincial heterogeneity, there are also substantial commodity specific heterogeneities. For instance, it can be observed that there are important price differences, as illustrated by Figure 1 that plots the coefficients of variation of prices across provinces for the

² As the measure of remoteness was very small, in the table remoteness*1000 is reported, for convenience of presentation.

³ These two variables are only available at province level, for Soybeans, Rice and Maize.

five products considered.⁴ While for soybeans and maize the price differences across provinces can be higher than 30% of the average prices, the differences in rice and sugar markets are of 10% and 6% respectively. This is consistent with the higher trace statistic values in the latter two markets relative to the former two. As expected, in general, co-integrated markets (i.e.: markets whose prices exhibit a common stochastic long run trend) exhibit lower price differences.

To unveil this provincial heterogeneity in a simple way, Table 3 presents some summary statistics for key variables considered.

Table 3 shows that Irian Jaya is the most remote region (both in terms of distance and remoteness), and Table 4 that it is the one exhibiting the highest price difference with respect to all other provinces. Jakarta is, obviously, the core. In terms of transport infrastructure, quality is low in Irian Jaya and the Kalimantan provinces (with the exception of South Kalimantan). Jakarta and Irian Jaya exhibit the lowest levels of output of rice per capita, while East Kalimantan the largest. PCI is largest in East Kalimantan and Jakarta, lowest in East and West Nusatenggara.

Table 4 shows that Irian Jaya has the highest average price for rice, while South Sulawesi the lowest. After Irian Jaya, the largest price differences are exhibited by West Kalimantan.

D. MEASURING THE DEGREE OF SPATIAL INTEGRATION

In this section we briefly present the strategy used to measure spatial integration among Indonesian provinces in the markets for rice, soybeans, maize, sugar and cooking oil using monthly price time series, and the main findings.

Following Fackler and Goodwin (2001), two markets are defined as being integrated when shocks arising in one region are transmitted to the other region. More specifically, the market

⁴ These differences should be analyzed together with the average price.

for good x in region i is said to be spatially integrated with that of region j if i , a shock that shifts, say, demand in i but not in j affects the price in both i and j . This implies that the price series for commodity x in region i shares a long run stochastic trend with that of region j . If there is **perfect** integration, the effect of the shock on both prices would be the same.

Since the purpose here is to be able to measure the degree of integration in each market and to use that measure as an input for the analysis of determinants, a testable concept associated with a pair of provincial prices sharing a long run trend needs to be introduced. For that, the concept of co-integration first introduced by Granger (1981) and further elaborated further by Engle and Granger (1987) is of help.

Two price series are “co-integrated” if they are both integrated of the same order, say $I(1)$, and there exists a linear combination of them, $\beta_1 p_{1t} + \beta_2 p_{2t}$ which is stationary.⁵ The tests for co-integration basically check if that stationary linear combination exists. In this paper we use Johansen’s co-integration test (Johansen, 1988).⁶ The test suggests co-integration when the trace statistic (Johansen’s co-integration test statistic) is higher than a critical value. The two series are then said to share a common stochastic long-run trend. The higher the trace statistic for a pair of provincial prices, the more strongly co-integrated the series are, and therefore, the higher the degree of integration of the two provinces is.

Johansen co-integration tests were performed on all possible pairs of provincial prices for the period of analysis and for the commodities under consideration (January 1993–December 2007 for rice, sugar and cooking oil; January 1992– December 2006 for soybeans and maize).⁷

⁵ A series is said to be ‘stationary’ if its mean and variance do not vary with time.

⁶ A very good presentation of the Johansen cointegration procedure can be found in Banerjee *et al* (1995).

⁷ The price series considered here were found to be integrated of order one ($I(1)$). Augmented Dickey Fuller tests were performed on the series. The lag structure was chosen following the Akaike Information Criterion. First differences of the series proved to be integrated of order zero or $I(0)$. The results of the unit root tests are not reported here for brevity’s sake, and are available from the authors upon request.

Table 5 shows the trace statistic obtained for the rice market. Take for example the cell in the first column and second row: the trace statistic obtained when testing co-integration between the rice price series of Central Java and Bali is 30.4. This is higher than the critical value (15.41), and thus strongly suggests a high degree of co-integration, which in turn implies the two markets are spatially integrated. The higher the trace statistic, the higher is the degree of co-integration. Looking at the first column, thirteenth row, the evidence suggests that South Sulawesi and Bali's markets are not spatially integrated, as the value of trace statistic is lower than the critical value. In total, 300 co-integration tests (all possible combination of provincial prices) are performed, of which 229 suggest spatial integration. Thus, for the case of rice, we found evidence of spatial market integration in 76% of the cases.

Tables 6-9 show the same estimation for the markets of soybeans, maize, sugar and cooking oil respectively. In the soybean market only 26% of the pair of provinces are spatially integrated, 28% in the case of maize, 83% in the case of sugar, and 29% in the case of cooking oil.

The values of the trace statistic for every pair of provinces, in each commodity market will be a key input for the analysis of determinants of integration in Section D.

E. DETERMINANTS OF PRICE DIFFERENCES AND MARKET INTEGRATION

In this section the determinants of price differences across provinces and of market integration across provinces are examined.

Price differences between province i and province j , and their trace statistic tend to be negatively correlated. Provincial prices that are highly co-integrated exhibit lower price differences. Yet, the two are not equivalent. The notion of market integration between two provinces is compatible with significant price differentials, as long as these differentials are

stable over time.⁸ In the presence of logistic costs (transport and distribution costs), a pair of provinces can exhibit a high price differential, and still form a market with information flowing smoothly, and so price signals. This is why an alternative way of measuring market integration is to look at the stability of the price differentials over time.

Still, examining price differences across provinces at a given point in time is illuminating. Understanding whether price differences are driven by distance, poor infrastructure, market power, etc., gives essential information to the policymaker, at the time of deciding where to canalize scarce resources to increase availability of key staples.

This paper makes use of both measures. We proceed first with a preliminary examination of price differences and try to identify regularities associated with them. This will increase the understanding of what is the potential for government policy to reduce them. Then, we proceed to examining the determinants of market integration by looking at the factors that explain the trace statistic. Understanding market integration and its determinants is very relevant from a policy perspective. An integrated economy uses its factor resources more efficiently. In addition, integration also has implications on the costs and possibilities of government intervention. On one hand, market integration could make the costs of some types of intervention lower. If a government wants to sell (or buy) stocks of rice to affect average prices at the national level, it would be irrelevant where the rice is sold (or sold), as the shock of excess of supply (demand) in a given province, will be transmitted to the rest relatively fast. This would reduce the costs of the intervention. On the other hand, if, for whatever reason, the government is interested in maintaining inter-province price differences, market integration will make that intervention more costly in the short run, and probably impossible in the long run. These are some of the reasons why having information on the degree of integration, and on the factors that determine that integration is key therefore from an economic and a public policy perspective.

⁸ This assumes that logistic costs are stable over time. If they are always increasing, then a constantly increasing price differential may still be consistent with market integration

Before turning into the econometric analysis of determinants of price differences and of market integration a correlation matrix is constructed to understand how these variables co-move and identify possible sources of collinearities in the subsequent analysis. Table 10 shows bivariate correlation coefficients.

The price differences in rice, maize and sugar markets are significantly correlated with Distance and Remoteness, as expected. For all markets, price differences show a negative correlation with (transport) infrastructure. Better transport infrastructure would reduce transport costs and therefore, allow price convergence. PCI is positively correlated with price differences in rice, soybean and maize markets. This may be due to PCI capturing patterns of product quality differences in consumption. The correlation is not significant for sugar and cooking oil.⁹

One interesting feature is that for the rice, soybeans and maize markets the degree of market integration (the trace statistic) is significantly and negatively correlated with *Distance*, and the absolute value of the correlation increases when considering *Remoteness* instead. *Remoteness* attempts to capture transportation costs as well as “being part of a hub”.¹⁰ Therefore this variable is capturing two interacting forces: from one side it captures the physical cost of moving goods, which should negatively affect integration. At the same time, it also captures the “market potential”¹¹ effect or the effect of being closer to a “hub” which could be associated to higher information flows and a better functioning market, which should positively affect integration. The fact that *Remoteness* is more strongly correlated to the market integration than distance is suggesting that it is important to factor in the “market

⁹ It could be argued that the scope for quality differentials in sugar is lower than in the case of rice. That would explain the insignificant correlation of per capita income and the price differential. However, the same argument would not hold for cooking oil.

¹⁰ In fact, this is a measure of distance for a province ‘i’ that adjusts for the size of the closest main market to that province ‘i’.

¹¹ This “market potential” effect is related to the population size of the city.

potential” effect is important to be factored in and we should not only approximate the transport costs with the plain distance¹².

E.1 Determinants of Price Differentials

In section C, important price differences in the markets considered were documented, as well as important provincial heterogeneity in several dimensions (production conditions, geography, infrastructure, income per capita, etc.). The next step is to examine to what extent this heterogeneity can explain price differences across provinces. The average price difference between province i and province j , over the period January 1993 – December 2007 is estimated to see the effect of a number of covariates on these differences¹³.

This exercise is an attempt to explain divergences from the law of one price. With trade being costly, one could re-state the law of one price as the following condition:

$$|p_i - p_j| \leq t \quad (4)$$

The absolute difference between the price in i and the price in j is expected to be lower or equal to the transport and distribution costs, t . In other words, if the price of rice that results from the interaction of domestic supply and demand forces in Jakarta (p_j) is well above the price of rice in West Java (p_{WJ}) plus the cost associated with transporting the rice from West Java to Jakarta ($t_{WJ, J}$), then West Javanese producers would send their rice to Jakarta and the price in Jakarta would go down to $p_{WJ} + t_{WJ, J}$.

If instead, the initial difference is lower than the transportation cost (either because transport costs are high or because initial price differences are very small), then, prices in different locations will reflect supply and demand conditions in the province. If price differences are to be examined, then, these may lie in differences in supply conditions, which will be

¹² Interestingly, for sugar and cooking oil the correlations are positive and they don’t change significantly when looking at distance or remoteness.

¹³ The reason a panel is not used to analyze the determinants of price differences along time and across provinces is because data for most of the explanatory variables are available only for selected years, and in general, there is only limited overlapping among them.

determined by how efficient the process of production is (the level of efficiency will depend on how productive labor, capital and land are, and in the case of commodities, it will be definitely affected by weather conditions), as well as by differences in demand conditions will depend on consumers' purchasing power and population size.

Finally, another source of price differences is related to the unobserved quality heterogeneity. Take again the example of rice, different types are consumed in different provinces. One could argue that this could be solved by collecting data on a particular type of rice, say, IR-II (a particular variety of rice grain that is resistant to Imidazolinone), and then compare prices of IR-II across provinces. However, long enough time series of prices for IR-II across provinces are not readily available.¹⁴ The problem of quality differentials is difficult to avoid. However, if richer households consume better quality, and therefore more expensive rice, then PCI should control for quality differentials.

The model specified is the following:

$$\begin{aligned} (P_i - P_j) = & \beta_0 + \beta_1 \text{Remote}_i + \beta_2 \text{Remote}_j + \beta_3 \text{Remote} * \text{Infra}_i + \beta_4 \text{Remote} * \text{Infra}_j \\ & + \beta_5 \text{Contiguity}_{ij} + \beta_6 \text{Productivity}_i + \beta_7 \text{Productivity}_j + \beta_8 \text{OutputPC}_i + \beta_9 \text{OutputPC}_j \\ & + \beta_{10} \text{PCI}_i + \beta_{11} \text{PCI}_j + e_{ij} \end{aligned} \quad (5)$$

where $P_i - P_j$ is the price difference between province i and j measured in rupiah; Remote_i is the distance of province i to the closest main city weighted by the inverse of the population of that main city, and controls for transportation costs. Then, $\text{Remote} * \text{Infra}_i$ is an interaction term between the weighted distance and a measure of transport infrastructure (quality of roads). It is expected that distance affects the price more, the worse the quality of the transport infrastructure. The dummy variable contiguity that takes value 1 if the two provinces share a border and 0 otherwise, is trying to capture the fact that road transport is relatively cheaper than other types. Supply conditions are captured with Productivity_i , which

¹⁴ In addition to this, based on discussions with Bulog experts, even a very specific type of rice such as IR-II, varies by province.

is a measure of yield per hectare, and *Output PC_i*, which is the level of output of the commodity normalized by the population in the province. PCI_i is per capita income and captures demand-push effects, quality differences across provinces, and government intervention, as the latter is greater in poorer provinces, e_{ij} is an error term capturing all other factors affecting price differences, orthogonal to the included regressors.

Table 11 presents the results for the five commodities analyzed, and reports elasticities. Because data for output and productivity data by province is only available for soybeans, maize and rice, these variables are omitted in the regression for sugar and cooking oil. For rice, sugar and cooking oil, data is available for 25 provinces, yielding 300 possible price differences ($25 \times 24/2$). For soybeans and maize data is available for 14 provinces, yielding 91 possible price differences ($14 \times 13/2$). For ease of interpretation of the results, the model is run on the 300 pairs for which the price difference is positive. This means that the price in province i is always higher than in j . A variable that increases the price in i , ceteris paribus, will increase the price difference, while one that increases the price in j will decrease it.¹⁵

In the case of rice, the expected signs in remoteness, the interaction of remoteness and infrastructure. In particular, we found price difference to be relatively inelastic to remoteness. A 1% increase in remoteness increases the price difference by about 0.375%, on average, and ceteris paribus. The effect of remoteness is significantly attenuated by good transport infrastructure. Our estimates suggest that for the province with best transport infrastructure, the effect of an increase in 1% in remoteness only increases the price difference by 0.21%. Output per capita of the commodity significantly affects the price differences. Provinces that produce more rice relative to their population face a lower price for the product. Productivity differences do not seem to affect the price differential, nor does the contiguity condition. The effect of differences in qualities consumed associated with income per capita seems to be

¹⁵ The degrees of freedom of the regression of the price differences are given by the number of provinces we have data on (25), and not by the number of pair-wise combination of provinces. This is taken into account when analyzing the significance of the coefficients.

dominating for the case of rice, as the coefficient for income per capita in province 1 is positive and significant.

For soybeans, the results are similar, though the size of the coefficients is significantly larger.¹⁶ The only difference is that the “development” effect of income pc seems to dominate over the quality differentials for this commodity. The same is found when looking at maize. For this commodity, productivity differentials explain price differentials as well. This is reasonable, since market integration for maize is much lower than for rice and land productivity is expected to play a more important role in price setting if provinces are less integrated. In addition, for the case of maize, when two provinces are contiguous, the price differential is lower.

For Sugar and Cooking Oil a reduced set of variables is incorporated due to a data availability constraint. Signs of remoteness and infrastructure are as expected in both cases. The effect of different qualities consumed of income per capita seems to be dominating for the case of sugar, while the “development” effect seems to dominate for Cooking Oil (this is surprising, as one would expect a larger variety of cooking oils, than of sugar).

These results suggest interesting patterns: remote provinces pay higher prices than central ones everything else equal. But it is not a geographic determinism for remote provinces to pay higher prices. Remoteness is less costly the better the transport infrastructure is. Furthermore, in less integrated markets, such as the soybean and the maize ones, domestic production conditions also seem to affect price differences across provinces.

E.2 Determinants of Spatial Integration

Attention is now turned to examining determinants of spatial market integration. The dependent variable is the test statistic calculated for the period January 1993 – December 2007 of the co-integration test between a pair of markets (Johansen’s trace statistic). A high

¹⁶ This is probably related to the reduced sample size for soybeans, due to lower data availability. The same consideration applies to maize.

value of that test statistic provides evidence of strong co-movement of prices and therefore of spatial integration, while a low value points to the opposite.

The potential determinants of spatial integration are a subset of those that explained price differentials:

- *Remoteness*: A higher weighted distance increases transport costs and therefore reduces the degree of spatial integration.

- *Contiguity*: A positive sign is expected since this variable attempts to better capture transportation costs. Given Indonesian geography, a measure of remoteness could prove insufficient to capture transportation costs. If for example, transportation by land is cheaper than by sea, one would expect that contiguous provinces are more integrated than those that are not, because trade between them is less costly for a given degree of remoteness.

- *Infrastructure (Interacted with remoteness)*: It is expected that better infrastructure will decrease transportation costs, and thus increase the degree of spatial integration).

- *PCI*: Income per capita would control for the fact that richer provinces will consume better quality rice. If that's the case, then when rice price series for different provinces are compared, the comparison may involve prices of different products and a rejection of co-integration would not be indicative of no spatial integration for one specific type of rice. If this effect is predominant, a negative coefficient will be observed for this control variable. On the other hand, PCI may also capture a development effect of the market. Markets with higher income per capita are more developed, exhibit better infrastructure, and so trading tends to be cheaper. If this effect is predominant, a positive coefficient for this variable will be observed.

- *Output PC*: Output of the relevant commodity normalized by the population of the province. Goodwin and Schroeder (1991) argue that low volume markets have “a bigger potential for exhibiting unwarranted price behavior”. On the other hand, it could be argued that provinces that are “self-sufficient” in a certain commodity (they produce enough to cover demand in the province) could be to some extent, isolated from extra-province’s price movements.

For these reasons, the effect of output on spatial integration is uncertain *a priori*. Worth mentioning is that this latter “self-sufficiency” effect would mean that the higher the level of output, the lower the degree of integration. However, beyond a certain threshold of output, one would expect that the province becomes an exporter of the commodity, which would lead to an increase in its linkages with neighboring markets. To test if a self-sufficient province is less integrated than one that is not, allowance needs to be made for a non-linear relationship between output and market integration. Thus, the squared value of output PC is added, *Sq Output PC*.

Then, Equation 6 is estimated:

$$TS_{ij} = \beta_0 + \beta_1 Remote_i + \beta_2 Remote_j + \beta_3 Contiguity_{i,j} + \beta_4 PCI_i + \beta_5 PCI_j + \beta_6 OutputPC_i + \beta_7 OutputPC_j + \beta_8 SqOutputPC_i + \beta_9 SqOutputPC_j + e_{ij} \quad (6)$$

Results of estimating equation (6) are reported in Table 12. The first thing to observe is that the model for the soybean market is not well determined. None of the covariates are significant, nor the model as a whole. A quite robust result, for the rest of the commodities considered, is that remoter provinces seem to be less integrated than central provinces. This seems reasonable and is in line with what has been found in the literature (Goodwin and Schroeder, 1991; Goletti, Raisuddin, and Farid, 1995). The effect of remoteness on market integration is attenuated by the quality of infrastructure only in the markets for maize and

sugar, while in the rice and cooking oil markets, the results are not significant or they are even mixed. *Contiguity* seems to affect market integration positively only in the sugar market – given that we are controlling for remoteness, this seems to suggest that road transport is cheaper than other forms of transport. So, for a given degree of remoteness, two contiguous provinces are more likely to be integrated, given that transportation is less costly. This result does not hold for the rest of the products, though. The quality effect of *PCI* seems to dominate in the market for rice, as the coefficient on *PCI* is negative, while the “market development” effect seems to dominate for the case of maize and sugar.¹⁷ One interesting finding is that related to the self-sufficiency hypothesis. The results for the market for rice suggest that market integration is related to output in a non-linear way. More output produced leads to less market integration, up to a certain level, after which the relationship changes sign.¹⁸ Self-sufficiency seems to affect market integration only for rice.

¹⁷ It has been already argued that the scope for quality differences in the case of sugar is lower than that in the case of rice. For maize, probably the same could be argued, given that maize is generally used for animal feeding purposes.

¹⁸ This turning point was estimated at about 0.7 tons per capita of paddy rice. The conversion from paddy to white rice is generally done at 1.5 kilos of paddy rice for 1 of white rice, which would imply, assuming no waste, that the turning point is when the province produces more than approximately 466 kilos of rice per capita.

F. CONCLUSIONS

In this paper we have studied the determinants of market integration and price transmission for five major commodities in Indonesia. In a context where commodity prices have been changing dramatically, it is particularly relevant for natural resource abundant countries, like Indonesia, to understand what drives the transmission of price signals. On the one hand, this will allow the government to take appropriate measures to facilitate price transmission across regions so that producers can take optimal production decisions. On the other hand, it will allow the government to better target its policies geographically to mitigate the impact of a particular price shock on the poor population. Using detailed price data covering 25 Indonesian provinces for more than a decade, we shed some light on the drivers of the transmission of price signals and our findings can be summarized as follows.

First, we found that the degree of market integration varies across different commodities. Rice and sugar markets are highly spatially integrated, while cooking oil, soybeans and maize markets much less so. This is consistent with smaller price differences across provinces in the former markets than in the latter.

Second, when focusing on the determinants of these price differences among provinces we obtained some consistent findings irrespectively of the commodity analyzed. Remoteness and the interaction between remoteness and quality of infrastructure clearly influence price differentials. Remote provinces pay a higher price, but the effect of remoteness is attenuated by good transport infrastructure. Thus, there is no geographical determinism for remote provinces to pay much higher prices. Furthermore, price differences are also significantly explained by output per capita and land productivity.

Third, unlike in the case of the previous variables, the effect of income per capita on price differentials varies across commodities. We argue that income per capita is at the same time

capturing unobserved quality differences across provinces as well as development and local production capacities. In fact, we expect that richer provinces tend to consumer higher quality commodities and hence more expensive products, this is particularly important for those products where there are large quality differentials like rice. At the same time, we reckon that for those commodities where quality differentials are not very important, i.e. sugar, soybeans and maize, the predominant effect is that of development and local production capacities, and it is better local production capacities that help to maintain prices lower.

Fourth, when focusing explicitly on market integration we found that this is clearly explained by remoteness and infrastructure. We also found some limited evidence, though just for the rice market, supporting the argument of “self-sufficiency” being associated with a lower degree of integration.

Our analysis points towards two important policy implications. First of all, it confirms the importance of investing in infrastructure showing that the constraints generated by geography and remoteness can be alleviated by upgrading the infrastructure quality – which can be achieved through improvements in the investment climate to promote private investment and through investments in public works. Secondly, our findings point towards the importance of strengthening the capacities of farmers and their productivity as an important mean not only to improve their livelihoods but also as an instrument to foster more efficient markets with faster supply responses to changes in prices.

The analysis also has implications for the design of strategies to tackle future food crises. It is particularly relevant for the case of Indonesia (although its relevance is not restricted to Indonesia), where the Government is working on two specific programs: the first is the cash transfer program for the poor, which has been used in the past food crisis, but is being fine-tuned to enhance its targeting. The second is the development of an early warning system that

will raise the alarm when prices appear to spike. This paper's findings emphasize the importance of taking into account the spatial dimension and infrastructure conditions when forecasting how a price shock will be spread across the country and how it will hurt the population. The analysis also highlights that for some commodities shocks can be expected to be more homogenously spread across provinces than for others.

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Table 1 – Summary of the Literature

Authors	Date	Location	Product	Method of Analysis	Dets of integration?	Dets of price volat?	Journal
Ravallion, M.	1986	Bangladesh	Rice	Error Correction Model - Instrumental Variables	No	No	American Journal of Agricultural Economics
Goodwin, B.K., T.C.Schroeder	1991	USA	Cattle	Cointegration Analysis	Yes - Regression Analysis	No	American Journal of Agricultural Economics
Alexander, C., J. Wyeth	1994	Indonesia	Rice	Error Correction Model, Cointegration, Causality Tests	No	No	Journal of Development Studies
Goletti, F., R.Ahmed, N.Farid	1995	Bangladesh	Rice	Correlation Coeff, Cointegration, dynamic multipliers	Yes - Regression Analysis	No	The Developing Economies
Baulch, B.	1997a	Philippines	Rice	Parity Bound Model	No	No	American Journal of Agricultural Economics
Ismet, M., A.P.Barkley, R.V.Llewelyn	1998	Indonesia	Rice	Multivariate cointegration (Johansen, Juselius)	Yes - Regression Analysis	No	Agricultural Economics
Badiane, O., G.E.Shively	1998	Ghana	Maize	Cointegration, ARCH models	Yes - Simulation	Yes - ARCH	Journal of Development Economics
Baffes, J., M.I. Ajwad	2001	World (Selected Regions)	Cotton	Error Correction Model, Cointegration.	No	No	Applied Economics
Goodwin, B.K., N. E. Piggot	2001	North Carolina, US	Soybeans	Threshold autorregressive cointegration models, impulse resonse functions	No	No	American Journal of Agricultural Economics
Rapsomanikis, G., D.Hallam, P.Conforti	2003?	Ethiopia, Rwanda, Uganda; Egypt	Coffee; Wheat	Multivariate cointegration (Johansen, Juselius), Causality Test Asymmetric Adj. Tests	No	No	Book chapter, in: Commodity Mkt Review FAO, 2003-2004
Abdulai, A.	2003?	Ghana	Maize	Threshold autorregressive and cointegration	No	No	Book Chapter.
Rashid, S.	2004	Uganda	Maize	Multivariate cointegration (Johansen, Juselius)	Not formally	No	Journal of African Economies
Van Campenhout, B.	2007	Tanzania	Maize	Threshold autorregressive (with a trend for the threshold)	No	No	Food Policy
Fossati, S., F.Lorenzo, C.M.Rodriguez	2007	Uruguay	Sorghum, maize, wheat, beef	Multivariate cointegration (Johansen, Juselius)	No	No	Journal of Applied Economics

Source: Own Elaboration

Table 2 – Descriptive Statistics

	Variable	Mean	Std Dev	Min	Max	80/20th Pct
	Distance	570.87	587.84	0.00	2381.13	2.82
	Remoteness	0.071	0.092	0.000	0.341	13.78
	Infrastructure	0.53	0.24	0.15	0.98	2.46
	Population	6,538	9,462	1,520	35,000	3.72
	PCI	1,998	1,762	682	7,915	2.47
Rice	Output PC	229.06	173.83	1.74	1442.26	3.37
	Productivity	40	8	25	55	1.49
	Trace Stat	19.51	5.47	9.60	42.82	1.54
	Price Diff	259	186	6	870	4.54
	Price	2,520	221	2,174	3,044	1.17
Soybeans	Output PC	2.95	4.08	0.55	22.88	3.23
	Productivity	11.96	1.53	8.48	14.96	1.25
	Trace Stat	12.14	5.04	3.81	28.51	2.20
	Price Diff	850	725	4	2,555	11.76
	Price	2,664	770	1,872	4,427	1.65
Maize	Output PC	36.55	42.35	0.01	170.78	11.98
	Productivity	26.14	6.45	16.00	45.00	1.42
	Trace Stat	13.85	9.13	2.83	51.65	2.36
	Price Diff	359	284	3	1,298	5.93
	Price	973	316	478	1,776	1.73
Sugar	Trace Stat	26.69	11.99	7.59	65.19	2.33
	Price Diff	191	173	0	720	5.89
	Price	3,369	179	3,161	3,880	1.07
C. Oil	Trace Stat	13.74	8.54	3.71	74.19	2.26
	Price Diff	565	422	2	1,929	4.54
	Price	4,192	489	2,958	4,887	1.16

Notes: (1) Population and PCI are expressed in thousands.

Source: Own Elaboration, based on data from BPS and Bulog

Table 3: Descriptive statistics by province

Province	Distance	Remote	Population	PCI	Infrast
Aceh	424	0.037	3,990	2,714	0.45
North Sumatra	0	0.000	11,600	1,878	0.49
West Sumatra	460	0.123	4,396	1,617	0.71
Riau	291	0.078	3,734	4,880	0.35
Jambi	304	0.082	2,498	1,210	0.58
South Sumatra	424	0.047	6,512	1,714	0.53
Bengkulu	566	0.063	1,520	1,069	0.72
Lampung	195	0.022	6,836	933	0.49
Jakarta	0	0.000	9,000	6,298	0.98
West Java	121	0.000	34,900	1,526	0.70
Central Java	258	0.007	31,400	1,216	0.64
Yogyakarta	264	0.008	3,040	1,542	0.76
East Java	0	0.000	35,000	1,566	0.58
West Kalimantan	607	0.163	3,817	1,667	0.31
Central Kalimantan	624	0.018	1,837	2,066	0.15
South Kalimantan	485	0.014	3,032	1,854	0.56
East Kalimantan	583	0.084	2,543	7,915	0.21
North Sulawesi	953	0.136	1,982	1,235	0.72
Central Sulawesi	484	0.069	2,072	1,046	0.54
South Sulawesi	0	0.000	6,985	1,150	0.51
SE Sulawesi	367	0.053	1,755	901	0.45
Bali	317	0.009	3,085	2,223	0.97
West Nusatenggara	402	0.012	3,843	858	0.76
East Nusatenggara	726	0.104	3,828	682	0.40
Irian Jaya	2381	0.341	1,633	3,132	0.15

Notes: Population is expressed in thousands. PCI in rupiah at constant prices of 1993, in thousands. Distance is in kilometers, to one of the 5 main cities.

Infrastructure is the % of asphalted roads in the province. Remoteness weights distance to the main city by the inverse of the population of the main city.

Source: BPS and CEIC Data Company Ltd.

Table 4 – Descriptive Statistics by Province for Commodity Specific Variables

Province	Rice				Soybean				Maize				Sugar				Cooking Oil			
	P'tivity	Outp	PC	Price Diff	Trace	P'tivity	Outp	PC	Price Diff	Trace	P'tivity	Outp	PC	Price Diff	Trace	P'tivity	Outp	PC	Price Diff	Trace
Aceh	42	0.35	234.41	19.93		13	12	155.36	12.29		29	18	165.05	18.86				434.79	11.97	
North Sumatra	41	0.28	294.64	20.02		11	1	150.37	9.88		33	58	82.06	17.18				704.66	19.73	
West Sumatra	44	0.42	283.20	15.66		13	1	127.57	12.61		37	23	144.47	37.53				410.44	13.35	
Riau	31	0.12	278.07	17.88		10	1				22	11						699.15	15.27	
Jambi	37	0.23	86.59	19.29		13	2				30	11								
South Sumatra	36	0.28	95.89	20.85		13	1				27	12						397.39	10.67	
Bengkulu	37	0.25	157.22	19.54		9	2				23	38						433.18	14.10	
Lampung	42	0.28	92.22	21.96		10	2	162.24	10.93		31	171	171.09	3.56				583.31	16.85	
Jakarta	47	0.00	385.95	19.85							19							378.42	12.45	
West Java	52	0.28	162.43	22.15		13	1	168.19	15.92		45	14	130.06	14.95				438.26	12.65	
Central Java	52	0.27	124.66	21.53		14	5	138.60	11.94		35	56	150.28	8.92				642.41	10.44	
Yogyakarta	51	0.22	88.30	19.31		11	16	133.95	14.82		31	64	132.89	14.84				382.42	11.25	
East Java	53	0.25	103.14	20.18		13	10	113.31	14.50		36	109	166.43	13.44				446.84	7.13	
West Kalimantan	29	0.10	454.19	14.75		11	1				30	20						602.12	12.09	
Central Kalimantan	25	0.22	224.64	15.99		11	1				19	4						472.18	8.57	
South Kalimantan	34	0.20	46.06	14.10		12	2	272.18	10.75		26	13						436.14	13.82	
East Kalimantan	33	1.44	49.72	15.22		12	1				22	5						368.89	5.21	
North Sulawesi	45	0.15	62.01	15.61		13	3	146.25	11.33		25	90	117.77	11.29				514.73	9.06	
Central Sulawesi	40	0.39	172.58	21.03		11	1				24	27	246.72	9.65				461.79	10.99	
South Sulawesi	46	0.19	0.00			15	4	89.62	10.63		33	93	81.50	10.08				576.18	11.90	
SE Sulawesi	37	0.26	180.12	20.73		9	2				22	43						592.15	10.61	
Bali	55	0.30	156.27	21.07		14	4	58.43	6.12		28	28	310.49	15.92				617.40	15.72	
West Nusat	45	0.10	244.59	29.21		12	23				23	19	98.34	12.15				724.13	17.19	
East Nusat	29	0.35	131.91	18.86		10	1				23	147						286.91	11.64	
Irian Jaya	32	0.04	545.83	18.16		11	3				16	4						594.24	17.55	

Table 5 – Trace Statistic Matrix for Rice

Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bali																			
Central Java	30.45																		
Central Kalim	23.46	15.31																	
Central Sulaw	18.75	29.95	16.51																
East Java	18.01	18.66	15.67	24.05															
East Kalim	17.65	17.59	23.48	15.15	13.70														
East Nusat	22.66	21.48	12.93	20.55	23.34	16.87													
Irian Jaya	22.20	21.77	26.34	20.64	20.15	18.93	15.58												
Jakarta	24.68	18.88	14.87	20.65	13.27	18.73	24.89	18.74											
North Sulaw	18.01	26.59	11.19	17.03	16.83	15.17	15.25	16.98	19.27										
SE Sulaw	18.83	25.55	14.71	24.62	20.93	12.72	19.00	17.11	23.41	15.36									
South Kalim	20.20	18.22	18.22	15.38	19.91	18.04	20.44	40.11	19.81	13.80	13.99								
South Sulaw	12.73	25.96	13.20	26.48	23.72	12.44	14.80	13.94	17.78	17.42	25.24	14.10							
Sum Aceh	14.22	20.37	13.64	21.89	18.13	10.44	15.01	10.50	16.29	15.89	23.49	16.53	31.11						
Sum Bengk	23.58	22.18	15.48	19.63	17.23	19.30	17.52	12.71	25.91	24.26	23.48	15.26	18.27	20.14					
Sum Jambi	15.32	20.80	14.67	20.11	19.93	13.45	20.39	13.10	20.77	18.05	23.29	19.46	19.86	22.92	21.11				
Sum Lamp	21.79	29.70	16.39	22.48	31.42	21.84	20.93	22.09	19.20	21.39	20.58	23.27	17.93	19.54	17.35	22.56			
Sum Medan	15.97	21.50	16.32	25.31	15.89	12.24	16.99	11.24	22.91	18.54	30.39	15.94	22.98	17.91	28.47	18.96	18.78		
Sum Padang	16.34	16.72	13.35	14.63	13.09	18.98	13.98	20.62	15.35	26.39	11.72	11.23	12.47	13.03	19.71	16.41	17.62	15.71	
Sum Palemb	24.11	18.73	13.53	16.64	17.15	13.22	15.52	13.50	21.07	24.04	21.69	17.04	17.84	33.00	19.95	23.27	20.27	20.31	15.27
Sum Riau	18.00	18.93	11.26	17.98	16.84	17.69	21.07	13.67	23.20	21.67	19.09	13.93	12.44	17.72	23.18	18.64	18.15	18.13	15.41
West Java	22.07	23.47	15.23	24.57	20.64	14.64	24.36	17.15	17.42	17.02	24.41	15.52	25.91	23.03	21.48	27.07	22.43	21.38	12.75
West Kalim	15.77	13.62	12.71	17.28	15.35	9.60	15.36	11.34	17.57	12.18	13.48	18.34	12.86	11.62	17.74	12.69	16.00	11.51	10.52
West Nusat	26.84	26.73	17.53	42.56	29.96	23.79	24.52	19.01	20.57	25.54	42.82	21.57	41.76	30.86	25.12	35.57	26.44	31.19	18.80
Yogyakarta	28.34	17.56	15.85	23.62	18.76	18.85	22.22	18.52	17.71	21.55	21.18	18.94	17.90	19.45	22.53	22.37	25.37	17.59	15.32

Notes: (1) Significant coefficients in **bold**

(2) Numbers in column headings correspond to the same provinces as in row headings.

Table 6 – Trace Statistic for Soybeans

Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Bali																			
2 Central Java	6.69																		
3 Central Sulawesi	13.79	4.22																	
4 East Java	6.39	16.77	6.05																
5 East Kalimantan	7.85	5.38	7.83	9.95															
6 North Sulawesi	19.47	6.26	12.97	12.14	11.10														
7 SE Sulawesi	10.74	5.60	10.50	13.46	28.51	15.15													
8 South Kalimantan	5.72	11.30	9.90	8.34	9.59	12.20	13.02												
9 South Sulawesi	5.09	10.45	4.86	17.22	8.19	3.81	15.53	10.04											
10 Sumatra	4.63	10.70	5.32	15.94	10.97	5.52	17.34	10.78	19.94										
11 Sumatra	11.36	4.05	9.20	6.41	8.81	14.64	22.21	9.81	5.10	7.48									
12 Sumatra	11.25	8.20	8.92	8.95	6.76	11.61	17.17	13.21	12.35	9.84	12.16								
13 Sumatra	7.35	11.81	11.03	8.51	11.98	14.13	13.37	15.39	11.83	7.35	11.97	15.01							
14 Sumatra	5.30	9.28	7.19	7.31	6.81	5.54	8.91	12.20	8.82	8.20	4.93	8.17	17.43						
15 Sumatra	8.56	19.44	9.78	11.70	14.52	19.01	19.06	15.10	13.57	10.96	11.39	10.03	20.73	15.51					
16 Sumatra	18.08	17.69	16.48	17.93	13.27	26.80	15.09	13.80	16.73	15.41	15.04	20.70	19.10	10.07	17.16				
17 Sumatra	25.68	10.00	9.49	11.05	6.75	11.49	9.17	11.30	7.40	7.84	7.21	12.73	15.33	9.85	10.02	20.57			
18 West Java	7.65	17.97	5.98	18.30	8.42	8.43	10.57	12.73	10.48	9.99	6.99	9.70	15.36	9.12	14.99	23.41	8.48		
19 West Nusa Tenggara	6.12	18.68	8.26	17.61	15.89	11.51	22.04	7.85	16.17	17.16	10.30	15.28	7.53	7.84	9.76	15.91	18.79	25.97	
20 Yogyakarta	9.01	18.00	7.68	17.31	11.21	18.85	14.46	7.37	16.61	17.97	8.62	12.92	8.71	7.52	11.02	18.50	23.32	23.48	16.99

Notes: (1) Significant coefficients in bold

(2) Numbers in column headings correspond to the same provinces as in row headings.

Table 7 – Trace Statistic Matrix for Maize

Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Bali																			
2 Central Java	9.01																		
3 Central Sulawesi	12.65	11.28																	
4 East Java	15.79	7.10	7.43																
5 East Kalimantan	18.12	11.46	4.49	10.07															
6 North Sulawesi	17.41	14.84	4.85	17.78	3.58														
7 SE Sulawesi	15.77	8.95	15.47	8.21	9.78	3.67													
8 South Kalimantan	2.98	4.42	5.03	5.13	9.55	4.72	5.19												
9 South Sulawesi	18.96	9.66	4.57	23.07	18.44	19.06	14.02	4.24											
10 Sumatra	15.47	17.64	5.92	11.85	10.11	22.37	6.78	3.55	11.70										
11 Sumatra	10.92	13.19	4.01	10.15	15.32	7.33	8.68	17.51	13.94	8.53									
12 Sumatra	17.89	14.47	8.20	11.47	14.78	8.24	13.18	18.66	15.56	15.36	15.53								
13 Sumatra	13.14	13.43	10.21	8.65	11.60	14.30	10.51	3.56	8.20	23.20	10.87	18.93							
14 Sumatra	16.59	26.98	12.43	8.91	15.20	15.94	13.27	3.49	9.24	22.21	12.70	17.38	22.17						
15 Sumatra	49.21	39.71	23.45	33.51	30.51	40.22	25.09	12.78	51.65	50.24	31.01	37.48	32.17	44.89					
16 Sumatra	12.95	6.73	11.68	9.26	9.25	7.21	14.32	2.83	8.91	12.15	8.85	13.48	10.42	10.84	18.06				
17 Sumatra	11.06	9.01	8.62	9.20	6.21	3.80	12.97	5.98	4.78	9.08	7.28	13.63	11.02	14.14	27.79	15.54			
18 West Java	14.54	19.22	12.00	9.91	9.27	15.69	8.66	3.33	9.39	20.02	9.12	13.62	14.64	31.56	39.00	8.88	6.46		
19 West Nusa Tenggara	9.70	12.77	4.49	9.22	4.93	19.37	4.56	4.03	10.09	11.28	9.39	14.89	12.43	17.31	39.84	6.99	5.74	10.78	
20 Yogyakarta	19.50	9.75	14.13	11.15	12.23	20.17	12.53	6.45	20.22	13.44	11.41	13.14	9.15	11.95	34.76	9.30	11.75	10.80	10.33

Notes: (1) Significant coefficients in **bold**

(2) Numbers in column headings correspond to the same provinces as in row headings.

Table 8 – Trace Statistic Matrix for Sugar

Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Bali																							
2 Central Java	43.57																						
3 Central Kalim	32.22	23.25																					
4 Central Sulaw	58.53	65.19	43.38																				
5 East Java	17.84	30.15	21.25	34.84																			
6 East Kalim	37.91	38.44	23.54	45.43	16.81																		
7 East Nusat	21.24	14.55	20.56	25.57	12.12	20.22																	
8 Irian Jaya	38.96	54.75	40.41	42.76	40.34	37.32	28.31																
9 Jakarta	56.84	33.43	22.08	65.08	21.82	28.53	20.48	46.42															
10 North Sulaw	34.06	46.24	38.56	43.31	31.35	28.77	17.63	33.93	35.79														
11 SE Sulaw	43.88	50.19	50.79	46.41	21.98	50.97	30.33	20.24	51.77	27.31													
12 South Kalim	43.90	47.12	39.09	52.51	31.29	41.60	19.83	44.79	38.93	46.97	54.38												
13 South Sulaw	37.65	43.71	32.47	41.71	19.51	36.78	18.65	28.40	38.12	25.05	30.56	38.67											
14 Sum Aeh	21.54	15.41	15.60	23.19	14.97	15.69	28.83	22.24	18.21	16.18	24.18	16.64	16.98										
15 Sum Bengk	28.32	18.96	21.17	31.72	14.00	17.23	27.35	29.17	18.94	20.71	33.80	21.00	22.80	23.05									
16 Sum Jambi	22.20	15.24	21.00	31.20	10.02	16.14	24.06	25.24	17.54	16.24	31.28	15.11	17.15	31.91	41.82								
17 Sum Lamp	39.78	39.41	25.88	48.32	20.20	34.90	16.74	40.18	41.42	32.12	38.64	37.82	37.77	17.32	18.33	14.53							
18 Sum Medan	19.14	11.02	11.88	19.93	10.71	10.97	20.32	22.66	10.86	12.57	17.70	13.57	15.61	18.97	16.41	21.40	12.98						
19 Sum Padang	23.55	19.62	18.31	26.84	13.94	19.07	28.78	24.86	20.89	19.63	30.10	19.00	20.40	27.20	25.44	40.68	17.64	26.06					
20 Sum Palemb	24.37	16.78	21.38	36.16	10.70	18.46	28.94	25.46	17.48	18.88	34.37	15.24	17.20	24.19	44.93	27.95	17.91	21.92	33.64				
21 Sum Riau	20.56	14.61	17.45	26.68	13.63	17.45	20.96	25.76	18.26	15.26	25.86	13.52	17.68	30.34	27.17	34.59	16.33	26.61	47.46	21.96			
22 West Java	49.26	24.44	16.68	49.12	26.32	22.87	16.15	46.81	27.52	42.69	49.12	35.05	47.12	14.43	15.26	15.29	34.17	10.16	16.77	16.36	13.38		
23 West Kalim	12.53	9.38	14.34	13.48	7.59	9.13	12.70	18.26	9.71	10.85	16.32	11.50	11.63	22.86	20.28	22.40	10.19	17.13	31.40	18.68	34.63	7.98	
24 West Nusat	32.90	28.25	24.61	48.25	13.07	29.66	23.28	38.67	51.02	27.84	36.31	28.88	31.03	24.05	27.08	22.51	33.08	18.94	25.64	29.52	22.50	31.29	13.61
25 Yogyakarta	28.61	32.90	21.82	47.25	27.48	28.83	16.32	49.49	19.91	42.38	43.98	51.73	34.94	14.38	15.71	13.33	30.27	9.43	16.20	14.24	14.05	20.18	8.41

Notes: (1) Significant coefficients in **bold**

(2) Numbers in column headings correspond to the same provinces as in row headings.

Table 9 – Trace Statistic Matrix for Cooking Oil

Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1 Bali																								
2 Central Java	9.80																							
3 Central Kalim	6.56	7.85																						
4 Central Sulaw	7.92	13.84	6.97																					
5 East Java	14.98	9.76	6.51	8.61																				
6 East Kalim	8.72	9.47	4.27	6.32	10.57																			
7 East Nusat	5.10	7.57	4.51	10.60	4.07	5.03																		
8 Irian Jaya	15.68	10.03	10.89	9.17	11.21	6.43	6.82																	
9 Jakarta	17.30	10.79	20.79	17.05	10.12	8.23	23.97	23.59																
10 North Sulaw	16.04	9.61	10.34	11.63	9.36	6.44	15.63	25.26	12.90															
11 SE Sulaw	10.60	16.26	8.44	11.60	11.60	15.21	8.55	9.06	7.88	8.40														
12 South Kalim	21.55	11.79	9.28	9.97	24.33	10.46	8.40	19.15	13.16	12.14	11.13													
13 South Sulaw	12.47	16.02	8.65	15.33	8.83	7.50	9.06	15.17	13.91	11.55	8.37	12.71												
14 Sum Aceh	17.29	19.15	10.19	13.86	17.65	13.38	8.30	15.20	7.44	10.50	13.86	16.79	16.45											
15 Sum Bengk	33.62	9.74	11.33	12.51	15.20	7.43	5.43	50.72	8.80	12.19	9.36	20.07	12.02	12.74										
16 Sum Jambi	6.31	6.70	8.04	8.05	4.52	5.39	11.64	6.50	9.15	5.10	6.64	6.07	6.34	5.43	4.29									
17 Sum Lamp	22.56	12.42	6.26	9.54	25.47	8.83	6.78	11.15	11.91	12.28	11.81	17.95	13.93	21.73	44.32	4.93								
18 Sum Medan	30.47	11.60	8.45	10.75	16.88	7.13	8.12	28.52	18.90	20.16	9.57	21.92	15.51	19.90	74.19	6.18	14.91							
19 Sum Padang	12.12	11.12	5.58	8.46	30.56	17.02	5.50	9.80	9.62	8.84	13.73	21.51	10.86	17.15	15.08	4.82	12.73	9.29						
20 Sum Palemb	26.13	9.27	5.84	8.79	21.93	8.59	4.51	16.05	8.16	8.24	10.64	19.76	9.60	13.26	15.06	3.71	41.69	29.23	11.40					
21 Sum Riau	19.41	11.66	8.88	15.28	25.31	12.60	8.15	15.21	10.42	12.12	11.35	17.49	11.44	19.89	16.32	5.86	31.65	23.15	22.94	18.88				
22 West Java	24.03	11.02	15.32	17.83	10.54	6.98	18.83	49.12	12.08	14.83	7.65	15.95	17.00	9.00	17.83	5.37	17.25	27.19	7.28	9.29	11.31			
23 West Kalim	8.97	9.13	11.41	12.45	7.29	5.39	13.93	17.47	39.66	14.02	6.89	8.19	14.75	8.46	9.18	9.84	8.87	12.82	6.84	4.82	7.13	25.31		
24 West Nusat	20.68	10.25	7.10	12.84	15.11	7.38	7.27	21.39	19.32	16.86	8.65	18.65	12.40	16.76	47.48	6.09	24.10	29.66	7.82	20.33	15.45	28.96	9.92	
25 Yogyakarta	24.00	8.91	7.77	13.20	10.64	7.19	9.00	27.71	15.25	14.41	8.81	20.25	12.20	12.87	37.83	5.26	14.78	32.40	7.96	11.94	14.83	26.35	10.91	27.97

Notes: (1) Significant coefficients in **bold**

(2) Numbers in column headings correspond to the same provinces as in row headings.

Table 10: Correlation Matrix

		Distance	Remote	Pop	PCI	Infra	Output PC	P'tivity	Trace
	Distance								
	Remote	0.901							
	Pop	-0.376	-0.349						
	PCI	0.059	0.096	-0.112					
	Infra	-0.461	-0.468	0.209	-0.172				
Rice	Output PC	-0.229	-0.222	0.051	-0.155	-0.020			
	P'tivity	-0.467	-0.510	0.576	-0.040	0.826	0.127		
	Trace	-0.138	-0.254	0.134	-0.141	0.278	-0.065	0.314	
	Diff Price	0.412	0.486	-0.195	0.276	-0.233	-0.404	-0.268	-0.159
Soybeans	Output PC	-0.058	-0.312	0.020	0.001	0.254			
	P'tivity	-0.119	-0.147	0.137	-0.051	0.125	0.208		
	Trace	-0.043	-0.088	0.100	0.101	0.040	0.034	-0.130	
	Diff Price	0.084	0.232	-0.386	0.152	-0.486	-0.451	0.047	0.183
Maize	Output PC	-0.438	-0.413	0.407	-0.444	0.148			
	P'tivity	-0.598	-0.716	0.815	-0.244	0.394	0.319		
	Trace	-0.163	-0.345	0.183	-0.052	0.255	0.058	0.398	
	Diff Price	0.180	0.431	-0.364	0.275	-0.346	-0.313	-0.639	-0.342
Suga	Trace	0.189	0.206	-0.215	-0.031	-0.044			
	Diff Price	0.626	0.620	-0.236	-0.064	-0.425			0.013
C Oil	Trace	0.061	0.052	-0.065	0.025	0.016			
	Diff Price	-0.006	0.006	-0.008	-0.001	-0.033			-0.209

Table 11: Determinants of Cross-Province Price Differentials

Dep Var: Price Difference 'i-j'	Rice Coef.	Soybeans Coef.	Maize Coef.	Sugar Coef.	Cooking Oil Coef.
Remoteness 1	0.375 (6.57)***	4.607 (11.67)***	1.134 (3.8)***	0.600 (14.28)***	0.073 (1.68)***
Remoteness 2	0.100 (0.38)	-0.586 (-3.27)***	-0.262 (-0.91)	0.035 (0.41)	0.001 (0.01)
Contiguity	-0.195 (-1.52)	-0.028 (-0.14)	0.029 (0.17)	-0.303 (-3.04)***	0.102 (0.64)
Remote*Infra 1	-0.162 (-2.64)***	-3.493 (-11.92)***	-1.073 (-4.89)***	-0.217 (-4.97)***	-0.110 (-1.96)*
Remote*Infra 2	-0.020 (-0.1)	0.494 (3.09)***	0.241 (0.96)	-0.038 (-0.45)	0.191 (2.49)**
Income PC 1	0.300 (3.14)***	-1.030 (-9.33)***	-0.258 (-1.76)*	-0.176 (-4.1)***	-0.033 (-0.5)
Income PC 2	0.075 (1.11)	0.092 (0.63)	-0.281 (-1.62)	-0.088 (-1.38)	0.114 (2.3)**
Land Productivity 1	-0.156 (-0.88)	1.420 (2.2)**	-2.118 (-4.35)***		
Land Productivity 2	0.181 (0.62)	0.758 (1.55)	0.237 (0.49)		
Output of Rel Comm 1	0.210 (1.56)	-0.146 (-3.09)***	-0.081 (-1.24)		
Output of Rel Comm 1	0.425 (2.92)***	0.038 (0.56)	0.189 (1.83)*		
Constant	-80.706 (-0.61)	-74779.590 (-1.35)	95522.850 (4.12)***	173.907 (9.01)***	427.005 (7.02)***
Obs.	300	91	91	300	300
Prob> F	0.000	0.000	0.000	0.000	0.000
R-Squared	0.3605	0.7217	0.6043	0.4405	0.0752

Notes: (1) *** indicates significance at 1%,
** significance at 5%, * significance at 10%.
(2) T-statistics in brackets.

Table 12: Determinants of Spatial Market Integration in Indonesia

Dep Var:	Rice		Soybeans		Maize		Sugar	Cooking Oil
Trace Statistic	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(1)
Remoteness 1	-0.075 (-3.03)***	-0.090 (-3.01)***	0.043 (0.813)	-0.052 (-0.27)	-0.296 (-2.12)**	-0.397 (-2.44)**	-0.238 (-5.9)***	-0.249 (-3.84)***
Remoteness 2	-0.029 (-1.51)	-0.048 (-2.3)**	0.164 (0.397)	0.112 (0.570)	-0.594 (-3.53)***	-0.568 (-3.2)***	0.066 (2.76)***	0.106 (2.17)**
Contiguity	-0.001 (-0.33)	0.000 (-0.14)	0.009 (0.551)	0.009 (0.620)	-0.004 (-0.22)	-0.005 (-0.28)	0.021 (3.11)***	0.007 (0.580)
Remote*Infra	-0.005 (-0.2)	0.009 (0.32)	-0.045 (0.794)	0.025 (0.140)	0.209 (1.73)*	0.295 (2.08)**	0.129 (3.47)***	0.146 (2.33)**
Remote*Infra	-0.011 (-0.51)	-0.009 (-0.39)	-0.093 (0.552)	-0.052 (-0.33)	0.481 (3.61)***	0.459 (3.21)***	0.001 (0.030)	-0.142 (-3.21)***
PCI 1	-0.063 (-3.36)***	-0.082 (-2.63)***	-0.097 (0.382)	-0.056 (-0.49)	0.150 (1.380)	0.123 (1.070)	0.078 (1.87)*	0.046 (1.100)
PCI 2	-0.038 (-2.02)**	-0.134 (-3.21)***	0.020 (0.848)	0.003 (0.020)	0.144 (1.85)*	0.138 (1.77)*	-0.054 (-2.32)**	-0.091 (-3.38)***
Output PC 1	0.009 (0.590)	-0.059 (-0.69)	0.109 (0.080)	-0.227 (-0.9)	-0.013 (-0.21)	-0.294 (-1.14)		
Output PC 2	-0.023 (-1.5)	-0.306 (-2.99)***	0.010 (0.788)	-0.179 (-1.24)	-0.001 (-0.02)	0.037 (0.190)		
Sq Output PC 1		0.024 (-0.83)		0.207 (1.390)		0.137 (1.140)		
Sq Output PC 2		0.129 (2.83)***		0.089 (1.400)		-0.023 (-0.22)		
Obs	300	300	91	91	91	91	300	300
Prob> F	0.000	0.000	0.508	0.242	0.003	0.002	0.000	0.000
R2	0.1563	0.1946	0.0840	0.1217	0.1935	0.2060	0.1271	0.0672

Notes: (1) *** indicates significance at 1%, ** significance at 5%, * significance at 10%
(2) T-statistics in brackets.

Figure 1: Coefficient of Variation of Prices across Provinces

Note: Authors' calculations based on BPS data.