

Food market integration and price differential across provinces in Indonesia

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Introduction

Indonesia is experiencing rapid urbanization, demographic changes, and changing dietary preferences.

These trends have implications for the future of food demand and supply in the country. A joint WFP-FAO study estimates that Indonesia's food demand will significantly increase by 2045, both in quantity and quality.¹ The study shows that demand for cereals (except rice) will decrease while that of fruits and vegetables, meat, fish, and dairy products is likely to increase in the coming three decades. Indonesia's future food supply and demand will thus be different from what they are today. These future dynamics have policy relevance to domestic food production and to market infrastructure improvement in the country. While they are home for about 60 percent of Indonesia's population, Java and Bali have largely been exploited for food production and there will be increased competition for land and water, for non-agricultural uses, on those islands. Food production would therefore be expected to expand to other parts of the country. Whether the country's food markets and related logistic infrastructures are ready to respond to such changes is a key question. This study aims to assess the spatial integration of Indonesia's domestic food markets to identify aspects of market and logistics efficiency that would inform food systems planning going forward.

Market integration is a critical issue for Indonesia, the world's biggest archipelago. Good market and related infrastructure is key to connect food surplus regions with deficit regions in an efficient and effective manner with minimal additional costs. Part of a cost reduction strategy is to minimize post-harvest losses, which is challenging for perishable goods especially when moving along a lengthy and fragmented supply chain. The geography of Indonesia as archipelago by nature creates long supply chains for trading produce within and across islands. The degree to which food producers can gain profit or incur loss from price changes depends on how integrated domestic food markets are with the world and other domestic markets. Indonesia's reliance on domestic production, through its food self-sufficiency policy, increases the exposure of consumers to localized production risks. More integrated domestic food markets, including with international markets, are therefore critical to reduce such risks.

There are large trading cost differences across islands for different food products, especially for food commodities that are critical for food and nutrition security. The cost of shipping a 40ft container from Padang at the coast of West Sumatra to Jakarta can be three times its shipment cost between Jakarta and Singapore. Quality of logistics and related costs are important in explaining why food prices in some markets are much higher than those in other markets (Figure 1). The results of inadequate quality logistics and infrastructure is also evident in weak spatial domestic food market integration. This can create problems for achieving inclusive food and nutrition security in the country. The geography of Indonesia

¹ Modeling the future of Indonesian food consumption (WFP and FAO 2018)

and economic inequality make trade and information flows across islands challenging and costly. For instance, a regional dynamic analysis in Indonesia indicated that importing fruits (such as oranges from China) can be cheaper than trading it from other islands in the country (such oranges from Kalimantan).²

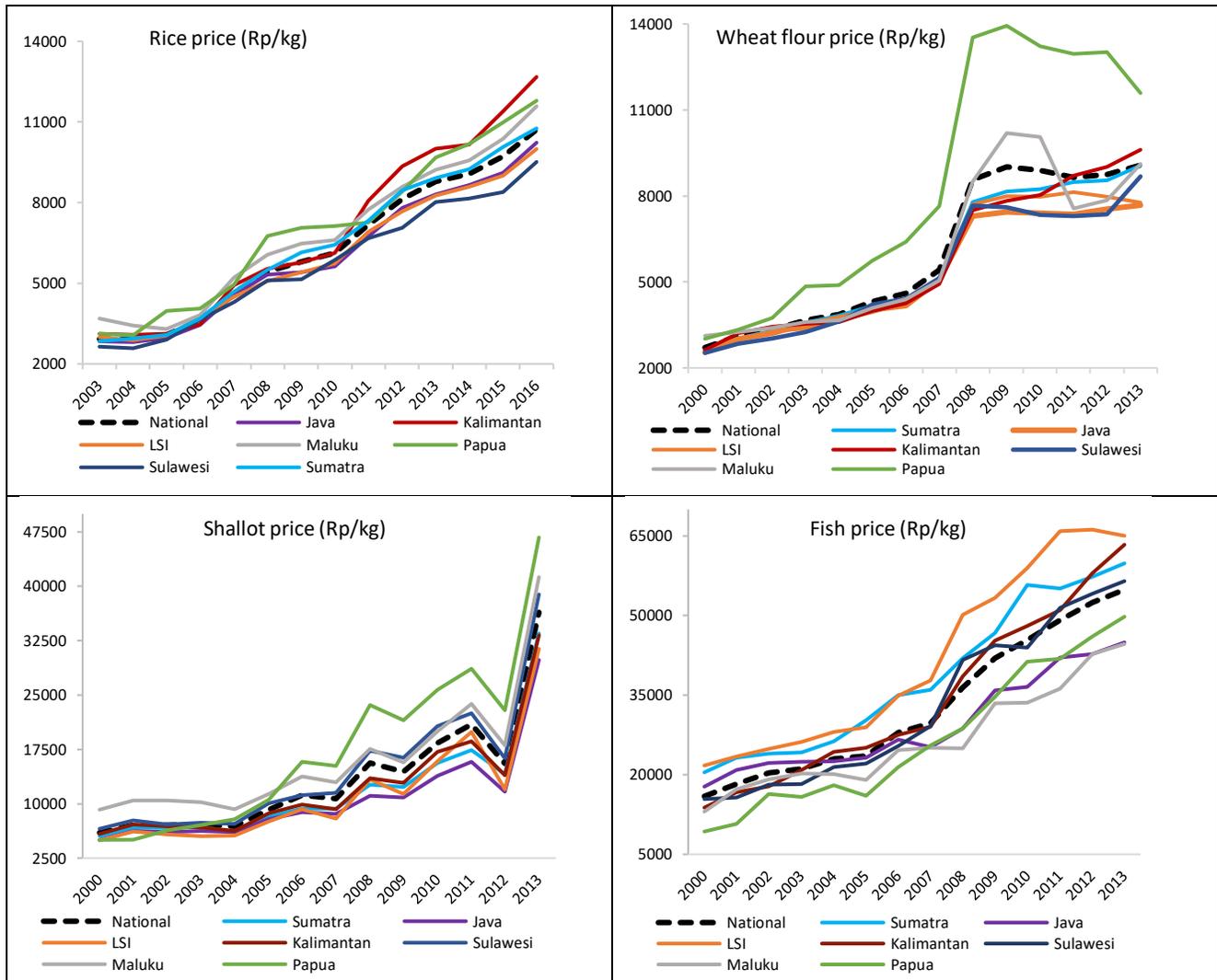


Figure 1. Retail food prices in selected markets in Indonesia

This study uses monthly food prices to analyze spatial integration and price transmission of selected food markets in the country. In so doing, the study identifies apparent major bottlenecks for market

² Regional Dynamics in a Decentralized Indonesia Singapore (Hill 2014).

performance and may inform further discussions on needed logistics and infrastructure improvements in support of efficient and effective food systems in the future.

This study provides the following three key findings drawn from price differential analysis, Granger causality tests, and market cointegration estimations. *First*, food prices exhibit large variations across provinces and islands. Average price differences across the main islands were in the range of 3-18 percent for rice, 8-46 percent for wheat flour, 7-35 percent for sugar, 26-70 percent for cooking oil, 26-61 percent for shallots, 1-92 percent for tomatoes, 40-90 percent for fish, and 42-81 percent for beef. Food prices are generally much higher for consumers in Papua, Kalimantan, and Maluku islands than consumers in the rest of the country. *Second*, for each food item a few markets were identified as “lead” markets, markets whose price movements can help predict price behaviors in several other markets. For instance, price changes in Manado, Jambi, Medan, and Semarang rice markets lead to changes in the prices of more than 50 percent of the rice markets in the country. Similarly, price changes in Pontianak (West Kalimantan) and Bandung (West Java) wheat flour markets have effects on nearly all other wheat flour markets in the country. The Ambon (Maluku) sugar market, the Surabaya (East Java) fish market, and the Bengkulu beef market can be considered as “lead” markets as prices changes in these markets precede changes in the respective food prices in more than half of the markets. *Third*, the findings show that spatial food market integration in Indonesia varies across food items as well as across islands, with generally stronger integrations in the Java island. While markets for shallots, sugar, and rice are well integrated, those for cooking oil, wheat flour, beef, and tomato are poorly integrated. Yet, there are a few “key” markets in each island that are well integrated with most markets in other islands.

Data and analysis

We use price series for the period January 2000 to December 2016 for eight key food items in Indonesia.³ The analysis uses monthly retail prices of rice, wheat flour, sugar, cooking oil, fish, shallots, beef, and tomato from 26 major markets in the country. The sample markets in this study are among the 33 main markets of the capital city provinces in Indonesia which spread in its five main islands and 30 other smaller islands. The data come from *Badan Pusat Statistik* (BPS), a national bureau of statistics of Indonesia. BPS regularly publishes weighted average retail prices of several food items that are sold in all major retail markets in the country.

The main analysis in this paper assesses spatial market integration across islands and markets in Indonesia. The theoretical underpinning of spatial market integration analysis is the law of one price, which states that prices of homogeneous goods in different markets should be the same once market

³ For some food items price series ends in December 2013.

margins are accounted for.⁴ If there are divergences from the law of one price—that is, if prices are not equal after accounting for transport and other market costs—traders would seek to arbitrage between the markets until these price differences are eliminated. In the absence of market integration, there will not be complete price transmission across markets and price differences may persist. In this study we conducted three main analyses to assess the extent of market integration and price transmission within and across islands in Indonesia. These include i) correlation and price differential analysis, ii) Granger causality tests, and iii) cointegration analysis. Our approach is based on the information provided by market prices.

Econometric framework

Granger causality: we perform granger causality tests to determine the lead-lag relationship between the price series, that is, to identify the key markets whose price developments help market agents form their price expectation in other markets. Granger causality analysis is a statistical hypothesis test which suggests whether a time series is useful in forecasting another series.⁵ To perform Grange causality tests, we set up a vector autoregression (VAR) model in the levels of the log-transformed price variables in our dataset. We have added appropriate lags in each specification. The Wald test statistics are asymptotically chi-square distributed under the null hypothesis of Granger non-causality.⁶

Cointegration analysis: The econometric approach used to test co-integration is set out by Engle and Granger.⁷ The approach requires testing the presence of a co-integrating relationship for series that exhibit the same ‘trend’ over time. This trend is defined based on the notion of whether the series has a stationary mean or not, and if not, whether the series have the same non-stationary process. For example, a series may not have a stationary mean, but when the first difference is taken, the resulting series does. This time series variable would be known to be integrated of order one, $I(1)$, or that the series has a ‘unit root’. In such an instance, test begins with exploring whether the different series are integrated of the same order, and if so, whether evidence of a co-integrating relationship exists. Based on the Engle and Granger procedure, these time series variables are deemed co-integrated if the residuals of the regression of one-time series variable against the other exhibit a stationary trend. The Johansen maximum likelihood procedure can also be used to test for presence of cointegration relationship.⁸ This procedure allows

⁴ Horizontal price transmission in agricultural markets: fundamental concepts and open empirical Issues (Listorti and Esposti 2012).

⁵ Investigating Causal Relations by Econometric Models and Cross-spectral Methods (Granger 1969).

⁶ Statistical inference in vector autoregressions with possibly integrated processes (Toda and Yamamoto1995).

⁷ Co-integration and error correction: Representation, estimation, and testing (Engle and Granger 1987).

⁸ Maximum likelihood estimation and inference on cointegration with applications to the demand for money (Johansen and Juselius 1990).

testing for cointegrating relationships across a broader set of price series as well as between a pair of time series.

We applied the Augmented Dickey-Fuller (ADF) test to check the presence of unit root in all the price variables. The results show that all the series are non-stationary. The ADF test results show that all price variables are integrated of order one $I(1)$ in levels and become stationary by first differencing. Given non-stationary variable series, we then formally test if the price series are cointegrated. In this study, we tested price cointegration using both the Engle and Granger and Johansen maximum likelihood methods, which resulted in similar results. The lag length is determined based on the Akaike Information Criterion (AIC) and the Schwartz-Bayesian Information Criterion (SBIC).

Regional food price differences

Food prices exhibit large variations across provinces and islands in Indonesia. Food prices are generally much higher for consumers in Papua, Kalimantan and, Maluku islands. For six of the eight food items we considered in this study, consumers in the Papua island pay the highest market prices (Figure 2). The two exceptions are fish and cooking oil markets where prices are the highest in Lesser Sunda (West Nusa Tenggara market) and Maluku islands respectively. Considering the wheat flour market, for instance, consumers in the Papua island pay close to 50 percent higher prices than the national average wheat flour prices. Consumers in Java pay the lowest wheat flour price. For rice, the main staple food in the country, consumers pay the highest prices in Papua, Kalimantan, and Maluku islands. Rice prices in these islands are 18, 14, and 13 percent higher than the average price in the country, respectively. Food prices are generally lower in those markets located in Java, Sumatra, and Sulawesi islands. A few markets in Sumatra, including the Padang market for wheat flour, sugar, fish, and beef and the Riau shallot market, have competitive prices. Within Sulawesi, consumers pay the lowest prices for rice and cooking oil in Makassar and Medan markets respectively. Food price differences are generally the smallest in major markets such as West Sumatra, Central Java, Bali, and South Sulawesi among all the markets in the respective islands.

Looking at the geographic distribution of poverty in Indonesia, food prices tend to be highest in the parts of the country that have higher rates of poverty and undernutrition. Poverty rates are the highest in eastern part of Indonesia (as high as 30 percent in Papua and Maluku) where food prices are also the highest.⁹ These areas are also rated by the WFP as vulnerable or highly vulnerable to food insecurity.¹⁰ Food prices are the lowest in the islands of Java, Sumatra and Bali where poverty rates are among the lowest in the country.

⁹ Country Partnership Framework (CPF) for the Republic of Indonesia, FY16- FY 20 (World Bank 2015).

¹⁰ Food Security and Vulnerability Atlas of Indonesia 2015 (World Food Program, 2015).

Price variability across islands differ among food items. Price differences from the average national price are relatively low for rice, sugar, and wheat markets. These price differentials were in the range of 3-18 percent for rice, 7-35 percent for sugar, and 8-46 percent for wheat flour markets. In contrast, price differences were the largest for shallots, cooking oil, beef, fish, and tomato markets. Prices of these food items were up to 60 to 95 percent higher than their average national prices. The price distribution across markets shows that food prices in the 90th percentile are between three (fish) to close to eight (tomato) times those in the 10th percentile (table A1).

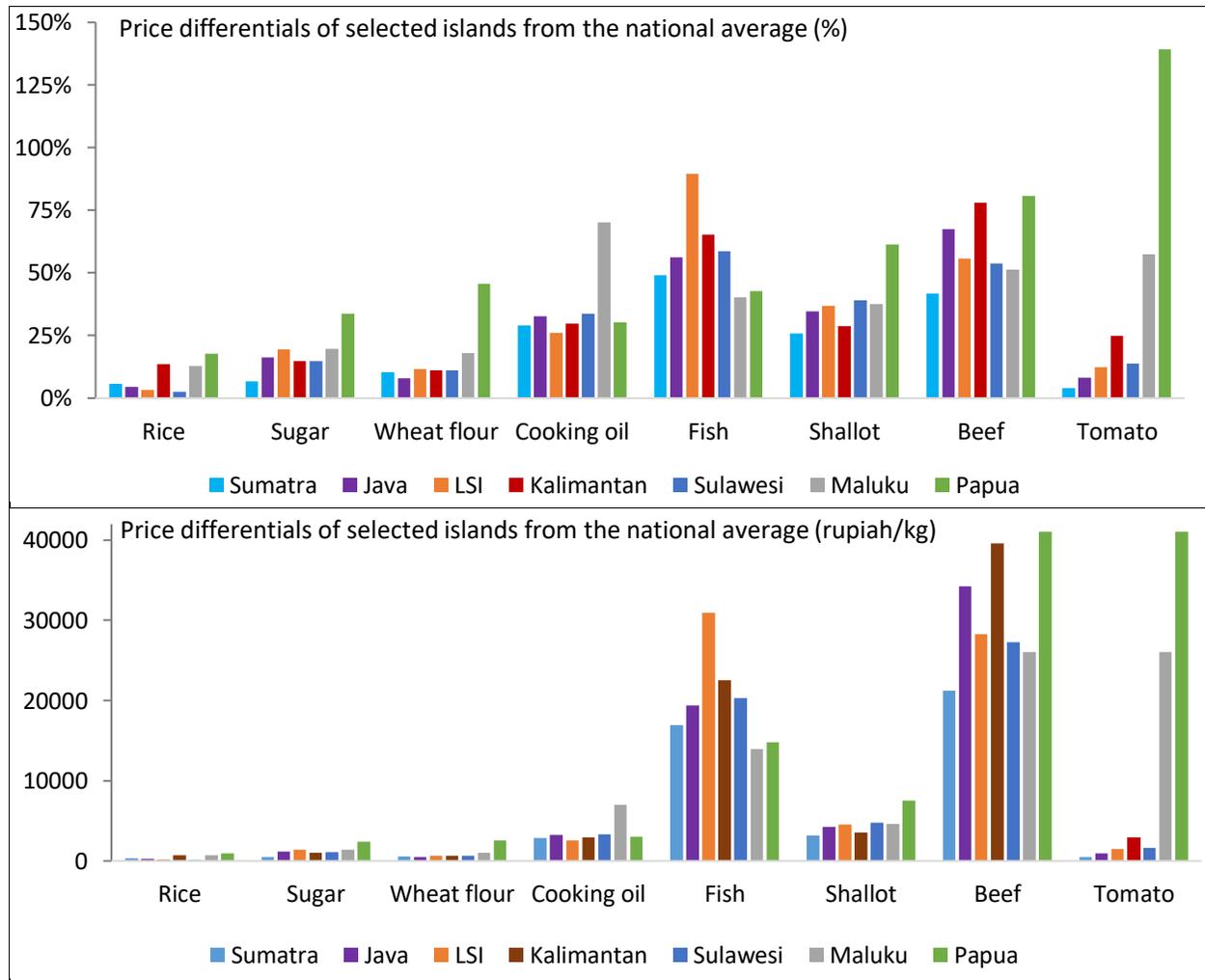


Figure 2. Price differences from the national average prices

The coefficient of variation (CV) across province level food prices also shows substantial commodity specific heterogeneities. Figure 3 plots the coefficients of variation (CV) of prices across provinces for the

seven food products. It illustrates important price differences across the food items. The price differences across provinces for cooking oil, fish, and wheat flour markets can be higher than 30 percent of their respective historical average prices. However, price differences in rice and sugar markets are relatively smaller, each in order of 10 percent. This is consistent with the above results on price disparities in each island relative to the national average. Regional food price variations have generally declined until the 2007/08 food price crises, after which food price gaps have increased reaching at a peak level during 2010-2011. Based on the CVs, price variations have declined overtime for rice, sugar, and beef markets, whereas variations have increased for cooking oil and wheat flour prices. These results indicate that more co-integrated food markets (see subsequent sections) generally exhibit lower price differences. Moreover, price variations have shown an increase in some food markets that are less competitive. These findings may imply that improving spatial market integration and supporting competitive market structure would reduce price disparity across islands.

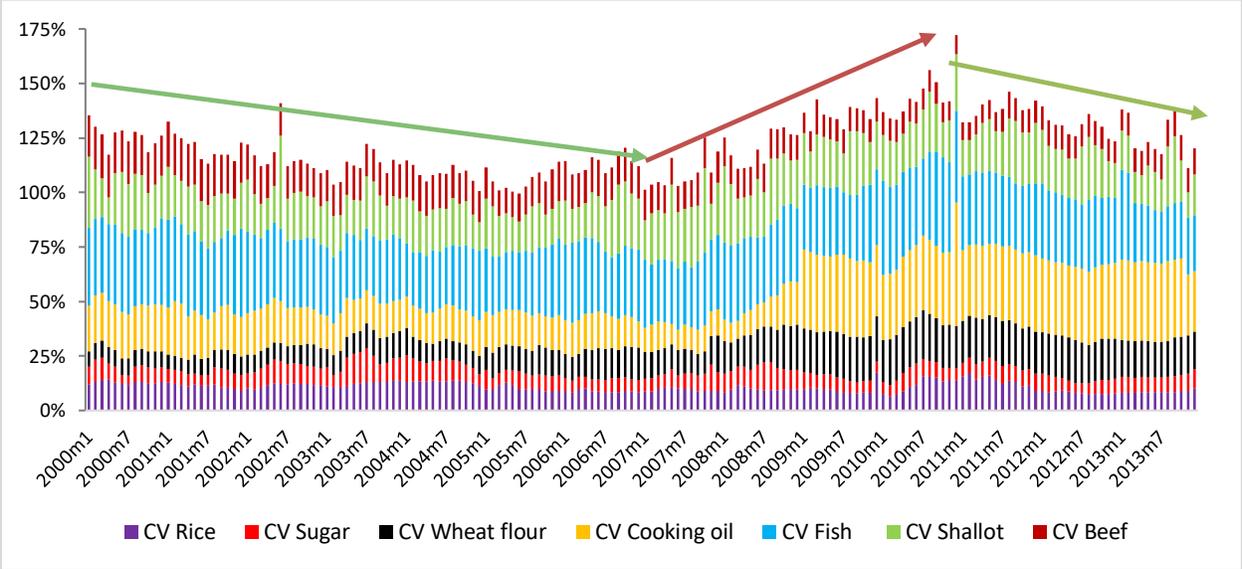


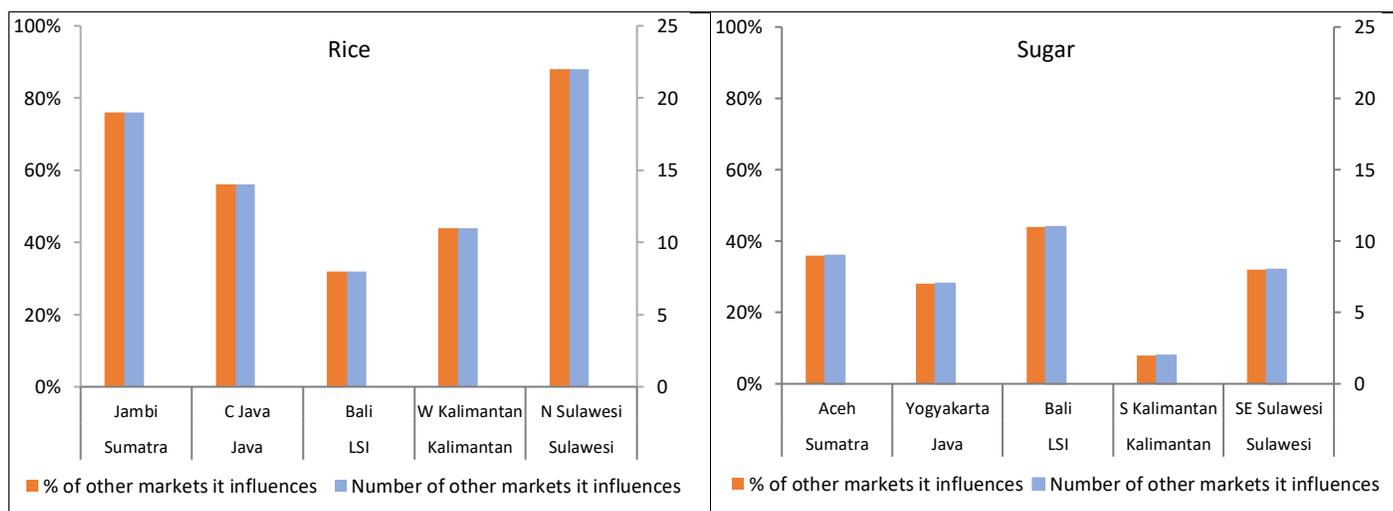
Figure 3. Coefficient of Variation (CV) of food prices across provinces in Indonesia

Identification of “lead” food markets

Results from the Granger causality test show the direction of price transmission between two food markets and possible arbitrage. The properties of co-integrated series also imply the existence of a Granger causality relation, that is, if past observations of one of the two prices predict future price developments of the other. We perform Granger causality test mainly for two key purposes. First, to understand which food markets act as a source of information for the other markets. Second, to identify “lead” food markets in each island and across all markets in the country. These markets can play a

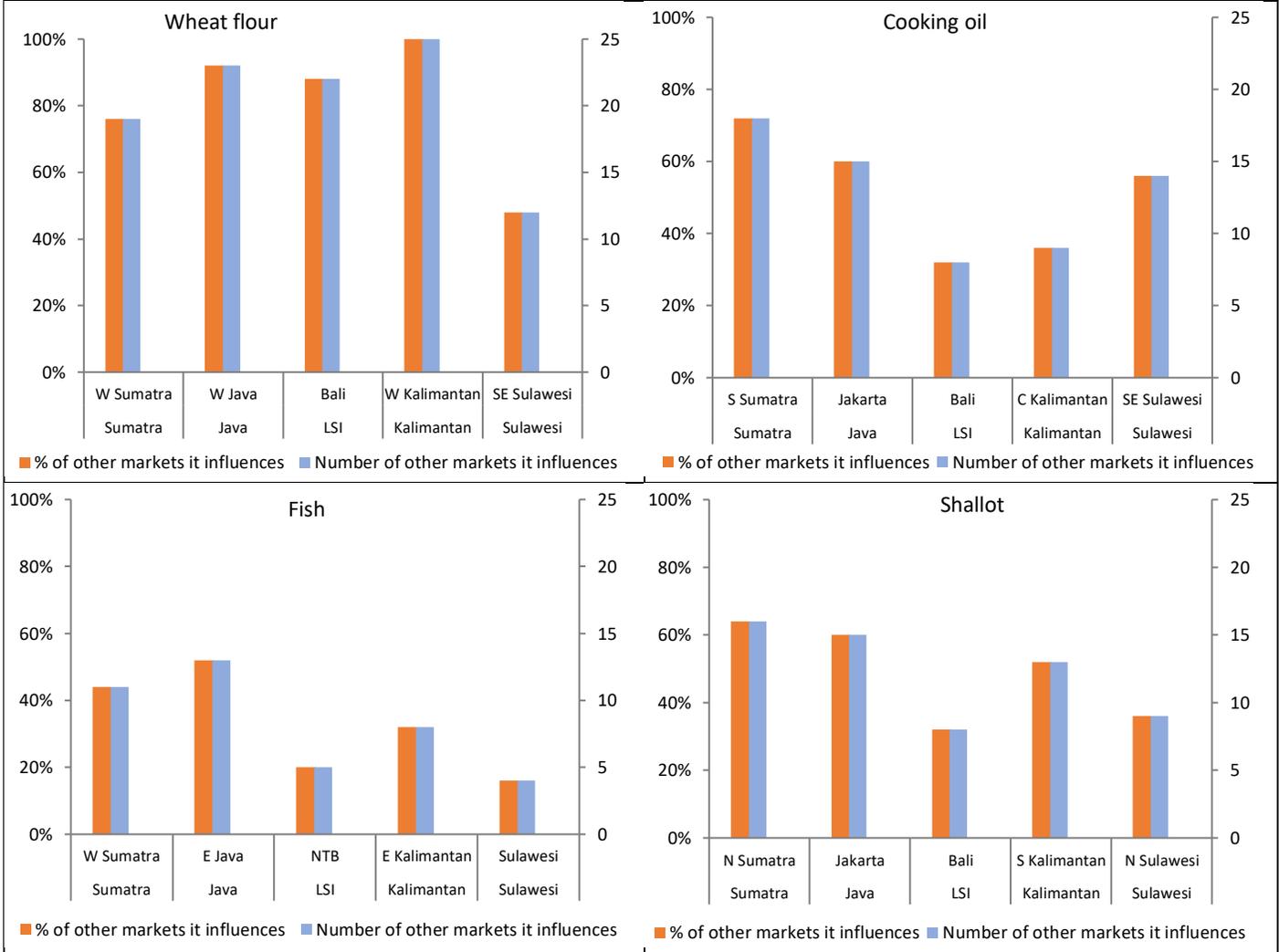
significant role in predicting price behavior in several other markets and hence will have policy relevance.¹¹ The main Granger causality test results are presented in Figure 4.¹²

The Granger causality tests indicate that rice prices in Central Java, Jambi, and North Sulawesi markets Granger-cause prices in 14, 19, and 22 of the 25 other rice markets, respectively. Thus, these markets can be considered as “lead” markets whose price movements can be used as source of information in predicting potential price changes in a large proportion of other rice markets in the country. Several rice markets in Lesser Sunda and Kalimantan islands can be considered as “follower” markets. In the case of sugar markets, the Bali market is identified as a “lead” market. Price changes at the Bali sugar market can help predict prices in about 11 other sugar markets. When considering the wheat flour market, we find that Granger causality runs in both directions for several market pairs. That is, lagged observations of wheat flour prices in one “lead” market explain the behavior of wheat flour prices in several other markets, and vice versa. For instance, price developments at the West Kalimantan wheat flour market transmit to price changes in all the 25 other wheat flour markets. Similarly flour prices in West Java and Bali wheat flour markets Granger cause prices in about 90 percent of the studied markets.



¹¹ A food market may be identified as a ‘lead’ market for several reasons, including its proximity to i) areas with large primary production; ii) large processing facilities; iii) major transport hubs and ports.

¹² Detailed Granger causality results with estimated coefficients and statistics are not presented for the sake of brevity.



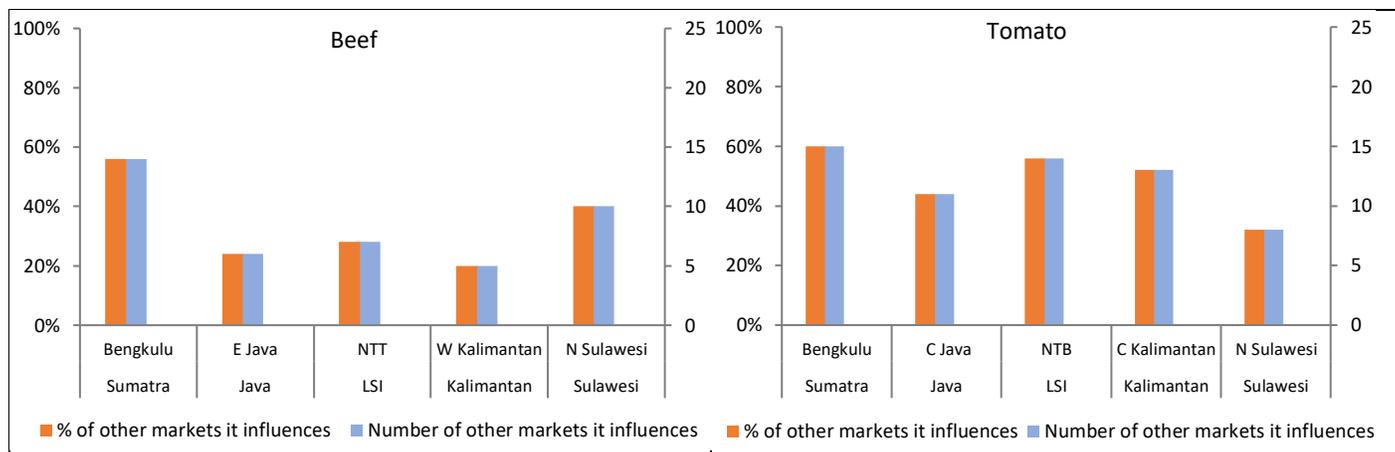


Figure 4. Price changes in some markets (labeled here as “lead” markets) have effects on prices in several other food markets

The countrywide “lead” food markets for each of cooking oil, shallots, and beef are located in the island of Sumatra. For instance, price changes at the South Sumatra cooking oil market Granger cause price changes in above 70 percent of other cooking oil markets. Similarly, price changes at the North Sumatra shallot market and the Bengkulu beef market precede price changes in above 70 and 55 percent of other markets in the country, respectively. The fish market in East Java can be identified as a “lead” market. Fish prices changes in the East Java market can be used as source of information for fish price dynamics in above 50 percent of other fish markets.

Intra- and inter-island food market integration

Because all price variables were found to be non-stationary series,¹³ we conducted the test for cointegration. We tested bivariate cointegration tests in both directions using the logarithmic form of prices. First, we tested for presence (or the lack thereof) of cointegrated price relationships among all possible market pairs within each of the five major islands—namely, Sumatra, Java, Sulawesi, Lesser Sunda, and Kalimantan.¹⁴ The results from these tests provide information on the extent of intra-island spatial market integration. For each food item, we also performed cointegration tests for a total of 325 market pairs (that is, all possible market pairs across the 26 provinces we considered in this study). Second, we performed cointegration tests among food prices across the abovementioned five islands as well as the Maluku and the Papua islands. As there are seven markets (one per island), there were 42 different possible market

¹³ While a stationary price series tends to constantly return to its mean value overtime, a non-stationary price series has a mean that varies overtime and has an infinitive variance.

¹⁴ As we only have single market prices from Papua and Maluku, we do not run intra-island cointegration tests.

pairs for each food type. The results from these tests provide evidence on inter-island spatial market integration. Third, we tested for cointegration of food prices across “key” markets from each of the major islands.¹⁵ These results are presented in the appendix (table A3). The results from these tests shed light on whether the “key” markets are more integrated with markets in other islands than the other markets in the respective islands.

Considering all 325 possible market pairs, the cointegration analysis shows that shallot and sugar markets are spatially well integrated. Similarly, we also found evidence of spatial market integration for above 60 and 80 percent of the fish and rice market pairs, respectively. Rice prices in South Kalimantan are the least cointegrated with prices in other markets in the country. Fish markets in Sulawesi and Java were among the most strongly integrated markets in Indonesia. Tomato, cooking oil, and beef market prices are in general poorly cointegrated with markets in other provinces, with just a quarter to a third of the possible market pairs found to be spatially integrated. A few exceptions are the tomato market in Bali, the oil market in West Java, and the beef markets in Riau and southeast Sulawesi that are strongly integrated with corresponding markets throughout the country.

These results suggest that the degree of spatial market integration varies across the studied food commodities and across islands. First, the variation across commodities could be explained by the overall market structure, product characteristics (perishability, homogeneity, storability), and degree of public intervention. This has implications for improving competitiveness in some food industries, such as the (cooking) oil and wheat flour industries. Investments in cold storage and marketing facilities could enhance spatial integration of perishable food markets, such as tomato, beef, and fish markets. Second, these results show stronger spatial integration across food markets in the relatively more developed central islands of Java, Sumatra, and Bali, than those in Kalimantan, Maluku, and Papua. Improving the rural market infrastructure in these relatively remote islands will have positive implications for greater connection of their food markets with the central islands and western islands.

Intra-island market integration

The markets of just three of the eight food items we analyzed can be considered having a well-integrated intra-island market. Figure 5 illustrates a summary of these within island market integration results.¹⁶ The results show that all shallot markets within each of the five major islands are strongly integrated. In other words, shallot markets are interdependent and that price changes in one shallot

¹⁵ Key markets in each island are defined as those markets: i) with the smallest market differences, ii) Granger cause the largest proportion of other market prices, and iii) most integrated in their respective islands.

¹⁶ The intra-island cointegration tests are performed on a total of 56 market pairs in Sumatra, 20 in Java, 12 market pairs in each of Kalimantan and Sulawesi, and 6 market pairs in Lesser Sunda islands.

market are fully passed on to other markets. Following shallot markets, sugar and rice markets exhibit the largest intra-island market integration. About 90 percent of sugar and 82 percent of rice markets in all but Kalimantan islands are well integrated. The other food markets—that is, wheat flour, cooking oil, beef, fish, and tomato markets—have poor to moderate intra-island market integration. For nearly all food items we analyzed, markets within Kalimantan are the least spatially integrated markets, where food prices in at least 50 percent of the markets were not yet cointegrated (shallot market is an exception).¹⁷

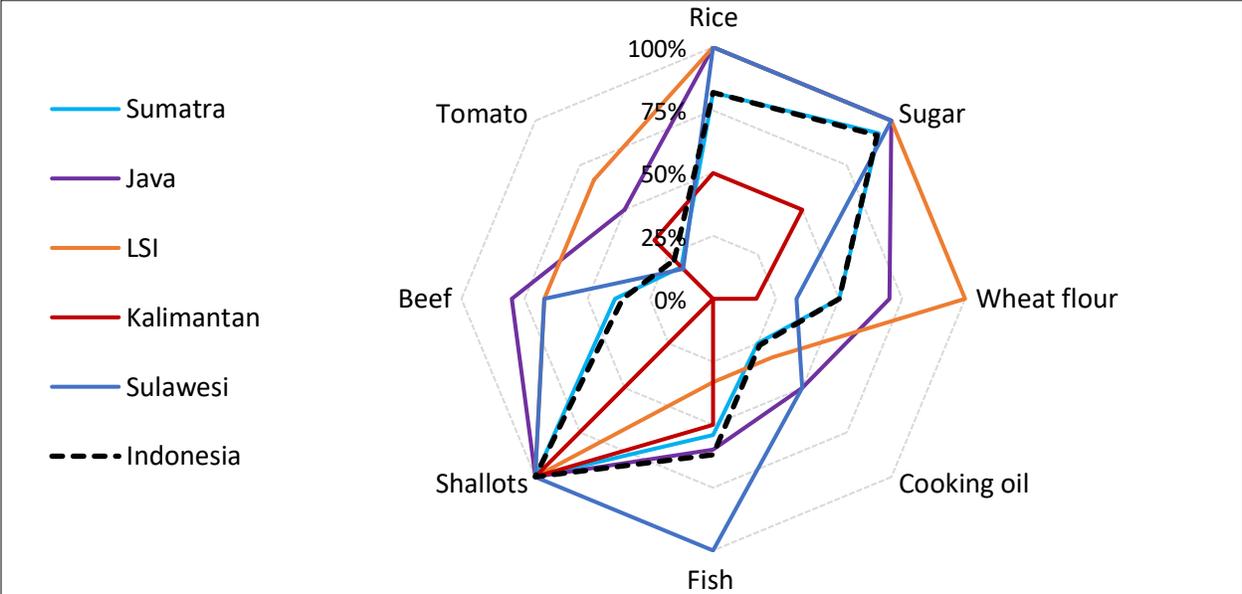


Figure 5. Intra-island market cointegration, proportion of market pairs that are strongly cointegrated

Inter-island market integration

Tables 1 and 2 report the inter-island market price cointegration test results. The Engle and Granger procedure indicated that the number of co-integration relationships range from 1 to 7 across the food items, with all seven of the shallot price series found to be cointegrated.¹⁸ In agreement to the within market integration results for rice and sugar, there were five cointegration relationships within the seven price series – that is, rice and sugar prices within and across the seven islands are mostly co-integrated. Considering the 1 percent level of significance, about 90 percent of the market pairs for sugar, 62 percent

¹⁷ The relatively stronger government interventions to control price inflation in shallot could have impacted observed price patterns in shallot markets than in the other markets.

¹⁸ As there are seven price series, one for each island, seven is the maximum possible number of cointegration.

for each of rice and fish market pairs, and all possible shallot market pairs were spatially integrated across the seven islands.

Table 1. Inter-island food market integration among the major islands in Indonesia

<i>Rice market</i>							
<i>a) Island</i>	Sumatra	Java	LSI	Kalimantan	Sulawesi	Maluku	Papua
Sumatra		-4.58*	-4.51*	-3.24	-5.59*	-4.29*	-3.68**
Java	-4.56*		-4.83*	-4.17*	-5.36*	-4.24*	-3.66**
LSI	-4.49*	-4.84*		-3.19	-6.20*	-4.78*	-4.05*
Kalimantan	-3.24	-4.19*	-3.22		-3.12	-3.37	-2.51
Sulawesi	-5.57*	-5.36*	-6.20*	-3.10		-4.27*	-3.75**
Maluku	-4.16*	-4.15*	-4.68*	-3.23	-4.16*		-4.74*
Papua	-3.67**	-3.68**	-4.06*	-2.49	-3.76**	-4.85*	
<i>Sugar market</i>							
Sumatra		-3.48**	-4.90*	-4.89*	-4.41*	-5.13*	-5.17*
Java	-3.48**		-4.55*	-4.17*	-6.80*	-6.68*	-6.08*
LSI	-4.89*	-4.54*		-3.88**	-4.89*	-4.96*	-6.01*
Kalimantan	-4.90*	-4.19*	-3.90*		-4.69*	-5.54*	-5.49*
Sulawesi	-4.42*	-6.81*	-4.91*	-4.69*		-6.94*	-5.86*
Maluku	-5.12*	-6.66*	-4.95*	-5.52*	-6.92*		-6.08*
Papua	-5.18*	-6.10*	-6.03*	-5.49*	-5.86*	-6.10*	
<i>Wheat flour market</i>							
Sumatra		-2.99	-0.83	-2.39	-1.65	-0.90	-0.20
Java	-3.02		-1.26	-2.52	-2.01	-1.27	-0.66
LSI	0.56*	-0.83		-2.55	-3.38**	-3.88**	-3.48**
Kalimantan	-3.73**	-3.54**	-2.62		-2.72	-2.87	-1.79
Sulawesi	-1.63	-2.82	-3.41**	-2.69		-3.00	-3.12
Maluku	0.03*	-0.67	-3.89**	-2.81	-2.96		-3.33
Papua	-1.37	0.39*	-3.49**	-1.71	-3.10	-3.33	
<i>Cooking oil market</i>							
Sumatra		-4.07*	-2.28	-3.41**	-3.06	-1.77	-3.22
Java	-4.08*		3.31	-5.16*	-4.85*	-2.50	-3.10
LSI	-2.34	-3.35		-2.48	-2.25	-1.84	-3.19
Kalimantan	-3.47**	-5.20*	-2.49		-3.14	-1.96	-2.71
Sulawesi	-3.03	-4.83*	-2.14	-3.04		-1.86	-2.52
Maluku	-2.00	-2.66	-1.99	-2.08	-2.14		-1.78
Papua	-3.19	-3.05	-3.11	-2.60	-2.52	-1.47	

Notes: The pairwise cointegration tests were performed using the Engle and Granger procedure specified with 2 lags to control for series correlation. * and ** represent significance at a 1% and a 5% critical value respectively (null hypothesis: markets are not cointegrated).

The inter-island market integration results suggest that rice prices in Kalimantan and Papua remain poorly integrated with prices in the rest of the islands. Table 1 also shows that wheat flour and cooking oil markets have poor spatial market integration across islands. Yet, the cooking oil markets in Java are strongly cointegrated with those in Sumatra, Kalimantan, and Sulawesi (table A3). When considering only the “key” markets in each island, wheat flour prices across the “key” markets in the five major islands (except Maluku and Papua) are strongly co-integrated. The Maluku wheat flour market is weakly integrated with key markets in other islands while wheat flour prices in Papua are not yet cointegrated with market prices in other islands.

Inter-island beef and tomato market integration remains poor in Indonesia. Even the “key” beef markets in Kalimantan, Lesser Sunda, and Papua islands were not well integrated with key markets in other islands. Yet, the key beef markets Sumatra (Riau), Sulawesi (Southeast Sulawesi), and Maluku are well integrated. Similarly, tomato prices in the key markets of Java and Bali are integrated with corresponding key markets in other islands. While fish markets have moderate inter-island integration, the key markets across the seven major islands are strongly integrated.

In summary, food markets within the same island are more integrated than food markets across islands (table 3). All intra-island and inter-island shallot markets and above 80 percent of the sugar and rice markets are well integrated with the respective markets in the country. This means that price changes in these food markets are fully transmitted to respective markets throughout the country, implying greater marketing efficiency. Rice markets in Kalimantan are the least cointegrated among all rice markets in Indonesia, both within and across islands. Beef, tomato, cooking oil, and wheat flour markets are generally poorly integrated, with above 50 percent of these food market prices found not yet cointegrated. This conclusion remains true for both intra- and inter-island market integration. These results suggest that price changes in these food markets are not well transmitted to respective food markets in other part of the country. It would suggest that marketing inefficiencies constrain full price transmission of these food items around the country. Fish markets are moderately integrated, with above 60 percent of intra-island and inter-island market integration.

Table 2. Inter-island food market integration among the major islands in Indonesia

<i>Fish market</i>							
Sumatra		-3.54**	-5.01*	-4.30*	-5.50*	-4.35*	-3.99*
Java	-3.48**		-3.79**	3.38**	-3.35**	-5.30*	-3.48**
LSI	-5.02*	-3.86**		-4.05*	-5.26*	-5.02*	-4.19*
Kalimantan	-4.34*	-3.49**	-4.08*		-4.77*	-3.59**	-5.17*
Sulawesi	-5.49*	-3.41**	-5.24*	-4.73*		-3.83**	-5.51*
Maluku	-4.27*	-5.28*	-4.94*	-3.45**	-3.75**		-4.09*
Papua	-3.99*	-3.54**	-4.17*	-5.13*	-5.51*	-4.16*	
<i>Shallot market</i>							
Sumatra		-7.21*	-6.21*	-6.95*	-6.9*	-7.74*	-4.3*
Java	-7.13*		-7.13*	-8.32*	-8.07*	-8.67*	-4.81*
LSI	-5.88*	-7.21*		-6.42*	-6.26*	-6.64*	-4.45*
Kalimantan	-6.60*	-8.39*	-6.33*		-6.71*	-7.5*	-4.32*
Sulawesi	-6.74*	-8.33*	-6.37*	-6.90*		-5.62*	-4.84*
Maluku	-7.40*	-8.77*	-6.56*	-7.52*	-5.47*		-3.91*
Papua	-4.28*	-5.13*	-4.72*	-4.67*	-5.01*	-4.18*	
<i>Beef market</i>							
Sumatra		-3.09	-3.73**	-2.88	-2.56	-4.62*	-2.70
Java	-3.16		-3.08	-3.68**	-1.93	-4.54*	-2.76
LSI	-3.75**	-3.04		-3.41**	-3.44**	-4.92*	-2.70
Kalimantan	-2.97	-3.72**	-3.47**		-2.10	-5.15*	-3.13
Sulawesi	-2.53	-1.82	-3.40**	-1.98		-4.27*	-3.20
Maluku	-4.58*	-4.45*	-4.86*	-5.05*	-4.24*		-2.72
Papua	-2.75	-2.75	-2.72	-3.08	-3.25	-4.08*	
<i>Tomato market</i>							
Sumatra		-3.22	-3.08	-4.04*	-2.18	-2.67	-1.32
Java	-3.38		-4.10*	-3.95**	-4.59*	-2.24	-2.91
LSI	-4.21*	-5.02*		-4.88*	-3.57**	-2.40	-1.92
Kalimantan	-3.39	-3.20	-3.12		-2.49	-2.32	-1.91
Sulawesi	-2.88	-4.78*	-2.851	-3.90**		-2.58	-4.43*
Maluku	-3.74**	-3.23	-2.24	-4.26*	-3.07		-1.95
Papua	-3.26	-4.28*	-2.41	-4.29*	-5.53*	-2.73	

Notes: The pairwise cointegration tests were performed using the Engle and Granger procedure specified with 2 lags to control for series correlation. * and ** represent significance at a 1% and a 5% critical value respectively (null hypothesis: markets are not cointegrated).

The “key” markets are generally more integrated with markets in other islands than the other markets. For instance, nearly all the “key” fish markets and above 60 percent of the “key” beef markets show strong inter-island integration (compared to just 62 and 26 percent of markets integrated when all markets were considered, respectively). The results imply that (i) inter-island market integration is largely poor for “non-

key or “non-important” markets in each island; (ii) Islands with stronger intra-island market integration tend to have stronger inter-island market integration; (iii) market integration appears to largely depend on the characteristics of the food items.

Table 3. Summary: proportion of spatially integrated food market pairs

Market	Intra-island (average of the 5 major islands)	Inter-island (across 7 islands)	Inter-island (across 7 “key” markets)	Nationwide (across 26 market pairs)
Rice	89%	62%	81%	82%
Sugar	91%	90%	100%	92%
Wheat flour	45%	7%	48%	50%
Cooking oil	26%	14%	43%	26%
Shallot	100%	100%	100%	100%
Fish	66%	62%	98%	62%
Beef	42%	26%	64%	36%
Tomato	31%	29%	33%	22%

Notes: These values are based on the cointegration test results with a 1 percent level of significance.

Potential explanations for weak spatial food market integration

Logistics inefficiency and related costs could play a role in the weak spatial food market integration. An inadequate logistic system, together with regulatory constraints on entry into logistical and related services, increases the cost of moving food around Indonesia’s archipelago. Figure 6 shows that trucking cost at the destination city represents the largest proportion of transportation costs. Trucking costs at the destination city makes up two thirds of the cost of transporting a twenty-foot equivalent unit (TEU) per kilometer of food from Surabaya to Sorong.¹⁹ Poor road infrastructure and local regulatory constraints that limit the movement of containerized transportation contribute to high trucking costs in the country. Relatively higher costs are also associated with logistics administration, transport, warehousing, and inventory management—the latter affected by time delays.

¹⁹ World Bank survey 2014; and Improving Indonesia’s Freight Logistics System: A Plan of Action (World Bank 2015).

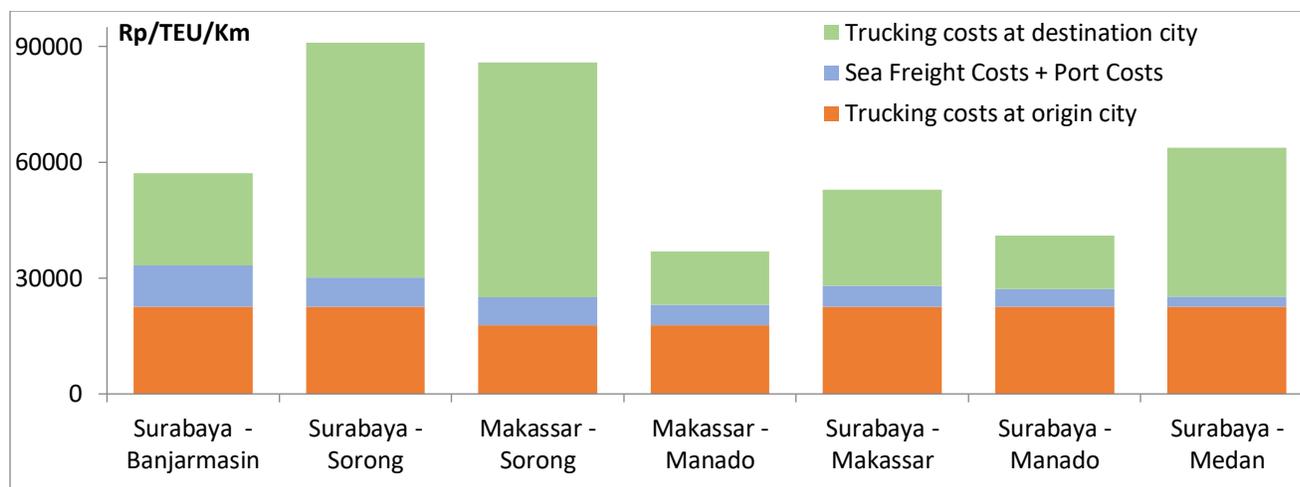


Figure 6. logistic costs across markets in Indonesia

Source: WB (2014); OECD Services Trade Restrictiveness Index (STRI) Database.

High post-harvest and processing costs contribute to weak spatial food market integration in Indonesia.

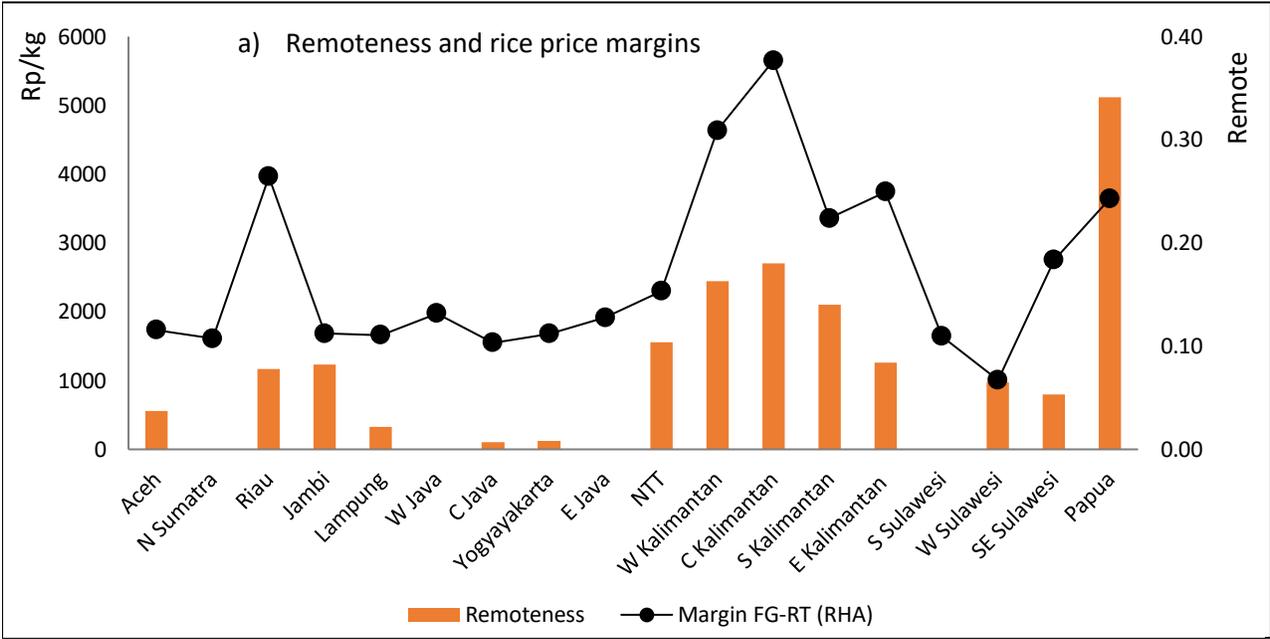
If we consider rice, by far the main staple food in the region, Indonesia has one of the lowest net marketing margins compared to many other countries (table 4). This is due mainly to high milling and distribution costs in Indonesia. Indonesia's rice milling is highly fragmented and has poor technical efficiency. For instance, around 175 thousand small mills have a milling recovery of less than 56 percent, whereas around 2000 large scale mills have above 62 percent recovery. Poor road infrastructure and congestion in driving and trucking escalate intra-island trade costs. Other factors like backhaul problem, low shipment frequency, and poor port infrastructure for driving and shipping increase inter-island trade costs. Moreover, inadequate dry and cold storage facilities result in quantity and quality losses, lowering product value in destination markets. This is particularly crucial for marketing of perishable products.

Table 4. Differential marketing margins and marketing costs for rice (2013-2014, USD per Kg)

	Philippines	Indonesia	Thailand	Vietnam
Gross marketing margins	0.204	0.126	0.119	0.102
Total marketing cost	0.104	0.112	0.061	0.085
<i>Drying cost</i>	0.006	0.014	0.007	0.012
<i>Transport cost</i>	0.047	0.050	0.024	0.040
<i>Milling cost</i>	0.031	0.027	0.020	0.021
<i>Storage cost</i>	0.004	0.009	0.005	0.005
<i>Packaging cost</i>	0.010	0.005	0.003	0.005
<i>Cost of working capital</i>	0.006	0.006	0.002	0.002
Net marketing margins	0.100	0.015	0.057	0.017

Source. CEIC, WB Staff Calculation, BPS.; Competitiveness of Philippine Rice in Asia (Bordey et al 2016)

Remote markets experience relatively higher prices and are less integrated with other markets in the country. While the above cointegration results show that some “key” markets that are distant from each other are integrated, central markets are more likely to be integrated with a larger number of other markets. Defined as the distance of markets (km) weighted by the inverse of population (millions) of the closest of one of the five major cities (Jakarta, Surabaya, Medan, Makasar or Batam), remoteness measures the notion of centrality.²⁰ With a few exceptions, figure 8 illustrates that remoteness is positively correlated with the price margins between farm gate and retail rice prices (FG-RT, panel a) and negatively correlated with the number of food markets a given market is integrated with (panel b). These results imply better organization of value chains and the development of logistics services and infrastructure are fundamentally critical in relatively remote areas.



²⁰ This definition is based on the study, “Determinants of Market Integration and Price Transmission in Indonesia” (World Bank 2012).

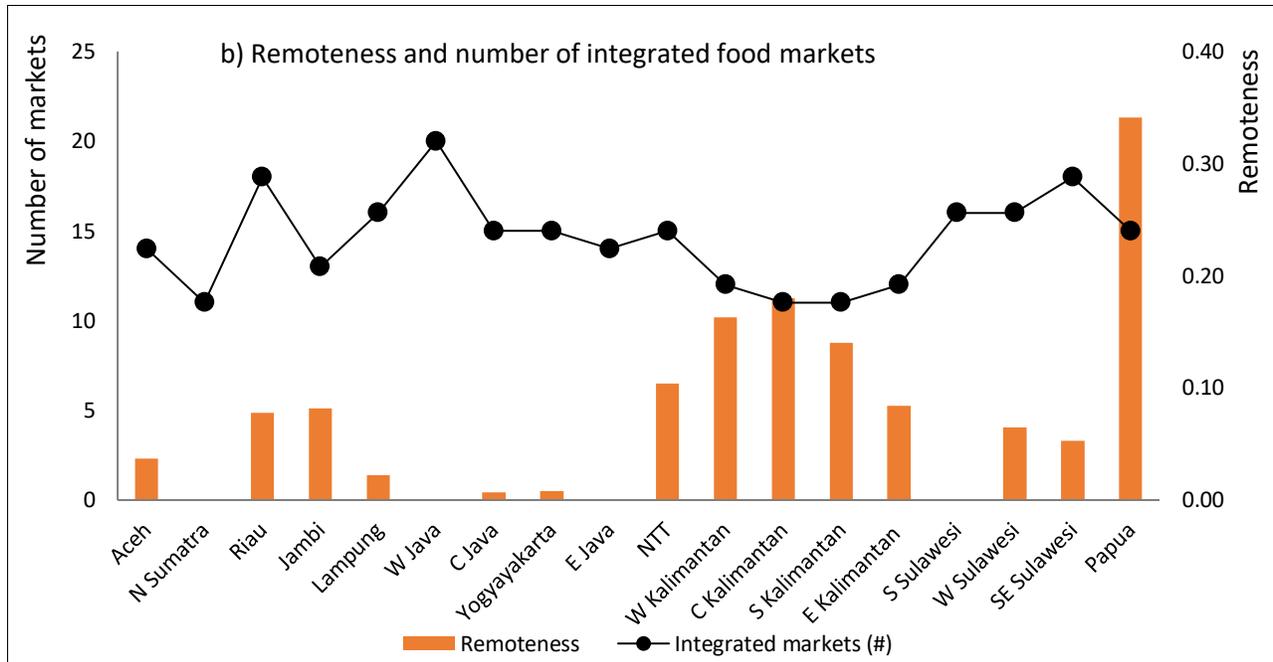


Figure 7. Remoteness and spatial market integration.

Conclusions

As the largest archipelago in the world, well integrated food markets are crucial to meet the food supply and demand of Indonesia's population across the various islands. The unique geography and physical structure of the country in turn plays a key role in the integration of their markets. Java and Bali's agricultural land area has largely been exploited for food production, with limited scope for further expansion. Agricultural production would therefore intensify and likely expand to areas outside of Java-Bali and distributed across the country. This implies that food will have to be produced in less exploited areas with agricultural potential and traded back to the populated areas of Java and Bali. This will put additional pressure on the capacity of Indonesia's market logistics and marketing efficiency.

Indonesia has large inefficiencies in market and logistics infrastructure. We suspect that these have resulted in the weak spatial food market integration. This study has tested this hypothesis using monthly retail rice prices of eight key food commodities from 26 major markets in Indonesia. The results provide insights on the degree of spatial integration of food markets.

Considering the overall results, the following key conclusions can be drawn.

- **The results show that the degree of spatial market integration varies across the studied food commodities.** This variation comes from the overall market structure, product characteristics (perishability, homogeneity, storability), and degree of public intervention. The evidence shows that shallot, sugar, and rice markets are spatially well integrated in the long term and have efficient causal relationships.
- **Intra-island food markets are more integrated than food markets across islands.** In general, prices in close by markets were more likely to be cointegrated while cointegration diminishes as the distance between the market pairs increased. However, some markets which were relatively close to each other did not show cointegration while a few markets separated by long distances, especially the “key” food markets, have strong price cointegration. The “key” markets in each island are different for the different food items. An important exception is the Bali market (Lesser Sunda Islands) where it is found to be the “key” market for all food items except for beef. Thus, not just distance but also infrastructure quality and connectivity as well as access to information are equally important for spatial integration of food markets.
- **Regardless of food items, there is stronger spatial integration across food markets in Java, Sumatra, Bali (LSI), and Sulawesi than those in Kalimantan, Maluku, and Papua.** The food market logistics in Java, Sumatra, and Bali are relatively efficient and have the capacity to move food within and across these islands. Similarly, food markets in Sulawesi can rely on a high frequency and decent quality shipping facility, indicating good market integration. Price transmission can be smoother and complete if there are more frequent shipping services across islands. For distant islands where shipping frequency is low, restocking food may take a prolonged period, suggesting that price changes in one market may not completely pass on to other markets. The risk of such low shipment frequency is much higher for perishable commodities, implying slow or incomplete price transmission and hence weak spatial market integration. These could explain why markets in distant islands of Maluku, Papua, and to some extent Kalimantan and those of perishable products (tomato, beef, and fish) exhibit poor spatial integration. Shallot markets are different as it can be transformed into a non-perishable product through drying and/or further processing.
- **In the presence of inadequate cold storage and other infrastructure, low shipping frequency, and transportation delays, trade in perishable food commodities across provinces may be limited.** In this case, there may be long lasting arbitrage opportunities, implying market inefficiencies and long-lasting price differences across markets. Intra-and inter-island trade is costly and challenging for temperature-controlled products such as fruits and vegetables, fish, and meat products. These products demand reefer containers that are often in short supply in Indonesia. This could explain the

poor spatial integrations of the tomato, fish, and beef markets in Indonesia. In this regard, Indonesia may learn lessons from the Philippines, especially from the Mindanao region which is a major exporter of tropical fruits and has invested in developing cold chain infrastructure.

- **Market structure and its implications for fair competition and for information transmission across markets could contribute to the differences in spatial integration of the different food commodities.** For instance, food commodities such as rice and shallots have low market concentration and their markets are spatially well integrated throughout the country. Although the rice market has been regulated by the *Badan Urusan Logistik* (BULOG), a state-owned trading enterprise that manages rice stocks to moderate price fluctuations, rice markets are largely cointegrated. This result indicates that BULOG's market intervention has been limited and has not negatively affected the domestic rice market integration. On the other hand, high cost of entry for millers and edible oil processors have led to high concentration in wheat flour and cooking oil markets, respectively. These two food markets were found to have weak spatial integration.

Policy implications

- **To feed a growing and urbanizing population, Indonesia's food system will need to adapt.** Area expansion and intensification of food production may increasingly occur further from consumption centers. The current state of market efficiency and efficacy, as described in this report, suggests that improvements are needed in terms of logistics and connectivity across the archipelago. To further inform food system policy and planning, an assessment of the nature and location of future food production expansion is needed.
- **Improving logistics services and infrastructure can enhance efficiency of the marketing system in agricultural commodities and reduce market distortions.** Enabling a competitive business environment for logistics service providers by increasing competition in (i) freight forwarding services, storage and distribution services; and (ii) auxiliary shipping services. Public investments in upgrading quality of physical infrastructure and expansion of paved roads would reduce costs and hence facilitate food trade. Similarly, investments in enhancing port governance and quality will be crucial. Such market infrastructure investments will enhance the capacity of Indonesia's future food markets to be able to respond to ongoing food and diet consumption transformation.
- **Improving access to market information and transparency across markets and market actors in the country.** This includes providing price information and increasing the human capital of food producers and consumers around the country. The public sector can play a role in upgrading the extension system, investing in R&D, facilitating the communication between supply chain actors. Digital

agricultural technologies, such ICT, can play a key role in providing market information, thereby reducing information asymmetry among market agents.

Appendix

Table A 1. Descriptive statistics of provincial level price differences for the period 2000-2016

Food item	Mean price	Provincial level price difference from the national average price				
		Mean	Std Dev	Max	Min	90/10th Percentile
Rice	5287	368	301	1171	0	7.7
Sugar	7219	1013	520	2422	169	4.4
Wheat flour	5671	677	509	2591	67	3.4
Cooking oil	9923	3159	1719	7692	1050	3.4
Shallot	12279	4065	1716	7519	573	5.0
Fish	34617	20226	9318	41603	1211	3.1
Beef	50827	29254	11624	43516	2000	4.8
Tomato	11742	2856	3536	16339	271	6.5

Source: Badan Pusat Statistik (BPS)

Table A 2. Markets that can be considered as “key” food markets in each island

Island	Rice	Sugar	Wheat flour	Cooking oil	Fish	Shallot	Beef	Tomato
Sumatra	Jambi	W Sumatra	Bengkulu	N Sumatra	W Sumatra	N Sumatra	Bengkulu	S Sumatra
Java	C Java	Yogyakarta	Yogyakarta	W Java	W Java	Jakarta	W Java	W Java
LSI	Bali	Bali	Bali	Bali	Bali	Bali	NTT	Bali
Kalimantan	E Kalimantan	S Kalimantan	W Kalimantan	C Kalimantan	W Kalimantan	S Kalimantan	S Kalimantan	E Kalimantan
Sulawesi	S Sulawesi	SE Sulawesi	SE Sulawesi	N Sulawesi	S Sulawesi	N Sulawesi	SE Sulawesi	C Sulawesi
Indonesia	S Sulawesi	W Sumatra	Yogyakarta	N Sumatra	W Sumatra	N Sumatra	Bengkulu	Bali
Specific market	Makassar	Padang	Yogyakarta	Medan	Padang	Medan	Bengkulu	Bali

Table A 3. Inter-island food market integration among the “key” markets of each major island

Rice	Jambi	C Java	Bali	E Kalimantan	S Sulawesi	Maluku	Papua
Jambi		-4.42*	-5.48*	-5.02*	-4.62*	-7.24*	-3.71**
C Java	-4.34*		-4.09*	-5.37*	-4.12*	-6.74*	-3.24
Bali	-5.47*	-4.16*		-5.76*	-5.48*	-7.71*	-4.46*
E Kalimantan	-5.00*	-5.42*	-5.75*		-5.04*	-6.60*	-3.94*
S Sulawesi	-4.58*	-4.16*	-5.46*	-5.03*		-7.32*	3.96*
Maluku	-6.99*	-6.58*	-7.47*	-6.39*	-7.10*		-8.34*
Papua	3.68**	-3.30	-4.46*	-3.94**	-3.98*	-8.60*	
Sugar	W Sumatra	Yogyakarta	Bali	S Kalimantan	SE Sulawesi	Maluku	Papua
W Sumatra		-8.62*	-9.07*	-8.80*	-8.98*	-8.04*	-7.61*
Yogyakarta	-9.05*		-4.96*	-6.16*	-6.02*	-7.21*	-6.01*
Bali	-9.55*	-4.97*		-4.64*	-6.12*	-5.71*	-5.90*
S Kalimantan	-9.25*	-6.17*	-4.65*		-5.66*	-6.04*	-5.55*
SE Sulawesi	-9.46*	-6.04*	-6.14*	-5.68*		-5.97*	-5.32*
Maluku	-8.43*	-7.21*	-5.71*	-6.03*	-5.94*		-6.08*
Papua	-8.00*	-6.04*	-5.92*	-5.57*	-5.32*	-6.10*	
Wheat flour	Bengkulu	Yogyakarta	Bali	W Kalimantan	SE Sulawesi	Maluku	Papua
Bengkulu		-6.02*	-4.42*	-5.61*	-5.90*	-3.85**	-3.27
Yogyakarta	-6.03*		-5.28*	-5.94*	-5.21*	-3.50**	-3.09
Bali	-4.42*	-5.27*		-4.87*	-5.68*	-3.72**	-2.96
W Kalimantan	-5.63*	-5.96*	-4.88*		-5.57*	-3.58**	-3.12
SE Sulawesi	-5.92*	-5.23*	-5.70*	-5.57*		-3.73**	-3.73**
Maluku	-3.86**	-3.50**	-3.74**	-3.56**	-3.72**		-3.33
Papua	-3.29	-3.10	-2.98	-3.12	-3.73**	-3.33	
Cooking oil	S Sumatra	W Java	Bali	C Kalimantan	N Sulawesi	Maluku	Papua
S Sumatra		-4.83*	-3.76**	-2.19	-2.74	-1.19	-4.00*
W Java	-4.71*		-4.97*	-5.97*	-6.35*	-3.54**	-6.54*
Bali	-3.73**	-5.58*		-2.68	-3.45**	-1.32	-5.08*
C Kalimantan	-2.32	-6.16*	-2.83		-3.46**	-1.44	-4.22*
N Sulawesi	-2.77	-6.52*	-3.51**	-3.40**		-2.00	-4.88*
Maluku	-1.57	-3.83**	-1.77	-1.62	-2.23		-1.78
Papua	-4.01*	-6.69*	-5.10*	-4.15*	-4.87*	-1.47	
Fish	W Sumatra	W Java	Bali	W Kalimantan	S Sulawesi	Maluku	Papua
W Sumatra		-4.56*	-5.07*	-6.20*	-6.09*	-5.28*	-4.06*
W Java	-4.52*		-4.59*	-4.55*	-5.54*	-5.66*	-4.22*
Bali	-5.13*	-4.69*		-5.01*	-6.70*	-4.98*	-5.16*
W Kalimantan	-6.24*	-4.64*	-5.00*		-4.47*	-4.05*	-4.21*
S Sulawesi	-6.05*	-5.54*	-6.60*	-4.37*		-4.83*	-5.72*
Maluku	-5.23*	-5.66*	-4.88*	-3.94*	-4.81*		-4.09*

Papua	-4.09*	-4.28*	-5.12*	-4.17*	-5.76*	-4.16*	
Shallots	N Sumatra	Jakarta	Bali	S Kalimantan	N Sulawesi	Maluku	Papua
N Sumatra		-7.34*	-7.09*	-6.85*	-6.57*	-7.13*	-4.60*
Jakarta	-7.31*		-8.11*	-7.71*	-9.90*	-8.79*	-4.69*
Bali	-6.38*	-7.39*		-6.80*	-7.32*	-8.30*	-4.66*
S Kalimantan	-6.33*	-7.20*	-6.94*		-8.51*	-7.76*	-4.57*
N Sulawesi	-6.16*	-9.40*	-7.62*	-8.65*		-6.87*	-4.59*
Maluku	-6.82*	-8.49*	-8.77*	-8.02*	-6.98*		-3.91**
Papua	-4.60*	-4.70*	-5.36*	-5.04*	-4.96*	-4.18*	
Beef	Riau	W Java	NTT	S Kalimantan	SE Sulawesi	Maluku	Papua
Riau		-6.55*	-5.48*	-6.83*	-6.20*	-6.50*	-5.47*
W Java	-8.69*		-3.32	-3.88**	-5.10*	-4.84*	-3.16
NTT	-7.21*	-3.34		-2.11	-4.36*	-3.40**	-2.75
S Kalimantan	-9.24*	-4.05*	-2.35		-4.47*	-4.11*	-2.74
SE Sulawesi	-7.89*	-4.93*	-4.20*	-4.15*		-5.90*	-6.55*
Maluku	-8.61*	-4.90*	-3.45**	-4.00*	-6.11*		-4.00*
Papua	-7.30*	-3.32	-2.90	-2.67	-6.87*	-4.08*	
Tomato	Riau	W Java	Bali	W Kalimantan	SE Sulawesi	Maluku	Papua
Riau		-4.93*	-4.79*	-3.16	-2.99	-3.02	-1.22
W Java	-3.33		-4.06*	-4.15*	-4.33*	-2.27	-2.26
Bali	-3.78**	-4.36*		-3.07	-3.35	-3.48**	-1.40
W Kalimantan	-3.33	-5.91*	-4.01*		-4.29*	-2.29	-0.92
SE Sulawesi	-2.76	-5.64*	-3.95**	-3.81**		-2.24	-2.61
Maluku	-3.70**	-4.52*	-4.98*	-3.17	-3.30		-2.06
Papua	-2.77	-5.05*	-3.79**	-2.52	-4.14*	-2.73	