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## A Spatial Integration Analysis of the Regional Fertilizer Markets in the Philippines

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**Philippine Institute for Development Studies**  
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# A Spatial Integration Analysis of the Regional Fertilizer Markets in the Philippines

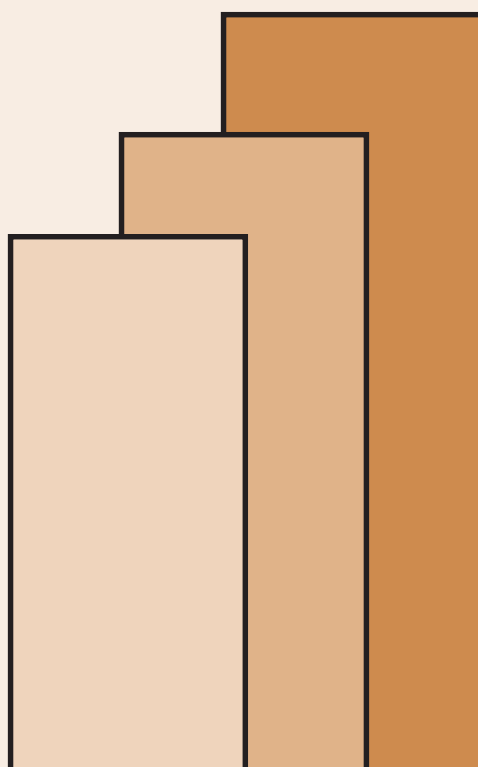
*Ivory Myka R. Galang*

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# **A Spatial Integration Analysis of the Regional Fertilizer Markets in the Philippines**

Ivory Myka R. Galang<sup>1</sup>

Fertilizer, which is an important production input, holds a significant share in total cost of production for some crops. Based on the available fertilizer price data, it can be observed that price levels vary greatly across regions. To help determine whether or not this variability is alarmingly high, a spatial market integration analysis was done. Based on the Granger causality test, it is found that the price in one region either causes or affects prices in another region. The cointegration test suggest that regional markets are integrated. Long-run relationships are also shown to be statistically significant. The finding that regional fertilizer markets in the Philippines are integrated is consistent with the absence of market power in the fertilizer industry. The number of market players in the industry makes it highly unlikely for one or few dealers of fertilizer to control the market price of fertilizer.

**Keywords:** fertilizer, spatial market integration, Granger causality, Johansen cointegration test

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## **I. Introduction**

Fertilizer, which is an important production input, holds quite a significant share in total cost of production for some crops (e.g. 12 percent for rice, 30 percent for tomato and potato). This implies that any change in the price of fertilizer may have direct implications on the total farm production cost of some commodities.

The level of fertilizer prices, however, may differ across regions. Wide disparities in the regional prices of fertilizer are apparent based on the official data (i.e. dealers' price of urea). Given the archipelagic nature of the country, one possible cause of such disparity is the poor condition of the domestic transport infrastructure. Alternatively, it could also be due to the presence of market power in the fertilizer industry. A recent study by Briones (2014), however, does not support the latter at the national level. His findings suggest that the domestic market is integrated with the international market. This means that any price changes in the international market are readily transmitted to the domestic market. To help determine whether or not the variability across the regional domestic markets is alarmingly high, we could do a spatial market integration analysis.

Market integration studies, in general, are being undertaken to understand market conditions. The resulting information from such studies are pertinent to building of economic models, determination of the status of market competition, and crafting of policy interventions in the short- and long-run (Barrett 1996).

This paper aims to determine whether or not regional fertilizer markets in the country are well integrated. The main objectives are: 1) to check the appropriateness of the available fertilizer price data for the proposed econometric analysis; 2) to apply cointegration techniques and other tests on all pairwise combinations of the 16 regions; 3) to determine the occurrence of price leaders in the markets for urea fertilizer; and 4) to conclude the existence of spatial market integration in the domestic fertilizer market.

The paper is divided into six parts. Section II provides a brief discussion on concepts related to market integration, approaches to market integration testing, and related empirical studies. Section III outlines the methodology and describes the fertilizer data used in this study. Section IV provides a short background on the regional fertilizer markets. Section V presents the results and discussion of the findings. The final section concludes the study.

## II. Review of Literature

### *Market efficiency*

Market players often rely on prices in their daily market transactions. In particular, price variations drive them to engage in trade. According to Rashid et al (2010), policymakers should not consider price differences between locations as a problem, but instead, what they should be wary about is the degree of variation—whether there is extreme variability or little or no variability at all (Rashid et al 2010).

Such price difference also creates arbitrage opportunities for traders. Upon reaching a point wherein all opportunities for spatial arbitrage profits have been exploited by spatial traders, then we can describe the markets as efficient. Market efficiency, as defined by Rashid et al (2010), is “the degree to which markets minimize costs and match supply with demand” (p.3).

The concept of efficiency has been implicitly incorporated in early analyses of market integration. It was Roll (1979) who was among the first to tackle the effects of having efficient commodity markets on spatial price linkages (Fackler and Goodwin 2001). Two decades after, Buccola (1989) provided a more general approach on price efficiency. He suggested that “efficiency in prices corresponds to the set of prices that result in an optimal (efficient) allocation of resources” (Fackler and Goodwin 2001, p.980). If efficiency exists, all information on demand and supply situations (including transactions costs) should manifest in market prices.

Oftentimes, inefficiency is thought to be caused by the failure of individuals to rationally respond to financial incentives (Fackler and Goodwin 2001). However, other factors may be causing it, such as the magnitude of transactions cost of trade. It is important to note that individuals can barely influence extremely high transactions cost. Some of the possible reasons for high transaction costs cited by Fackler and Goodwin (2001) are the following: 1) *poor contract enforcement*; 2) *inadequate police protection*; 3) *corruption*; 4) *excessively high taxes*; and 5) *inadequate transport and communications infrastructure*.

### *Market integration*

A necessary but not sufficient condition of efficiency is market integration. It has become a subject of numerous empirical studies. Barrett (1996) describes market integration as the condition in which prices, goods, and information move over time, space, and form without restraint. The ideal condition is known as *perfect market integration*, in which prices in two or more markets are moving together instantaneously (Goodwin and Schroeder 1990).

There are different forms of market integration. Whenever price signals are readily transmitted from one marketing channel to another, we say that *vertical integration* exists. On the other hand, if these signals are transmitted between spatially distinct markets, it is called *spatial integration* (Barrett 1996).

In spatial market integration, any shock to prices in one market would immediately be reflected in other markets (Barrett 1996). Rufino (2008) described spatial market integration as a condition wherein the difference between the prices of two geographically separated markets is being kept below the transfer cost by arbitrage activities. Spatial arbitrage happens when a commodity is transferred from a region with lower price to the region with a higher price. Such activity “force[s] prices at different locations to a unique equilibrium” (Goodwin and Schroeder 1990, p.173).

In the literature, the spatial arbitrage conditions are described by the following equations:

$$1. P_t^i + K_t^{ij} = P_t^j$$

$$2. P_t^i + K_t^{ij} > P_t^j$$

Where	$P_t^i$	refers to food price in the exporting market in period $t$
	$K_t^{ij}$	refers to transfer costs in the same period
	$P_t^j$	refers to food price in the importing market in period $t$

According to Baulch (1997), both of the conditions above are consistent with market integration. Whenever the first condition holds, trade occurs. However, when the second condition holds, there is no incentive to trade.

Among the factors causing the lack of spatial integration are, basically, also those that cause market failures, such as: 1) *inadequate provision of public goods (such as infrastructure)*; 2) *inefficient flow of information*; 3) *imperfect competition*; and 4) *incomplete or missing institutions for risk management like credit and insurance* (Rashid et al 2010).

Why is market integration important? Baulch (1997) described the possible outcomes in the absence of spatial market integration. First, areas having food surplus could not readily transfer commodities to food-deficit locations because transmission of price signal will be problematic. Second, prices will be unstable. Third, agricultural producers will find it hard to “specialize according to long-term comparative advantage” (p.477). Lastly, trade gains will not be realized.

Also, Digal et al (2010) explained that market integration helps people benefit from the gains brought about by development interventions, such as those that improve the flow of market information and infrastructure facilities. In addition, integrated markets are cheaper to finance since any intervention imposed on one market would have an effect on other markets. This reduces the redundancy in government interventions. For example, in the context of agricultural price stabilization policies, it may be more appropriate to implement a decentralized stockpiling policies for segmented regions, while centralized stockpiling may work for those integrated regions (Fackler and Goodwin 2001).

Barrett (1996) noted that, in terms of competition, segmented markets are more prone to the emergence of monopolies. However, even though we are able to establish that market integration exists, it is important to note that this does not automatically imply market efficiency. Rashid et al (2010) provides a case wherein markets are integrated but not efficient. Assuming that the transfer costs are twice as high as they can possibly be for one of the following reasons: 1) collusion; 2) regulated transportation rates; or 3) too many checkpoints needed to be paid. Trade is still possible to occur, as well as the co-movement of prices, if the price difference between the two markets is large enough.

In addition, Faminow and Benson (1990) argue that “even if price differences exactly equal transfer costs, one cannot reasonably presume perfect competition, since this is equally consistent with monopolistic limit pricing, with collusive pricing by a spatial oligopoly” (Barrett 1996, p.828).

### ***Approaches***

There are a number of approaches to test for market integration. Barrett (1996) described the hierarchy of market analysis methods as Levels I, II, and III. Level I methods make use of price data only. Apart from price data, Level II methods utilize transaction cost, while Level III methods use trade flow data.

Level I methods have been employed in most of the studies on market integration. These are also referred to as the standard approaches. Among the methods which depend on price data only are correlation-based analysis, Granger causality test, error correction, and economic cointegration.

According to Fackler and Goodwin (2001), several authors have evaluated market integration using correlation analysis such as Jasdanwalla (1966), Gupta (1973), and Ejiga (1977). Mohendru (1973), was the first to use correlation-based tests in market analysis (Fackler and Goodwin 2001). A more empirical analysis was done by Lele (1967), who examined market integration of agricultural commodities in underdeveloped countries. He suggests that there are three likely reasons for observing low correlation between markets. First is the immobility brought about by lack of or poor quality of transport facilities. It hinders the free flow of goods between regions. Another reason is the lack of scientific grading to ascertain homogeneity among commodities. Wide price differences, which are really caused by the heterogeneity of commodities, are often blamed on the presence of “speculative elements in trade”. Ultimately, he considered the poor dissemination of knowledge about current market situations as a reason for possibly low correlation between markets. The results of his study showed strong integration between Indian grain markets.

However, the use of correlation coefficients in market integration testing has been widely criticized. Barrett (1996) and Harriss (1979) have identified a number of inferential problems in this approach. Harriss (1979) believes that the correlation of price data is spurious and may incorrectly describe spatial market integration (Fackler and Goodwin 2001). Barrett (1996) cites three causes of a spurious regression: 1) *common exogenous trends*; 2) *common periodicity*; and 3) *autocorrelation*.

Another approach that depends on the analysis of the co-movement of prices is the estimation of the Ravallion's error correction model (1986). This standard approach follows a radial structure, "which assumes price shocks originate from one central market whose prices are weakly exogenous from those of other markets" (Barrett 1996, p.826). In addition, transfer costs are assumed to be constant.

Among other Level II methods is the Parity Bounds Model (PBM) by Baulch (1997). In this model, transaction cost data are being used to "estimate the probability of attaining inter-market arbitrage conditions" (Barrett 1996, p.827). Transportation, loading and unloading costs, and the trader's normal profit are among the factors in determining the size of the transfer cost. Baulch (1997) discussed in his paper the three possible scenarios between transfer costs and the price spread (i.e. difference in prices between two regions). First, when the transfer cost and spread are equal, trade between two markets is unrestricted and the spatial arbitrage conditions hold. The second case is when the transfer cost exceeds the spread. Under this case, trade is impossible to occur and the spatial arbitrage conditions do not hold. The third case, as described by Baulch (1997), is when the spread exceeds transfer cost. Even if trade occurs, spatial arbitrage conditions are violated. Its violation implies the existence of trade barriers between markets, thus the absence of market integration.

### ***Related empirical studies***

Market integration analysis techniques have been applied to real-world market setting, mostly in developing countries. Rufino (2008) provides a succinct review of studies related to spatial market integration of various commodities (e.g. rice and corn) in different countries including the Philippines.

Bulk of Rufino's literature review focused on rice market integration. Among the studies with Philippine setting is that of Baulch (1997). Baulch (1997) applied the PBM to assess the degree of integration of wholesale rice markets in six selected regions of the country. Northern Luzon and Central Luzon represent the rice-surplus regions, while the National Capital Region Central Visayas represent the rice-deficit regions. In addition, Western Mindanao is included because of its ability to be rice self-sufficient even though it is quite isolated. Using the Bureau of Agricultural Statistics (BAS) monthly wholesale price for special-grade rice for the period 1980 to 1993 and the transportation cost (i.e. shipping and freight costs) estimates gathered from interviews, Baulch (1997) implemented the maximum likelihood estimation of the PBM. The results show that the rice markets in the country are well integrated.

Rufino (2008) was also able to establish market integration in the wholesale rice markets in the country. Using cointegration and other econometric techniques, he was able to find that most of the pairwise combination of the 16 regions in the country are well integrated. Only few pairs were found to be segregated.

Analyses of rice market integration were also conducted in other countries—e.g. Indonesia, Vietnam, China, and India.



Applying improvements on the Ravallion's model, Alexander and Wyeth (1994) examined integration of the Indonesian rice market. Their model is an error correction version of the standard Ravallion model. They employed the Augmented Dickey Fuller procedure to establish cointegration in all the pairwise combinations of the seven rice-producing provinces. They found that only Surabaya to Ujung Pandaj failed the cointegration test.

The study of rice market of Vietnam by Goleti et al (1996) adopted correlation-based analysis. Based on their analysis, they discovered that for years 1986 to 1990, market integration was stronger than the subsequent period 1991 to 1995. They attributed the segregated nature of some of the market pairs in Vietnam to the poor infrastructure quality in those areas.

In China, commodities such as rice and corn were also among the usual subjects of market integration analysis. Rozelle et al. (1997) assessed integration of rice and corn markets in China. Apart from traditional statistical methods, they adopted the Parity Bounds Model originally introduced by Sexton, Kling, and Carman (1991). This helped in confirming that rice and corn markets are indeed integrated. In addition, Laping (2001) analyzed rice, corn, and pork markets using different tools to test short- and long-run market integration. The results of his study support the existence of market integration in the long-run.

In India, Jha et al (2005) find that the 55 wholesale rice markets are not fully integrated due to excessive interference in the markets. They adopted the Gonzalez-Rivera-and-Helfand (GRH) approach and utilized monthly data for the period 1970 to 1999.

A study by Nga and Lantican (2009) was an analysis of the spatial integration of rice markets in Vietnam using monthly retail price data which covered the period 1998 to 2005. They analyzed the extent, pattern, and degree of integration through various cointegration tests. Accordingly, they found that only 9 out of 34 rice markets are integrated into a common rice market.

Apart from rice, market integration analyses for other commodities such as for livestock have also been done. For instance, Goodwin and Schroeder's (1990) study focused on testing the concept of the Law of One Price in cattle markets in the United States (US). They have used the Generalized Method of Moments (GMM) procedure which addresses inferential issues such as simultaneity and serial correlation.

A more rigorous testing was done by Fafchamps and Gavian (1996) to assess whether Niger livestock markets are integrated. They have applied tests for cointegration and Granger causality, and estimated Ravallion's model and PBM. All of these resulted in defining Niger livestock markets as related but not closely integrated.

Other spatial analysis studies for various agricultural commodities are summarized by Fackler and Goodwin (2001). They were able to juxtapose the authors, date of publication, location, product and method of analysis in a table.

Apart from spatial market integration, other researches also delved into vertical market integration. In the Philippines, Digal et al (2010) made a spatial and vertical market integration analysis of selected fruits and vegetables in Mindanao. They described the market layers present in the production of each commodity. Using farm gate, wholesale, and retail prices, they employed cointegration and Ravallion model, and price transmission analysis to examine spatial and vertical integration, respectively. They found varied results; some chains are integrated while some are segmented. Some of their recommendations include the improvement of the infrastructure facilities and market information flow in the segmented areas.

Mangabat et al (2010) performed various techniques for its inter-temporal and vertical integration analysis of the rice markets in the country, and in some selected regions. Covering the period from 2000 to 2008, they used different price data series (farmgate, wholesale, retail, and world) and volume data (imports and NFA distribution). Based on their findings, farmgate to retail prices were strongly correlated, which implied that any price shock to one market stage would instantaneously be transmitted to other stages. The world and domestic prices were also shown to be integrated.

Another vertical market integration study, which focused on the symmetry of rice prices, is that of Reeder (2000). She investigated the magnitude and speed of adjustment of price changes in two levels: 1) farm to wholesale; and 2) wholesale to retail. Using official price data series from the Bureau of Statistical Statistics (BAS) covering the period 1973 to 1996, she estimated the following model:

$$\Delta P_t^i = \alpha + \sum_{i=1}^k \theta_1 POS_{t-i}^j + \sum_{i=1}^k \pi_1 NEG_{t-i}^j \sum_{i=1}^k \psi_1 SEASON_1 ,$$

Where $\Delta P_t^i$	refers to food changes in rice prices at market i, where i includes farm, wholesale, and retail.
$\Delta POS_{t-k}^j$	refers to the positive changes in rice prices in the other market j.
$\Delta NEG_{t-k}^j$	refers to the negative changes in rice prices in the other market j.

There are two sub-periods considered. The first sub-period (1973 to 1985) described the case in which local rice markets are heavily controlled by the government, while the second subperiod (1986 to 1996) represented the time of liberalized rice markets.

The findings suggest that market shocks usually originate from the farm-level, which are then transmitted to wholesale and to retail markets. Farm price changes have weak effects on wholesale prices compared to the effects of wholesale price changes on retail prices.

The symmetry test results indicate that effects of increasing and decreasing farm prices on wholesale prices were not significantly different from each other. The same happens for wholesale to retail prices.

In terms of speed of adjustment, it takes one month for changes in farm prices to have an effect on wholesale prices, while it takes three months for wholesale to retail. These are observed from both of the subperiods considered.

### III. Methodology

#### *Law of One Price*

The Law of One Price (LOP) is based on testing for the co-movement of prices. It is considered as a fundamental principle in commodity arbitrage (Baffes 1991). LOP postulates that there is a price prevailing at all markets for a commodity (Baffes 1991). In terms of international trade models, the price of a commodity in country A must be the same with country B after expressing the prices in common currency and incorporating the transaction costs. LOP is usually used to test if the one-for-one transmission of price changes happens in the short-run.

A modified version of the LOP model, which was introduced by Richardson (1978), is denoted by the following standard bivariate regression equation (Fackler and Goodwin 2001):

$$P_{1t} = \beta_0 + \beta_1 P_{2t} + \epsilon_t \quad (1)$$

where  $P_{it}$  refers to the price in market  $i$ ,  
 $\epsilon_t$  refers to residual errors.

When  $\beta_1 = 1$  and  $\beta_0 = 0$ , we say that the markets are perfectly integrated. In addition, if the model is evaluated in logarithmic form, the coefficients are interpreted as *price transmission elasticities*.

According to Spiller and Huang (1986) as cited in Sexton, Kling, and Carman (1991), there are three likely reasons for failing to adhere to LOP: 1) *regions are not linked by arbitrage*; 2) *presence of impediments to efficient arbitrage*; and 3) *imperfect competition in one or more of the markets*.

#### *Granger causality*

The Granger causality test works within the framework of a vector autoregression model (Fackler and Goodwin 2001). Gupta and Mueller (1982), as cited in Fackler and Goodwin (2001) applied Granger causality in their price adjustment analysis of the hog markets in Germany. They interpreted the causality as an indication of market inefficiency. This was soon refuted by Granger (1988) where he showed that there is Granger causality in at least one direction if a cointegration relationship is established.

Even though Granger causality provides some inference on spatial price linkages, it still has some limitations. Among these are the following: 1) it indicates only whether a price relationship is statistically different from zero; and 2) the limitations of other tests such as regression and correlation-based approaches are also applied here.

#### *Cointegration analysis*

As discussed in earlier section, correlation tests were criticized for a number of inferential problems, which is caused by the lack of a certain time series property

called stationarity. Unit root tests, such as the Augmented Dickey Fuller test, are adopted to test for the stationarity of time series data, which is denoted by  $I(0)$ . Price data series are usually nonstationary or  $I(d)$ . Nonstationarity implies heteroskedasticity, which means that the variance of the error is not constant. Homoskedasticity is one of the basic assumptions in Ordinary Least Squares (OLS) regression. When this condition is violated, the estimators will become inefficient and usual inferences will no longer be valid. To address this issue, one way is to transform the time series through *differencing*. When a nonstationary series is differenced  $d$  times, it is said to be integrated of order  $d$  or  $I(d)$ .

Granger (1981) as cited in Ardeni (1989) noted that it is possible to find a linear combination of a vector of nonstationary time series that has a stationary property. When two time series are integrated of order 1,  $I(1)$ , this means that the expected time for them to cross is infinite and that achieving an equilibrium may virtually never occur. They may need to undergo some transformation before achieving stationarity. On the other hand, for  $I(0)$  time series, there is no need for any transformation.

Cointegration among series may be used to test for long-run equilibrium relationship. Although prices may vary in the short-run, they will move closer to each other or towards a common “equilibrium” value (Ardeni 1989). Since the major assumption in cointegration tests is that transaction costs are stationary, we can say that spatial prices will move close to each other in an efficient market.

One of the most common approach is that of Johansen (1991), which applies maximum likelihood estimation (Stata).

$$\Delta y_t = \alpha \beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \epsilon_t ,$$

where

$y$  is a  $(K \times 1)$  vector of  $I(1)$  variables  
 $\alpha$  and  $\beta$  are  $(K \times r)$  parameter matrices with rank  $r < K$   
 $\Gamma_1, \dots, \Gamma_{p-1}$  are  $(K \times K)$  matrices of parameters  
 $\epsilon_t$  is a  $(K \times 1)$  vector of normally distributed errors

## Data

The data used are time series on monthly dealers’ price of urea fertilizer by region. These were obtained from the Philippine Statistical Authority-Bureau of Agricultural Statistics. This study covered 288 observations spanning from the period 1990 to 2013. According to Rufino (2008), who used a 13-year period time series data, the said period is enough to capture price relationships exhibited by each region pairs even the long-run relationships.

Below is the list of variable names for the regions:

Name of the Region	Code
ILOCOS REGION	R1
CAGAYAN VALLEY	R2
CENTRAL LUZON	R3
CALABARZON	R4
MIMAROPA	R5
BICOL REGION	R6
WESTERN VISAYAS	R7

CENTRAL VISAYAS	R8
EASTERN VISAYAS	R9
ZAMBOANGA PENINSULA	R10
NORTHERN MINDANAO	R11
DAVAO REGION	R12
SOCCKSARGEN	R13
CAR	R14
CARAGA	R15
ARMM	R16

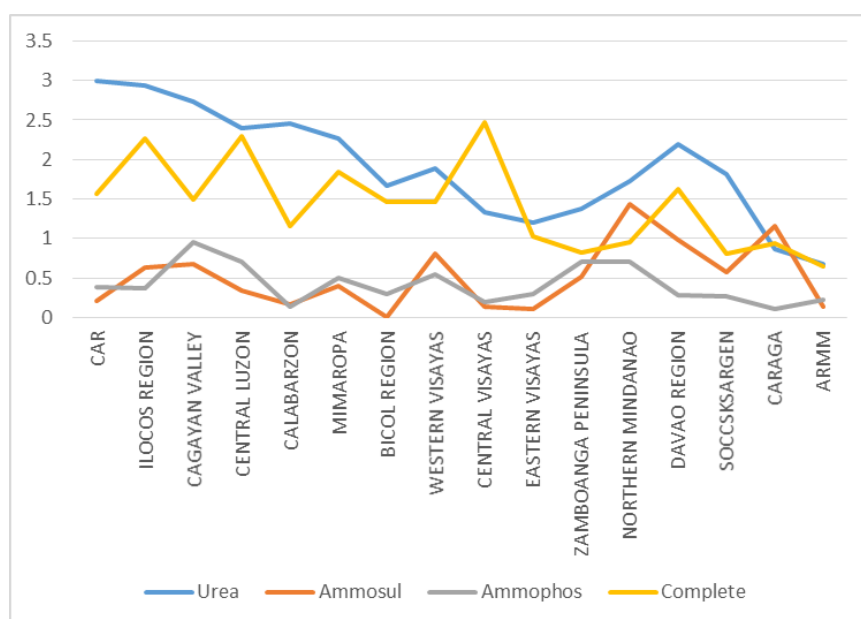
Before implementing the standard approaches in Stata 13, initial data processing and assessment are needed. The price data are transformed into its natural logarithmic form following the assumption that transfer costs are proportional to the price. Then, another procedure was done to ensure that the time series data possess a certain property called stationarity.

Due to time and data constraints, this study only includes the assessment of the spatial integration of fertilizer markets between regions. Integration across the different levels of the fertilizer supply chain are not covered.

#### IV. Empirical Application: Fertilizer market by region

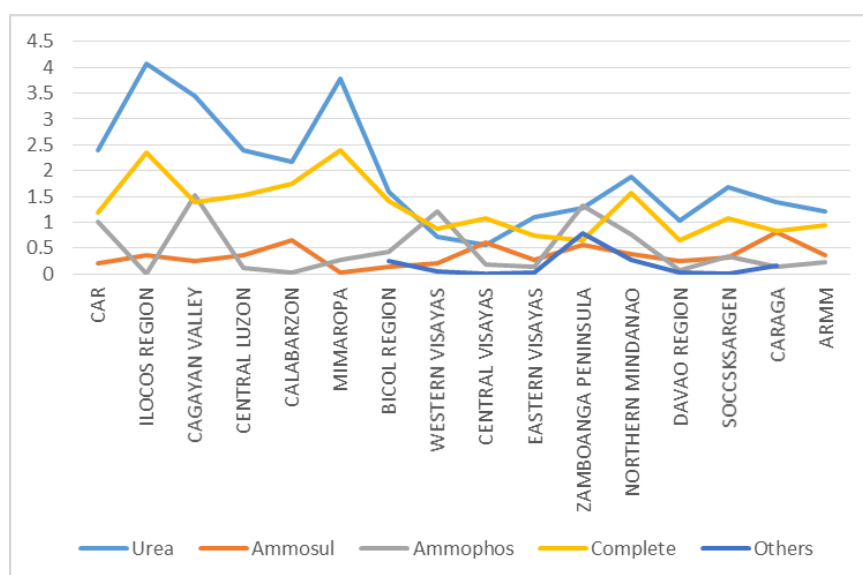
Among the grades of fertilizer, urea is the most used based on average quantity applied across regions. Figure 1 and Figure 2 show the breakdown of fertilizer use by grade and region for palay and corn production, respectively. For instance, in Central Luzon, which is the top regional producer of rice, farmers apply about 3 bags of 50 kg urea fertilizer, about 1.5 bags of 50kg complete, while less than 0.5 bags of 50 kg Ammosul and Ammophos fertilizers.

**Figure 1. Fertilizer use by grade and region for palay, 2013 (bags of 50kg)**



Source: PSA-BAS

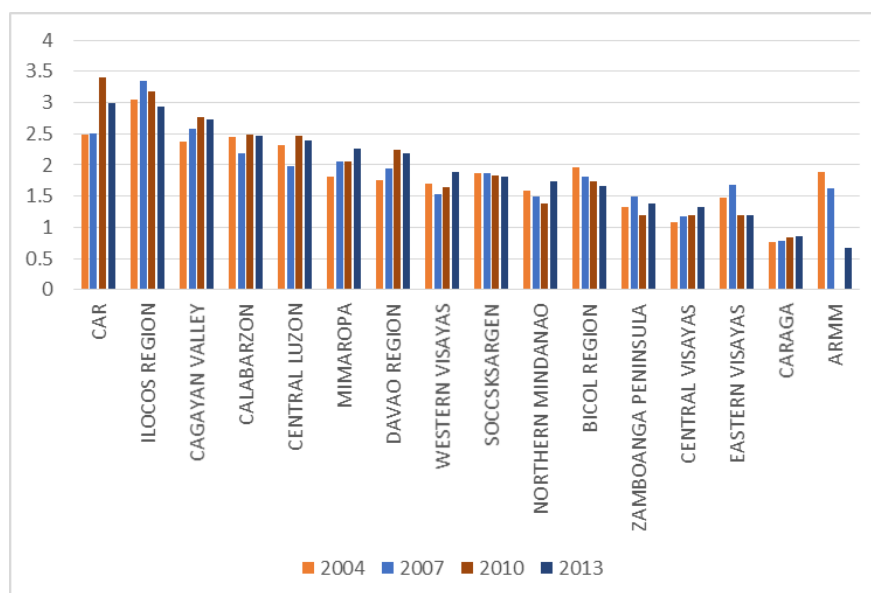
**Figure 2. Fertilizer use by grade and region for corn, 2013(bags of 50kg)**



Source: PSA-BAS

Based on the period 2004 to 2013, the regions that are top users of urea are CAR, Ilocos Region, Cagayan Valley, CALABARZON, Central Luzon, MIMAROPA, and Davao Region. This covers the average use of urea fertilizer for all commodities.

**Figure 3. Urea use by region for selected years (bags of 50kg)**



Source: PSA-BAS

In terms of prices from 2003 to 2013, wide disparities are apparent in the regional dealers' price of urea. The table below shows the top three regions per year wherein prices are above the national average price (in red highlight). Especially in recent years, fertilizer prices in MIMAROPA, EASTERN VISAYAS, and ARMM are more expensive than national average prices.

**Table 1. Price difference with respect to the national average, in percent, from 2003 to 2013**

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ILOCOS REGION	-1.22	-1.21	-1.96	-5.81	-3.90	-0.93	-12.68	-5.24	-0.47	-4.11	-7.12
CAGAYAN VALLEY	0.05	-1.94	-2.46	-6.01	-3.62	-4.40	-13.62	-7.32	-3.43	-6.80	-3.25
CENTRAL LUZON	-0.60	-1.74	-2.64	-4.76	-4.55	-2.08	-11.44	-4.92	-1.57	-4.38	-4.49
CALABARZON	4.15	0.12	1.51	0.28	-0.09	-2.06	2.67	-0.81	-1.36	0.60	6.62
MIMAROPA	3.97	3.90	5.00	2.63	4.09	4.05	4.90	2.69	5.27	5.61	6.74
BICOL REGION	-0.12	-0.15	-0.79	-2.24	2.04	1.39	-0.83	2.56	0.73	1.95	6.00
WESTERN VISAYAS	-2.77	-2.74	-2.91	-3.13	-2.88	-0.85	-10.64	-8.09	-4.18	-6.29	-11.63
CENTRAL VISAYAS	0.65	-0.07	1.79	0.96	0.54	3.36	3.13	0.15	-0.62	1.53	2.28
EASTERN VISAYAS	4.57	2.69	4.18	7.85	6.56	1.78	14.52	9.13	2.68	8.26	18.35
ZAMBOANGA PENINSULA	3.69	4.76	-1.15	0.86	1.31	-0.54	-4.16	-2.58	1.35	2.05	-2.43
NORTHERN MINDANAO	-0.13	2.33	0.08	1.20	1.39	-0.26	-0.16	0.09	1.37	-0.03	-3.72
DAVAO REGION	-1.45	0.28	-1.62	-2.36	-2.83	0.86	-8.28	-7.52	-3.82	-2.85	-7.96
SOCCSKSARGEN	-1.20	-0.55	-2.24	-3.77	-3.37	-3.93	-11.48	-7.28	-4.61	-1.92	-6.56
CAR	-1.88	-1.76	0.96	-0.57	-0.98	0.15	0.68	-1.09	-3.17	-2.99	-1.38
CARAGA	-1.35	0.70	1.71	0.70	-0.92	3.26	-2.49	-5.20	-2.48	-1.24	-6.93
ARMM	-9.68	0.03	-0.16	16.54	7.87	-0.26	56.07	36.92	17.39	12.67	14.11

Source: Author's calculation (basic data from PSA-BAS)

To paint a picture of how well competition is in the fertilizer industry, the data from the Fertilizer and Pesticides Authority (FPA) on the number of licensed handlers helps achieve this aim. As of December 2012, there are 483 licensed handlers of both pesticides and fertilizers which are engaged in various activities (Briones 2014). Some examples of such activities are listed below.

Activity
Area Distributor
Bulk handler
Distributor
Distributor-Area Distributor
Exporter-Importer-Distributor
Formulator-Importer-Repacker-Distributor
Importer-Distributor-Area Distributor
Importer-End-user
Importer-End-user-Distributor
Importer-Formulator-Distributor
Importer-Indenter-Exporter-Distributor
Importer-Processor-Distributor-Exporter
Importer-Repacker-Distributor
Indenter
Manufacturer-Exporter-Distributor
Manufacturer-Importer-Exporter-Distributor
Processor-Importer-Distributor
Repacker
Repacker-Importer-Distributor-Exporter

## V. Discussion of the Results

### *Correlation matrix of prices*

The correlation coefficients are high (see **Table 2**), which ranges from 0.9676 to 0.9985. This may seem to reflect integration of the regional fertilizer markets. However, as discussed earlier, correlation-based tests may give spurious relationships. Thus, further tests are needed to establish the presence of spatial market integration in the fertilizer market.

**Table 2. Correlation matrix**

	logr1	logr2	logr3	logr4	logr5	logr6	logr7	logr8	logr9	logr10	logr11	logr12	logr13	logr14	logr15	logr16
logr1	1															
logr2	0.9982	1														
logr3	0.9985	0.9975	1													
logr4	0.9934	0.9929	0.9961	1												
logr5	0.9946	0.993	0.9971	0.9971	1											
logr6	0.9934	0.9931	0.9958	0.9951	0.9964	1										
logr7	0.9969	0.9971	0.9958	0.9906	0.9917	0.9921	1									
logr8	0.9958	0.9957	0.9961	0.9947	0.9951	0.9957	0.9958	1								
logr9	0.9905	0.9905	0.9931	0.9952	0.9955	0.9966	0.9895	0.995	1							
logr10	0.9968	0.9968	0.996	0.9923	0.993	0.9941	0.9977	0.9968	0.9923	1						
logr11	0.9898	0.9898	0.9888	0.9854	0.9861	0.9874	0.9904	0.9915	0.9858	0.9914	1					
logr12	0.9968	0.9967	0.9968	0.9928	0.9937	0.9942	0.9979	0.9965	0.9918	0.9982	0.9917	1				
logr13	0.9964	0.9969	0.995	0.99	0.991	0.9922	0.9973	0.9958	0.9895	0.9979	0.9914	0.9981	1			
logr14	0.9921	0.9897	0.9939	0.9939	0.9951	0.9946	0.9889	0.9928	0.9945	0.9908	0.9844	0.9915	0.9884	1		
logr15	0.9954	0.9952	0.9957	0.9928	0.994	0.996	0.9963	0.997	0.993	0.9969	0.991	0.9976	0.9963	0.9924	1	
logr16	0.9707	0.9676	0.9734	0.9782	0.9801	0.9805	0.969	0.9775	0.9868	0.9739	0.97	0.9716	0.9687	0.9832	0.9751	1

### *Unit root test*

Table 3 shows the results of the unit root test. It can be observed that, without transformation, the time series data are nonstationary. However, they are stationary in the first difference. This specifies that the price series data are appropriate for the cointegration test.

**Table 3. Unit root test results before and after transformation**

	natural log		first difference	
	Test Statistic	p-value	Test Statistic	p-value
<b>R1</b>	-1.403	0.5806	-8.033	0.000
<b>R2</b>	-1.391	0.5864	-10.074	0.000
<b>R3</b>	-1.453	0.5565	-8.125	0.000
<b>R4</b>	-1.246	0.6534	-10.079	0.000
<b>R5</b>	-1.216	0.6665	-8.914	0.000
<b>R6</b>	-1.093	0.7178	-9.127	0.000
<b>R7</b>	-1.543	0.5122	-9.382	0.000
<b>R8</b>	-1.145	0.6967	-9.895	0.000
<b>R9</b>	-0.807	0.8172	-8.862	0.000
<b>R10</b>	-1.205	0.6714	-9.261	0.000
<b>R11</b>	-1.712	0.425	-23.72	0.000
<b>R12</b>	-1.462	0.5521	-9.121	0.000
<b>R13</b>	-1.331	0.6148	-10.04	0.000



<b>R14</b>	-1.443	0.5616	-10.418	0.000
<b>R15</b>	-1.23	0.6607	-10.025	0.000
<b>R16</b>	-0.89	0.7914	-13.367	0.000

### *Granger Causality test*

The results of the Granger causality test show that all pairs exhibit at least a unidirectional causality. Moreover, feedback relationships or the two-way direction of causality is observed in fifty-five percent (55%) of the pairwise combinations.

Also, the table below indicates the direction of price transmission and this helps in determining which regions are price leaders and price followers/takers. The results suggest that top rice-producing regions, such as Cagayan Valley, Central Luzon, and Western Visayas, are price leaders in the fertilizer market. On the other hand, regions which do not produce that much rice, like Central Visayas, CALABARZON, Davao, CAR, CARAGA, and ARMM, are price followers.

**Table 4. Granger causality test results**

Y\X	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
<b>R1</b>	↔	→	↔	→	→	↔	↔	↔	↔	→	↔	↔	↔	→	→
<b>R2</b>		↔	→	↔	→	↔	↔	→	↔	→	→	↔	→	→	→
<b>R3</b>			↔	↔	→	↔	↔	↔	↔	↔	↔	↔	→	↔	→
<b>R4</b>				↔	↔	←	↔	↔	←	↔	←	←	↔	↔	→
<b>R5</b>					↔	←	↔	→	←	↔	↔	↔	↔	↔	↔
<b>R6</b>						←	↔	↔	←	↔	←	←	↔	↔	→
<b>R7</b>							→	→	↔	→	→	↔	→	→	→
<b>R8</b>								→	↔	↔	↔	↔	↔	↔	→
<b>R9</b>									←	↔	↔	←	↔	←	↔
<b>R10</b>										←	↔	↔	→	→	→
<b>R11</b>											←	←	↔	↔	↔
<b>R12</b>												↔	←	←	←
<b>R13</b>													→	→	→
<b>R14</b>														↔	↔
<b>R15</b>															↔

→ y Granger causes x  
← x Granger causes y  
↔ feedback

### *Cointegration of prices*

The number of lags per region pair was identified following the Schwarz-Bayesian information criterion (SBIC). This information on lags was then incorporated in running the Johansen tests for cointegration. This test determines the existence of cointegrating equations. As shown in the table in Annex A, there is only one pair which does not have at least one cointegrating equation based on 5 percent level of significance, and that is the pair CALABARZON-CAR.

Part of the cointegration output is the short-run adjustment equations. The table in Annex B shows that the some of the coefficients of  $Y$  in the  $D.X$  equation are significant, while others are not (figures in yellow highlight). This implies that prices in some regions are usually affected by prices in other regions.

The long-run relationships are expressed in the cointegrating equation. The table in Annex C shows the coefficients of the  $X$ 's, which are also referred to as the price transmission elasticity. All coefficients are statistically significant. This set of results is indicative of an integration relationship between the different regional pairs in the long-run.

## **VI. Conclusion**

Fertilizer is an important production input, which holds a significant share in the total cost of production of some crops. The most used grade of fertilizer in the country is urea based on the available regional data on the average quantity applied per region.

Since price changes in fertilizer have direct impact on production costs, it is important to determine the level at which prices differ across regions in the country. Based on the official data, dealers' price of urea vary greatly across the regions. Prices in three regions, namely, MIMAROPA, EASTERN VISAYAS, and ARMM, go above the national average price. Among the three, MIMAROPA is the only one which is also a top urea user.

The wide price disparities, however, cannot be immediately associated with unfair competition practices. To help determine whether or not the variability across the regional domestic markets is alarmingly high, a spatial market integration analysis was done. Although market integration does not automatically imply perfect competition and market efficiency, it could still provide useful information about the market conditions.

The results of the cointegration test and Granger causality tests implemented in this study support the claim that the regional fertilizer markets are integrated. The Granger causality test show that there is at least a unidirectional causality among all pairwise combinations. It also helped in identifying which regions are price leaders and price followers. The cointegration test results suggest that almost all regional market pairs are integrated. Only one pair out of 120 was found to be not integrated (CALABARZON-CAR). Consequently, it was shown that the long-run relationships of the pairwise combinations are all statistically significant.

This study, however, could not confirm the presence of market power in the fertilizer industry given the obtained results. Also, the number of market players in the industry gives the impression that the industry is competitive. It is highly unlikely that one or few dealers of fertilizer have the ability to affect the market price of fertilizer.

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# VIII. Annex A. Vecrank results

		maximum rank	trace statistics	lag
logr1	logr2	1	2.7321	2
logr1	logr3	1	2.7991	2
logr1	logr4	1	1.6308	2
logr1	logr5	1	2.1111	2
logr1	logr6	1	2.1743	2
logr1	logr7	1	3.0894	2
logr1	logr8	1	1.714	2
logr1	logr9	1	0.9104	2
logr1	logr10	1	2.3911	2
logr1	logr11	1	2.4057	2
logr1	logr12	1	2.3286	3
logr1	logr13	1	2.9058	2
logr1	logr14	1	2.2871	2
logr1	logr15	1	2.4948	2
logr1	logr16	1	1.4788	2
logr2	logr3	1	2.7894	2
logr2	logr4	1	2.3172	2
logr2	logr5	1	2.682	2
logr2	logr6	1	2.7031	2
logr2	logr7	1	2.8266	2
logr2	logr8	1	2.0084	2
logr2	logr9	1	1.4569	3
logr2	logr10	1	2.3734	2
logr2	logr11	1	2.376	2
logr2	logr12	1	2.6376	2
logr2	logr13	1	2.7661	2
logr2	logr14	1	2.7214	2
logr2	logr15	1	2.6125	2
logr2	logr16	1	2.2334	2
logr3	logr4	1	1.3635	2
logr3	logr5	1	2.0042	2
logr3	logr6	1	1.7777	2
logr3	logr7	1	3.4555	2
logr3	logr8	1	1.5407	2
logr3	logr9	1	0.5373	2
logr3	logr10	1	2.2238	2
logr3	logr11	1	2.497	2
logr3	logr12	1	2.1307	3
logr3	logr13	1	3.0922	2
logr3	logr14	1	2.4346	2
logr3	logr15	1	2.4346	2
logr3	logr16	1	1.45	2

logr4	logr5	1	2.0921	2
logr4	logr6	1	2.0132	2
logr4	logr7	1	2.3491	2
logr4	logr8	1	1.7985	2
logr4	logr9	1	1.4866	3
logr4	logr10	1	2.0432	2
logr4	logr11	1	1.8646	2
logr4	logr12	1	1.9633	2
logr4	logr13	1	2.3777	2
logr4	logr14	0	14.7889	2
logr4	logr15	1	2.1163	2
logr4	logr16	1	1.8975	2
logr5	logr6	1	2.4296	2
logr5	logr7	1	2.9829	2
logr5	logr8	1	2.0147	2
logr5	logr9	1	1.1343	2
logr5	logr10	1	2.5612	2
logr5	logr11	1	2.212	2
logr5	logr12	1	2.6821	3
logr5	logr13	1	2.7814	2
logr5	logr14	1	2.2221	2
logr5	logr15	1	2.5552	2
logr5	logr16	1	1.9157	2
logr6	logr7	1	3.1151	2
logr6	logr8	1	1.9708	2
logr6	logr9	1	1.159	3
logr6	logr10	1	2.4366	2
logr6	logr11	1	2.2747	2
logr6	logr12	1	2.3509	2
logr6	logr13	1	2.8237	2
logr6	logr14	1	2.2932	2
logr6	logr15	1	2.6156	2
logr6	logr16	1	1.6359	2
logr7	logr8	1	2.2598	2
logr7	logr9	1	1.9426	2
logr7	logr10	1	2.4238	2
logr7	logr11	1	2.7809	2
logr7	logr12	1	3.0963	2
logr7	logr13	1	3.2843	2
logr7	logr14	1	3.1125	2
logr7	logr15	1	2.9049	2
logr7	logr16	1	2.3697	2
logr8	logr9	1	1.6531	2
logr8	logr10	1	2.1025	2
logr8	logr11	1	1.6825	2

logr8	logr12	1	1.6777	2
logr8	logr13	1	2.0857	2
logr8	logr14	1	1.6184	2
logr8	logr15	1	1.7438	2
logr8	logr16	1	1.6635	2
logr9	logr10	1	1.8719	2
logr9	logr11	1	1.5004	2
logr9	logr12	1	0.8591	2
logr9	logr13	1	1.9103	2
logr9	logr14	1	0.5773	2
logr9	logr15	1	1.233	2
logr9	logr16	1	1.2079	2
logr10	logr11	1	2.1666	2
logr10	logr12	1	1.759	2
logr10	logr13	1	2.1781	2
logr10	logr14	1	2.4062	2
logr10	logr15	1	2.2916	2
logr10	logr16	1	2.0708	2
logr11	logr12	1	2.8048	2
logr11	logr13	1	2.6491	2
logr11	logr14	1	2.2406	2
logr11	logr15	1	2.4156	2
logr11	logr16	1	1.8351	2
logr12	logr13	1	2.925	2
logr12	logr14	1	2.947	2
logr12	logr15	1	2.4936	2
logr12	logr16	1	2.1931	2
logr13	logr14	1	2.9119	2
logr13	logr15	1	2.6998	2
logr13	logr16	1	2.3155	2
logr14	logr15	1	2.6978	2
logr14	logr16	1	2.0981	2
logr15	logr16	1	2.1571	2

IX. Annex B. Effect of regional prices in column Y on regional prices in row X

YX	logr1	logr2	logr3	logr4	logr5	logr6	logr7	logr8	logr9	logr10	logr11	logr12	logr13	logr14	logr15	logr16
logr1		0.4546	0.5060	0.3881	0.4582	0.3523	0.2854	0.3277	0.3792	0.3073	0.5564	0.4418	0.3935	0.5883	0.3777	0.2903
logr2	0.1603		<b>0.1340</b>	0.3160	0.3798	0.2557	0.1752	0.3075	0.2767	0.2690	0.4852	0.2014	0.2895	0.4300	0.3450	0.1549
logr3	<b>0.0860</b>	0.4049		0.5133	0.4439	0.4861	0.2740	0.4257	0.4682	0.2443	0.7562	0.4841	0.4081	0.6838	0.6110	0.2812
logr4	<b>-0.0909</b>	<b>-0.0240</b>	-0.1462		0.2476	<b>0.1526</b>	<b>-0.1001</b>	0.2312	0.4475	<b>-0.0037</b>	0.7840	<b>-0.0255</b>	<b>-0.1209</b>	0.2320	0.2209	0.2038
logr5	<b>0.0527</b>	0.2090	0.2071	0.3391		0.4115	<b>0.0820</b>	0.3637	0.4952	0.1858	0.9510	0.5194	0.2412	0.5263	0.4719	0.3056
logr6	<b>-0.0091</b>	<b>-0.0074</b>	<b>-0.0926</b>	0.3040	0.2926		<b>-0.0952</b>	0.2044	0.4876	<b>0.0008</b>	0.8376	<b>-0.0742</b>	<b>-0.0381</b>	0.3380	0.2772	0.2275
logr7	0.2512	0.3665	0.3181	0.3394	0.4531	0.3455		0.3544	0.3953	0.3203	0.3781	0.3962	0.3481	0.4312	0.3969	0.1581
logr8	<b>0.0517</b>	<b>0.1696</b>	<b>0.1070</b>	0.3092	0.2440	0.2546	<b>0.0993</b>		0.3693	0.1597	0.5094	0.1653	0.1879	0.2850	0.2687	0.2196
logr9	<b>-0.0772</b>	<b>-0.1354</b>	<b>-0.0361</b>	<b>0.1790</b>	<b>0.0051</b>	<b>0.0821</b>	<b>-0.1341</b>	<b>0.0657</b>		<b>0.0031</b>	0.7809	<b>-0.1328</b>	<b>-0.0237</b>	<b>0.1154</b>	<b>0.0683</b>	0.3375
logr10	0.3248	0.2946	0.2744	0.4078	0.4829	0.3467	0.3005	0.3668	0.3868		0.5765	0.2589	0.4669	0.4448	0.3198	0.2331
logr11	<b>-0.0365</b>	<b>0.0010</b>	<b>-0.0236</b>	<b>-0.0051</b>	<b>-0.0002</b>	<b>-0.0368</b>	<b>-0.0074</b>	-0.0881	<b>0.0367</b>	<b>-0.0432</b>		<b>-0.0503</b>	<b>-0.0364</b>	<b>-0.0079</b>	<b>-0.0391</b>	<b>-0.0119</b>
logr12	0.1588	<b>0.1179</b>	0.1518	0.3587	0.3172	0.3621	<b>0.1140</b>	0.2957	0.4396	0.3185	0.5137		0.3557	0.3551	0.5400	0.2079
logr13	0.1291	<b>0.1700</b>	<b>0.1197</b>	0.3120	0.3651	0.2156	0.2587	0.3047	0.3765	0.2841	0.3845	0.2655		0.2587	0.3786	0.2091
logr14	-0.1975	<b>-0.0430</b>	<b>-0.0906</b>	0.3579	0.3434	0.2176	<b>0.0051</b>	0.2820	0.4678	0.1343	0.7339	<b>0.0734</b>	<b>0.0244</b>		0.3827	0.2512
logr15	<b>0.0053</b>	<b>0.0886</b>	<b>-0.0195</b>	0.2569	0.1923	0.3249	<b>-0.0646</b>	0.2886	0.3535	<b>0.0631</b>	0.5931	<b>-0.1020</b>	<b>-0.0317</b>	0.2214		<b>0.1077</b>
logr16	<b>-0.0014</b>	<b>0.0841</b>	<b>-0.0160</b>	0.1126	0.1772	<b>0.0788</b>	<b>0.0223</b>	<b>0.0567</b>	0.1218	<b>0.0211</b>	0.6532	<b>0.1140</b>	<b>0.0472</b>	0.1501	0.1540	



**X. Annex C. Long-run relationships**

Y	X	Transmission elasticity from X to Y (%)	p-value
logr1	logr2	1.0094	0.0000
logr1	logr3	1.0156	0.0000
logr1	logr4	0.9802	0.0000
logr1	logr5	1.0101	0.0000
logr1	logr6	1.0266	0.0000
logr1	logr7	0.9719	0.0000
logr1	logr8	0.9514	0.0000
logr1	logr9	0.9914	0.0000
logr1	logr10	0.9711	0.0000
logr1	logr11	0.9478	0.0000
logr1	logr12	0.9619	0.0000
logr1	logr13	0.9806	0.0000
logr1	logr14	1.0642	0.0000
logr1	logr15	0.9988	0.0000
logr1	logr16	0.8700	0.0000
logr2	logr3	1.0075	0.0000
logr2	logr4	0.9715	0.0000
logr2	logr5	1.0013	0.0000
logr2	logr6	1.0196	0.0000
logr2	logr7	0.9638	0.0000
logr2	logr8	0.9419	0.0000
logr2	logr9	0.9808	0.0000
logr2	logr10	0.9633	0.0000
logr2	logr11	0.9395	0.0000
logr2	logr12	0.9545	0.0000
logr2	logr13	0.9716	0.0000
logr2	logr14	1.0624	0.0000
logr2	logr15	0.9904	0.0000
logr2	logr16	0.8672	0.0000
logr3	logr4	0.9662	0.0000
logr3	logr5	0.9986	0.0000
logr3	logr6	1.0099	0.0000
logr3	logr7	0.9540	0.0000
logr3	logr8	0.9354	0.0000
logr3	logr9	0.9756	0.0000
logr3	logr10	0.9552	0.0000
logr3	logr11	0.9328	0.0000
logr3	logr12	0.9486	0.0000
logr3	logr13	0.9636	0.0000

logr3	logr14	1.0436	0.0000
logr3	logr15	0.9804	0.0000
logr3	logr16	0.8587	0.0000
logr4	logr5	1.0352	0.0000
logr4	logr6	1.0513	0.0000
logr4	logr7	0.9949	0.0000
logr4	logr8	0.9683	0.0000
logr4	logr9	1.0132	0.0000
logr4	logr10	0.9947	0.0000
logr4	logr11	0.9662	0.0000
logr4	logr12	0.9882	0.0000
logr4	logr13	1.0028	0.0000
logr4	logr14	1.1098	0.0000
logr4	logr15	1.0248	0.0000
logr4	logr16	0.9001	0.0000
logr5	logr6	1.0139	0.0000
logr5	logr7	0.9710	0.0000
logr5	logr8	0.9340	0.0000
logr5	logr9	0.9756	0.0000
logr5	logr10	0.9624	0.0000
logr5	logr11	0.9333	0.0000
logr5	logr12	0.9487	0.0000
logr5	logr13	0.9752	0.0000
logr5	logr14	1.0653	0.0000
logr5	logr15	0.9886	0.0000
logr5	logr16	0.8639	0.0000
logr6	logr7	0.9464	0.0000
logr6	logr8	0.9220	0.0000
logr6	logr9	0.9691	0.0000
logr6	logr10	0.9459	0.0000
logr6	logr11	0.9196	0.0000
logr6	logr12	0.9396	0.0000
logr6	logr13	0.9529	0.0000
logr6	logr14	1.0451	0.0000
logr6	logr15	0.9755	0.0000
logr6	logr16	0.8587	0.0000
logr7	logr8	0.9775	0.0000
logr7	logr9	1.0113	0.0000
logr7	logr10	0.9986	0.0000
logr7	logr11	0.9768	0.0000
logr7	logr12	0.9923	0.0000
logr7	logr13	1.0094	0.0000
logr7	logr14	1.0990	0.0000

logr7	logr15	1.0290	0.0000
logr7	logr16	0.9026	0.0000
logr8	logr9	1.0488	0.0000
logr8	logr10	1.0248	0.0000
logr8	logr11	0.9920	0.0000
logr8	logr12	1.0123	0.0000
logr8	logr13	1.0327	0.0000
logr8	logr14	1.1351	0.0000
logr8	logr15	1.0515	0.0000
logr8	logr16	0.9322	0.0000
logr9	logr10	0.9796	0.0000
logr9	logr11	0.9478	0.0000
logr9	logr12	0.9819	0.0000
logr9	logr13	0.9919	0.0000
logr9	logr14	1.0929	0.0000
logr9	logr15	1.0152	0.0000
logr9	logr16	0.8880	0.0000
logr10	logr11	0.9718	0.0000
logr10	logr12	0.9890	0.0000
logr10	logr13	1.0106	0.0000
logr10	logr14	1.1048	0.0000
logr10	logr15	1.0262	0.0000
logr10	logr16	0.9025	0.0000
logr11	logr12	1.0145	0.0000
logr11	logr13	1.0340	0.0000
logr11	logr14	1.1296	0.0000
logr11	logr15	1.0547	0.0000
logr11	logr16	0.9373	0.0000
logr12	logr13	1.0167	0.0000
logr12	logr14	1.1036	0.0000
logr12	logr15	1.0374	0.0000
logr12	logr16	0.9054	0.0000
logr13	logr14	1.0913	0.0000
logr13	logr15	1.0191	0.0000
logr13	logr16	0.8909	0.0000
logr14	logr15	0.9321	0.0000
logr14	logr16	0.8274	0.0000
logr15	logr16	0.8834	0.0000