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SPATIAL MARKET INTEGRATION AND PRICE TRANSMISSION OF SELECTED PLANTAIN MARKETS IN GHANA

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Abstract

Spatial price analysis is important in explaining market performance and the degree of integration. This study therefore provides an econometric analysis of plantain markets integration. Using co integration analyses and vector error correction modelling, wholesale prices from three markets were used to test the degree of spatial market integration. The Johansen's co integration test indicated at least three co integrating vectors implying that the plantain markets during the study period were linked together. The result of the VECM reveals that if a shock is applied to Techiman market, 47% of it will be eliminated in the next period, this result suggest a moderate speed of price adjustment between the Techiman market and the other markets analysed given the perfect adjustment threshold of 100%.

Keywords: market integration, Johansen's multiple co integration, plantain, Vector Error Correction model, spatial price analysis

INTRODUCTION

The geographical separation of agricultural markets and the extent of spatial market integration have become very pertinent to policy makers in Ghana. Fundamentally, spatial market integration contributes to efficiency of the markets. Ghafoor, Mustafa, Mushtaq and Abedulla (2009) defined spatial market integration as co-movement or the long-run relationship among prices and thus, the smooth transmission of price signals and information across spatially separated markets. Prices in spatially integrated markets are determined simultaneously in various locations, and information of any change in price in one market is transmitted to the other markets (Gonzalez-River & Helfand, 2001). Faminow and Benson (1990) stated that spatial market integration of agricultural markets has been used as an indirect measure of market efficiency. Spatial markets are of special importance in agriculture, as often, agricultural products are bulky and/ or perishable, and the place of consumption may be different from that of production, implying possibly expensive transport costs (Sexton, Cling & Carmon, 1991). Apart from the role market integration play in the optimization of resource use, output management, increase in farm incomes, widening of markets, growth of agro-based industries, addition to national income through value addition, and employment creation, it ensures that accurate price signals are communicated to both consumers and producers for efficient product movement in addition to competitiveness, effective arbitrage and the efficiency of pricing. Lohano, Mari and Memon (2005) pointed out that market integration of agricultural products has retained importance in developing

countries due to its potential application to policy-making. They noted that information on the extent of market integration can be used by government to formulate policies that will prevent exploitation of the markets.

Plantain (*Musa paradisiaca*) is one of the major food staples cultivated in the whole of the tropical regions and play a vital role in the economy of most developing countries. In terms of gross amount of production, plantain is the world's fourth most important food crop after rice, wheat and corn and is a basic food product and goods of export (Nkendah & Nzouessin, 2006). In addition, the crop contribute to the food security of a million people in much of the developing world, and when they are sold on the local markets, constitute a source of employment and income for the local populations (Food and Agriculture Organisation[FAO], 2006). In Africa, eight countries are noted among the top ten producers in the world. In fact, Ghana happens to be the third producer in the world, the second in Africa and largest producer in West Africa by producing about 2,930,000 metric tonnes (Food and Agriculture Organisation Statistics Databases [FAOSTAT], 2007). The crop contributes about 13.1% to the Agricultural Gross Domestic Product and six out of the ten regions in Ghana are noted as the producing centres. Recently, it has become an important export commodity in the international market (Institute of Statistical, Social and Economic Research [ISSER], 2007) and thus, contributing to the foreign exchange earnings of the country.

Previous studies analysing spatial market integration in Ghana focused on the maize markets. These studies include (Alderman, 1992; Badiane & Shively, 1998; Abudulai, 2000). However, very little research has been undertaken to examine spatial market integration of other agricultural commodities such as plantain. A single study of spatial plantain market integration using Accra as the central market was conducted by Mensah –Bonsu, Agyei-Afrane and Kuwornu (2011). In other to broaden the scope of research studies and deepen understanding on the spatial plantain markets taking into consideration the importance of the commodity to food security, this study seeks to analyse spatial market integration and price transmission in selected plantain markets. The specific objectives are 1) investigate the order of integration of the wholesale prices 2) determine the extent of co integration between the prices and 3) analyse the price transmission process using the Vector Error Correction Model. The rest of the paper is organised as follows: materials and methods, results and discussion and conclusion.

MATERIALS AND METHODS

This section introduces the data used in the study, presents the Augmented Dickey-Fuller and Philip-Perron tests, the Johansen's multiple co integration test and the vector error correction model.

Data

The study employed weekly nominal prices per 7kg of plantain constituting 80 observations from August 2008 to February 2010. The price data were obtained from the Statistics, Research and Information Directorate of the Ministry of Food and Agriculture. Three markets; namely, Accra, Kumasi and Techiman were selected for the study. This was based on the availability of data, geographical location of markets and levels of production of the produce.

Stationarity

A stationary time series is a type of series whose statistical properties such as mean, variance and autocorrelation are all constant over time and non stationary time series as having time dependent statistical properties (Gopal, Raveendaran, & Rajan, 2009). In effect, a stationary series has a finite variance, transitory innovations from the mean and a tendency for the series to return to its mean value.

In analysing any time series data, testing for stationarity is a precondition since econometric relation between the time series has the presence of trend components (Davidson & Mackinnon, 1993). This involves testing for stationarity using tests such as Dicky-Fuller (DF) test, Augmented Dicky-Fuller (ADF) test (Dicky & Fuller, 1979, 1982) and the Philips- Perron (PP) test (Perron, 1988). If one identifies the series to be non stationary, the first difference of the series is tested for stationarity to determine the order of integration. The number of times (d) a series is differenced to make it stationary is termed as the order of integration, I (d). In this study, the ADF test was used to determine the data properties due to its common application in the time series literature. The ADF test as mentioned considers the null hypothesis that a given series is non stationary. The test is applied by running a regression of the following form:

$$\Delta Y_t = B\beta_t + \gamma Y_{t-1} + \alpha_t \sum \Delta Y_{t-1} + \varepsilon_t$$

If the coefficient "γ" is not statistically different from zero, then the series has a unit root and therefore is non-stationary. The plantain price series were tested for stationarity as in the equation above where Y_i denote price series of the plantain markets and i= 1, 2 ..., 3 (1-Techiman; 2-Kumasi; 3-Accra). After establishing the data properties as non stationary, we then proceeded to specify the Johansen's co integration to determine whether the system of equations is co integrated.

Johansen's Multiple Cointegration

If a linear combination of two non-stationary series is stationary, then the two series are considered to be co integrated (Gopal et al., 2009). The ADF test which is a test for stationarity is supplemented by Johansen-Julius Maximum likelihood method. This method is preferred to the others because it addresses endogeneity and simultaneity problems associated with other bivariate models as well as its ability to test more than two variables at a time. Here, a hypothesis of the presence of co integration vector is imposed on a group of stationary series, as the hypothesis of reduced rank of the long run impact matrix. Likelihood ratio and maximum likelihood tests are applied to derive test statistic for the hypothesis of a given number of co integration vectors and their weights. The specific linear combinations to be tested are the residuals from a static co integrating regression as $Y_{ti} = \beta_i + \beta_i X_{ti} + Z_{ti}$

Where Y_{ti} and X_{ti} (i=1, 2... 3) are price series in levels and Z_{ti} is the residual term. Testing for cointegration implies testing stationarity of the residual term Z_{ti}. The dependent variables Y_{ti} (i= 1, 2, 3) are prices of different plantain

markets and the independent variables X_{ti}(i=1, 2, 3) are prices of other plantain markets. For instance, the cointegration equation for Techiman plantain market with the other three plantain market prices is represented as:

$$TMAN = \beta_1 + \beta_2 KSI + \beta_3 Accra + \varepsilon_t$$

Thus, with Techiman market as the dependent variable and the other markets, independent, the Johansen's multiple co integration test was run in the form of the equation above.

Vector Error correction Model

An Error Correction Model (ECM) is an efficient way of combining the long run co integrating relationship between the levels variables and the short run relationship between the first differences of the variables. It has the merit that all the variables in the estimated equation are stationary; thus there is no problem of spurious correlation. The procedure of differencing results in the loss of valuable long run information in the data and so an error correction term is introduced in the theory of co integration to integrate the short run dynamics of the series with its long run value. The residuals obtained from the equation are introduced as explanatory variables into the system of variables in levels. The error correction term thus captures the adjustment towards long –run equilibrium.

Engle and Granger (1987) demonstrated that once a number of variables are found to be co integrated, then there existed a corresponding error correction representation which implied that changes in the dependent variables are a function of the level of disequilibrium in the co integrating relationship as well as changes in other variables. The importance of including a constant term without a trend has been addressed by Dicky and Fuller (1979) and Miller and Russek (1990). Based on their suggestions, ADF equations are estimated with an intercept and no time trend.

If the price series are I (1), then a linear combination will result in co integration and if there is the existence of co integration between the variables, it is not sufficient to estimate relationship between the two variables using the standard regression model. But it is important to incorporate the long run equilibrium relationship between them in their regression relationship subsequently; an error correction model is specified to relate the changes in the dependent variable to the independent variable as well as the error correction term where the error correction term measures the deviation from the long run equilibrium. A generalized error correction model formulation to understand both the short run and long run behaviour of prices can be considered by first taking the Autoregressive Distributed Lag (ADL) equation as:

$$Y_t = \alpha_{01} X_t + \alpha_{11} X_{t-1} + \alpha_{12} Y_{t-1} + \varepsilon_t$$

The above equation can be re written after adding and deleting Y_{t-1}, $\alpha_{11} X_{t-1}$ in ECM as follows:

$$\Delta Y_t = \alpha_{01} \Delta X_t + (1 - \alpha_{12}) \left[\frac{\alpha_{01} + \alpha_{11}}{1 - \alpha_{12}} X_{t-1} - Y_{t-1} \right] + \varepsilon_t$$

The generalized form of the equation for k lags and an intercept term is as follows:

$$\Delta Y_t = a_{00} + \sum_{i=0}^{k-1} a_{1i} \Delta X_{t-i} + \sum_{i=1}^{k-1} a_{2i} \Delta Y_{t-i} + m_0 (m_1 X_{t-k} - Y_{t-k}) + e_t$$

Where,

$$m_0 = \left(1 - \sum_{i=1}^{k} a_{2i}\right), \text{ and } m_1 = \sum_{i=0}^{k} a_{1i}$$

If all the variables are integrated of the order1 (I (1)), then they are stationary in the first difference. Therefore all the summations in the equation above are also stationary. In addition, if the variables are co integrated, the ECM term (linear combination of the variables represented in parenthesis) will also be stationary. The a_{ij} coefficients represent the short run effects and m_j coefficients represent the stationary long run impacts of the right hand side variables. The parameter m_0 measures the rate of adjustment of the short run deviations towards the long run equilibrium. This value theoretically lies between 0 and 1. Zero signifies no adjustments and 1 indicates an instantaneous adjustment. A value between 0 and 1 indicates that any deviations will have gradual adjustment to the long run equilibrium values.

Thus, the VECM is used to distinguish short term from long term association of variables included in the model. The long term causal relationship among the plantain markets will be implied through the significance of the "p" values of the lagged error correction term as it contains the long term information because it was derived from the long term relationship. The coefficient of the lagged error correction term is a short term adjustment coefficient and represents the proportion by which the plantain markets adjust in response to the long run disequilibrium. The number of lags to be incorporated in the model before estimating the ECM will be determined using Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC).The co integration only considers the long-run property of the model, and does not deal with the short-run dynamics explicitly. However, a good time series modelling should describe both short-run dynamics and the long-run equilibrium simultaneously. For this purpose, a Vector Error Correction Model (VECM) is specified.

RESULTS AND DISCUSSION

Market integration depicts that there is smooth transmission of prices from one market to the other. Integration of market has been used as an excellent marker of an efficient marketing system. The Johansen's multiple cointegration was used to analyse the integration of the plantain markets. The cointegration analyses begin with the assumption that if two time series variables could be co integrated, they should be of the same order of integration. To have the same order of integration, these variables should be stationary when they are differenced the same number of times. Thus, the test of cointegration begins with the test of stationarity at different differenced levels. The Augmented Dicky Fuller test was used for this purpose. The equations were estimated with intercept for each price series. The ADF test result is presented in Table 1. The Table indicates the results of the unit root tests of the price series both at levels and first difference. This was conducted to determine if the price series were integrated of order one I(1)

or otherwise. The model indicates that the null cannot be rejected for all the price series as the absolute value of the ADF statistics are well below the 95% critical value of the statistics.

Table 1: Result of Unit Root Test (ADF based) for selected plantain markets in Ghana

Variable	Level	First Difference	Critical Values
Techiman	-2.246874	-6.5771	-4.0887
Accra	-2.7656	-6.4534	-4.0784
Kumasi	-2.129614	-6.4178	-4.0817

Source: authors construct

The null hypothesis of non stationarity was tested based on the critical values reported by Mackinnon (1990). The results revealed that all the price series are non stationary and integrated of order one at the 0.05 alpha level. Having confirmed that the price series were stationary in their first difference, co integration among the selected markets was performed using the Johansen's multiple co integration method. Results of the Johansen's test are presented in Table 2. The result reveals that the selected markets are co integrated. Thus, there is a long run relationship among the plantain prices in Techiman, Accra and Kumasi. This suggests that the markets may be efficient since market integration has been used as a measure of market efficiency.

Table 2: Result of Johansen's Multiple Co integration Test

Plantain markets	Eigen value	Trace statistics	5 Percent Critical value	Hypothesized No. of CE (S)	Co integrating equations
Accra	0.2511	42.375	29.798	None*	
Kumasi	0.186	20.11	15.495	At most 1*	3
Techiman	0.053	4.227	3.84	At most 2*	

Source: authors construct

The trace test indicates three co integration equations at the 0.05 alpha level. Upon establishing that the markets were co integrated, the vector error correction model was applied to study the transmission among the markets. This was to analyse the short run dynamics of the effect of plantain prices in Techiman after establishing that co integration exist among the markets since according to Gujarati (2004), if two variables X and Y are co integrated, then the relationship between the two can be expressed using the error correction mechanism. The result of the VECM is presented in Table 3.

Table 3: Result from Vector Error Correction Model for the selected plantain markets

Variable	D (Techiman)	D (Accra)	D (Kumasi)
ECM	-0.4728**	0.0653	-0.06975
	(0.0997)	(0.1688)	(0.0502)
	[0.000]	[0.699]	[0.165]
Techiman (-1)	-0.0269	0.0846	0.0709
	(0.1149)	(0.1947)	(0.0578)
	[0.815]	[0.664]	[0.221]
Techiman (-2)	-0.0974	0.1578	-0.0269
	(0.1073)	(0.1817)	(0.0540)
	[0.364]	[0.385]	[0.617]
Accra (-1)	-0.0816	0.0238	0.0109
	(0.0714)	(0.1209)	(0.0359)
	[0.253]	[0.844]	[0.779]
Accra (-2)	-0.1225**	-0.1073	-0.0038
	(0.0704)	(0.1192)	(0.0354)
	[0.082]	[0.368]	[0.915]
Kumasi (-1)	-0.0519	-1.0589**	-0.4748**
	(0.2313)	(0.3919)	(0.1165)
	[0.822]	[0.007]	[0.000]
Kumasi (-2)	-0.1369	-0.7642**	-0.3456**
	(0.2365)	(0.4005)	(0.1190)
	[0.563]	[0.056]	[0.004]
Constant	-0.0059	0.0460	-0.0061
	(0.0669)	(0.1134)	-0.0337
	[0.920]	[0.697]	[0.901]
R-squared	0.31	0.15	0.25
Adj. R-squared	0.24	0.07	0.17
F-statistics	4.5	1.8	3.3
Log likelihood	-63	-104	-11
AIC	1.87	2.92	0.49
BIC	2.11	3.16	0.74

Standard errors in () & P values in [], P≥0.05 Source: Authors construct

When Techiman is the dependent variable, a greater percentage (31%) of its prices is explained by the current and previous prices in Accra and Kumasi as well as its previous prices as opposed to Accra or Kumasi as the dependent variable. The coefficients of the error correction term show the speed of convergence to the long run equilibrium as a result of shock of their own prices. The estimate of the error correction coefficients for the selected plantain markets indicate that the Techiman market is significant and has a correct sign (negative) indicating any disequilibrium in the long run wholesale price would be corrected in the short run thus, the short run price movements along the long run equilibrium path may be stable (Table 3). The significant value implies that there is a conservative force tendency to bring the model back into equilibrium whenever it strays too far. Although the coefficient of the error correction term for Kumasi has the correct sign, it is not significant. The Accra market has a wrong sign (positive) showing that the short run price movements along the long run equilibrium path may be unstable but is not significant.

About 47 percent of the disequilibrium corrected for each week in Techiman market is by changes in its own prices and the remaining influenced by other internal and external market forces. Accordingly, 7 percent of disequilibrium corrected for each week in Accra and Kumasi markets respectively is by changes in their own prices and the remaining influenced by other internal and external market forces. The speed of adjustment of 47% from the short run to the long run equilibrium in the Techiman market is relatively moderate as compared to a perfect adjustment of 100% threshold. However, the speed of adjustment of 7% for Accra and Kumasi markets is relatively weak as relate to Mensah-Bonsu et al. (2011) and Nkendah and Nzouessin (2006) who found 27.73% and 21-27% respectively and summed up that there is weak integration among the markets. The weak transmission of the Accra and Kumasi markets imply a weak transmission relating to the reference market and this could be attributed to the bad communication among the various markets (Nkendah & Nzouession, 2006; Mensah-Bonsu et al., 2011)

About 7 percent of the disequilibrium corrected with one week lag in the Techiman plantain market price is by the Kumasi market price. However, about 16 and 10 percent of the disequilibrium corrected in Techiman market prices by Accra and own prices respectively take place in two weeks lag. This implies that the disequilibrium in Techiman market is corrected better in two weeks lag period by Accra market and its own prices as compared with Kumasi that corrects in a week period. It is worth noting that the impact of the lag two price of Accra market was found to have a significant impact on the Techiman market prices. Also, lag one and two of the Kumasi prices have significant impact on the Accra and Kumasi market prices respectively.

CONCLUSION

Market integration which has been defined in several spheres as the co movement of prices has several importance to the agricultural economy of many countries if applied and explained properly. Owing to the importance of plantain to the economies of most developing countries particularly Ghana, the authors saw the need to study the integration of the plantain markets in Ghana spatially, more so when few studies have been conducted in that regard. The co integration and error correction models were applied to study the integration of the markets. The study found out that the price series have a unit root and therefore, non stationary. The Johansen's method revealed that there is

long run relationship among the market prices and suggesting that markets may be efficient. In addition, the vector error correction model proved that most of the disequilibrium in the market is corrected within 2 weeks. Prices correct a very small percentage of the disequilibrium in the markets with the greatest by the external and internal forces. This necessitates the need for future research, to investigate the influence of external and internal factors such as market infrastructure, government policy and self sufficient production, product characteristics and utilisation towards market integration.

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