Assessing the effectiveness of inter-regional trade in Ghana's soybean markets

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Abstract

Soybean production has been widely promoted in Sub Saharan Africa (SSA) as a means of improving rural household income. Several strategies have been employed to ensure soybean's commercialization. However, high transaction costs associated with the movement of soybean across regional markets poses a threat to household access and utilization. This has led to myriads of studies on the supply side with few studies on trade preferences and price transmission. Lack of in-depth analysis on soybean inter-regional trade can have a negative repercussion on the extent to which households' access and utilize soybean. This study employs a vector error correction model (VECM) model to ascertain how local markets are integrated and its connection with international soybean market. The results show that regional soybean markets are integrated and there is evidence of integration between the local and international markets. The international market Granger cause Kumasi, Bolgatanga, and Wa markets. We find evidence of Tamale and Kumasi as the two leading markets representing the production and consumption regions of soybean in Ghana. Findings of the study suggest that improving competitiveness in Kumasi, Bolgatanga, and Wa markets through provision of timely information and improvement in infrastructure will improve price signals to other regional markets.

1. Introduction

Lack of agricultural commercialization is one of the major economic challenges faced by most developing countries. It has the potential of impeding economic growth and development. However, commercialization normally takes a long transformation process as traders establish and build market relationships and learn arbitrage skills (Blanchard 1997). The negative impact associated with lack of agricultural commercialization in Africa have motivated the implementation of several economic reforms over the last two decades (Abdulai, 2000). Notably among these reforms is the Structural Adjustment Program (SAP) that led to the liberalization of most African economies. The purpose of the market liberalization is to integrate domestic and foreign markets through forces of demand and supply as well as offer relatively high price incentives for farmers. However, development practitioners and scholars have long deliberated on the importance of these reforms in both developing and emerging markets (Mafimisebi, 2012). Despite positive gains, some studies show that these reforms failed to increase production and integrate markets in some developing and transition economies (Kherallah, et. al., 2002; Eicher, 1999). Along the same lines some African countries like Ghana have also invested heavily in physical infrastructure that too should favorably spatial price transmission. We use price series data from Ghana to test a set of hypotheses testing integration among regional and international soybean markets.

Market efficiency and integration through market liberalization lead to efficient resource allocation (Frankel and Romer, 1999; Nielsen et al., 2006). Specifically, market integration involves information transmission speed and detail about demand and supply levels among spatially disparate locations (Negassa et al., 2003). Market information integration facilitates the efficient movement of commodities that leads to market expansion and increased competition with the long-term effect of increasing overall market system efficiency (Melitz, 2012). Alternatively, the lack of integration involves poor information transmission, which in turn promotes imperfectly competitive markets, market concentration, the need for government intervention, and opportunities for collusion in local markets. Price distortions and weak price transmission create market friction that result in high transaction costs for local firms and greatly limit market arbitrage (Roberts et al., 1994; Portugal-Perez and Wilson, 2008; Mtumbuka et al., 2014). Due to variability in local production, markets that are poorly integrated record higher price instability (Antonaci et al., 2014). For example, inland location of soybean production zones and high cost of internal transport hinder Ghana's competition in international soybean trade (Gage et al., 2009).

The increase in the world food market prices (2007-2008) motivated several African countries (Zambia, Ethiopia, Tanzania, Niger, and Ghana) to adopt efficiency promoting strategies to curtail high price volatility between domestic and international markets (UNCTAD, 2009). Some of the strategies include Warehouse Receipt System (WRS), commodity exchanges, contract farming, effective agricultural information systems delivery, grain stock management and trade policies. These strategies primarily targeted high transaction costs in the market, marketing information asymmetries, and price volatility (Galtier, 2009; Mtumbuka et al., 2014; Shepherd, 2011; Tollens, 2006).

To date there is little empirical evidence on the impact of these market policies on price transmission in the developing world. Onumah et al. (2003) evaluate the effectiveness of these strategies in general by identifying the implementation bottlenecks. However, little literature exists as to the specific question as to the state of spatial price transmission, specifically with respect to commercial crops like soybean. Importantly, scholars caution there exists market integration by assuming market efficiency (Barret, 2002; Rashid and Minot, 2010). For example, spatially integrated markets may not be efficient if marketing costs are higher than normal.

Part of the challenge of empirically testing price transmission efficiency results from a lack of the necessary price data. In our particular situation, we have been able to obtain a time series soybean price dataset for six markets in Ghana. We employ a Vector Error Correction Model (VECM) model to analyze the effectiveness of inter-regional soybean trade in Ghana and its connection with international markets. Our results show that there exists a cointegration relationship across the different regional markets and the international soybean market. Results from Granger causality tests provide evidence that international prices affect the Kumasi, Bolgatanga and Wa markets. In addition, following the law of one price, these three markets are the most connected in terms of price information across our study sites.

We organize the paper as follows: Section 2 provides literature review of soybean production in Ghana and past empirical studies. Section 3 describes the data and selection process, and empirical model for analyzing market integration and causality. We present the main analytical results and discussion in section 4. Section 5 presents concluding remarks.

2. Literature Review

2.1 Soybean Production and Marketing in Ghana

Soybean production is a relatively new crop in Ghana and cultivated mostly by smallholder farmers under rain-fed conditions (MiDA, 2010; Akramov & Malek, 2012). The average area cultivated to soybean is less than 0.8 hectares. Current domestic supply lags behind domestic demand thus requiring significant imports of soybean grain, meal, and oil (Gage et al., 2012). The Northern region alone contributes about 70 percent of national soybean area and about 77 percent of national production (SRID, 2012). Upper East, Upper West, Northern, Brong-Ahafo and Volta Regions are the major soybean production areas in Ghana (SRID, 2012). Soybean production though shows positive growth in Ghana since (SRID, 2015). Poultry and small-scale processing firms, as well as rising food oil demand account for the expansion of production (Gage et al., 2012). The poultry industry absorbs about 75 percent of the total soybean demanded annually. Most of these poultry industries and small-scale firms are located in the middle and southern belt of Ghana (Pradhan et al., 2010, Gage et al., 2012, Eshun et al, 2018;). Both the post-harvest committee and the National Food Buffer Stock Company, both government agencies tasked with price and supply stabilization, have been active in maize and rice markets, but absent from the relatively nascent soybean sector.

2.2 Agricultural market integration: empirical evidence

We found no previous work analyzing soybean market integration at the national level within a developing country context. Our work will also fill a void understanding pure market effects in an emerging market where there exists little government intervention and the subject commodity is a relatively new commercial crop.

Abdulai (2000) examined price relationships between three principal markets in Ghana using the threshold cointegration model. In the past, maize marketing used to be the responsibility of private commercial systems with periodic intervention by the government to help stabilize domestic price. However, the economic reforms in Ghana led to complete liberalization of the maize markets and improvement in infrastructure such as upgrade of trunk and feeder roads that links major production and consumption centres. Alderman and Shively, (1996) show that this improvement led to improved trade flows among regional markets and a reduction in real maize price. Wholesaler traders faced with high transaction cost can engage in collusive behavior to extract monopsony profit from farmers. Despite this widely held claim, there is no supporting empirical evidence, though for the period 1980 to 1997 there exists asymmetry in the cost of inventory adjustment (Abdulai, 2000).

Tostao and Brorsen (2005) studied the efficiency of spatial maize arbitrage in Mozambique during the post-reform period. Prior to the reform, procurement, distribution, and processing of maize was the responsibility of subsidized government-owned companies. The system failed to ensure food security despite the subsidies the authors identify transportation restrictions as the major challenge to spatial arbitrage in Mozambique. Using monthly retail price and monthly transportation data, the authors test whether market efficiency exists following the post reforms that allowed private entrepreneurs to engage in maize trading. Based on the empirical findings, they concluded that despite the improvement in spatial efficiency due to market liberalization, the relatively high transfer costs limited trade and potential benefits from operating a free market. Thus market liberalization was a necessary though not sufficient condition for reducing food shortages and price volatility. Infrastructure improvements in the form of roads, barge expansion, and rail too are necessary, in combination with market liberalization, for true market reform (Tostao and Brorsen, 2005).

In estimating the effect of policy on spatial market efficiency in the wheat and maize markets in Ethiopia, Negassa and Myers (2007) used an extension form of the parity bound model that allows for dynamic shifts in regime probabilities. They found that wheat traders make excess profits most of the time since the price differences exceed the transfer cost and maize traders often make losses across the policy regimes tested.

Myers (2013) evaluated the effectiveness of inter-regional trade and storage in Malawi's private sector maize markets. Transportation of maize across regional markets has been the major role of the private sector in ensuring efficient spatial arbitrage. However, there is little information regarding the role of the private sector affecting price transmission across regional markets, especially when there is a joint role of the private sector and the government parastatal setting price. The paper's major contribution was the use of a weekly price series and a non-linear cointegration model to establish how effective the private sector ensured effective inter-regional trade. In all the markets, long run market integration occurred but storage efficiency conditions were found to hold only in some markets.

3. Methodology

3.1 Data description and market selection

This study uses weekly data of wholesale prices collected from January 2011 to August 2017 by the trade and marketing team of ACDI/VOCA, nonprofit international economic development organization. Daily price per 109kg (a Ghanaian "bag") of soybean reflect and average of twice (morning and evening) daily collections from the out-grower businesses and aggregators in the selected markets. The ACDI-VOCA monitoring and evaluation (M&E) unit validates and cleans the price data. We use weekly US cash soybean prices from January 2011 to August 2017 from Chicago Mercantile Exchange (CME) group as the international price series.

The local price data covers six major regions of Ghana; 1) Upper West, 2) Upper East, 3) Northern, 4) Brong-Ahafo, 5) Ashanti, and 6) Greater Accra. In each of the regions, data collection took place in one major market center based on being the highest volume of soybean commercialization and data availability. Selected regional markets cities are 1) Wa, 2) Bolgatanga, 3) Tamale, 4) Techiman, 5) Kumasi, and 6) Accra (Figure 1). The first three markets are located in the northern part of Ghana. Techiman is located in the middle belt whereas Kumasi and Accra are located in the southern part of Ghana. The latter market is specifically located close to the coastal belt of Ghana. The center of soybean production takes place in the Northern Region while utilization occurs in the Ashanti Region and Greater Accra. Therefore, we hypothesize that: Ho1- Tamale, the center of production in Ghana, serves as a central point for the nation. Due to its location between the northern and southern markets, we hypothesize that: Ho2- the Techiman market serves as an intermediary market outlet for the country.

Soybean distribution channel consist mainly of farmers, NGOs, community agents, itinerant wholesalers, processing firms, wholesalers and retailers, and consumers (Martey and Goldsmith, 2018).

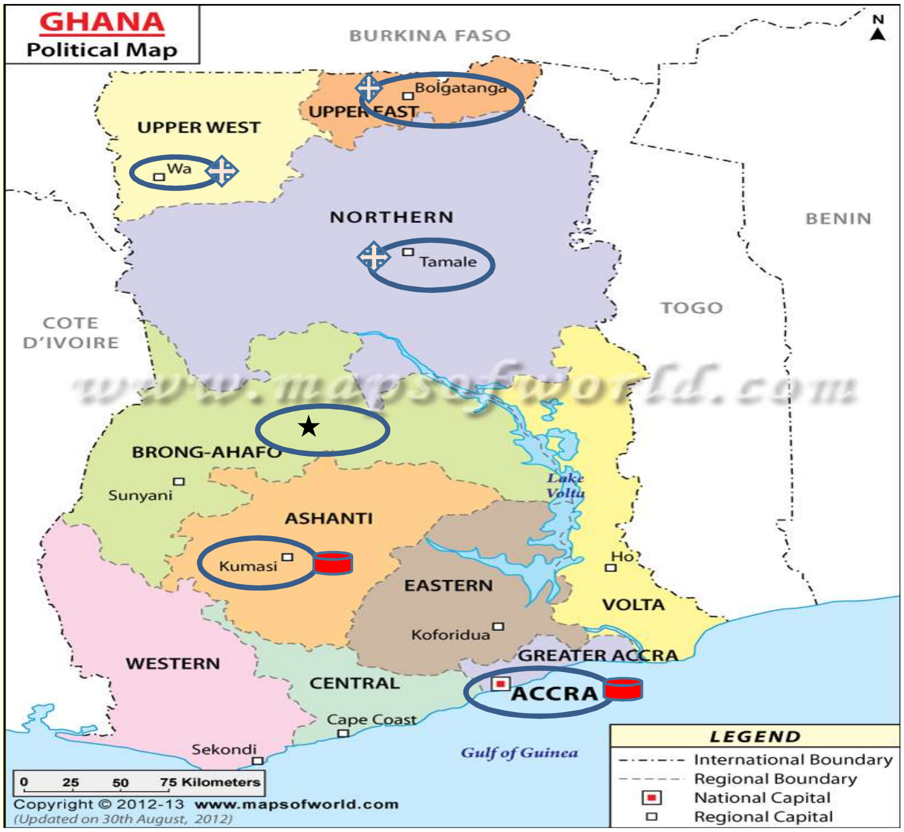

Figure 1. Administrative map of Ghana showing soybean markets

Notes: ✥ *Represents soybean production zones in Ghana.*

★ *Represents Techiman soybean market in Ghana.*

Represents the consumption zones in Ghana

We consider Tamale as the reference production market and compare it with the other marketing outlets. Major and minor routes classifications reflect the level of soybean commercialization between markets and transfer costs (Figure 1). The major routes are Tamale-Techiman, Tamale-Kumasi, Kumasi-Techiman, Kumasi-Accra and Techiman-Accra. Tamale-Bolgatanga, and Bolgatanga-Wa constitute the minor market routes. Prices in the southern markets are higher than the observed prices in the northern markets.

Tamale serves as the reference market for Wa and Bolgatanga due to its; state of local excess supply, proximity, and relatively low cost of transport. Simultaneously, Tamale and Wa supply soybean that is sold in Bolgatanga due to its proximity to Burkina Faso, a high demand-low production international market. Therefore, we hypothesize that Ho3- Tamale and Wa serve as pricing points for Bolgatanga.

Kumasi is the most active agro-industrial area that buys and sells many commodities, including soybean (Eshun et al, 2018). Kumasi serves as the largest buy-side market for soybean producers and wholesalers in Ghana. Additionally, the road networks that connect Bolgatanga, Tamale, Techiman with Kumasi are in good shape, thus facilitate trade. Therefore, we hypothesize: Ho4- that Kumasi is the central pricing point for soybean in Ghana.

However, the road infrastructure between Wa and Tamale and Wa and Bolgatanga are in poor condition during our study period, which increases the cost of transport. Transportation of commodities between these markets is expensive. Accra, too, operates internationally importing soybean oil and meal. Ghana currently imports 40% of its soybean, 35% of its soybean meal, and 70% of its soybean oil needs, respectively. Therefore, we hypothesize that: Ho5- Ghana prices are fully integrated with international prices.

3.2 Analysis of inter-regional market integration and causality

Markets are integrated when each of the prices in the different markets are non-stationary but there exists a linear combination of the price variables that is stationary which also implies a long-run equilibrium (Mafimisebi, 2012). This study analyzes the effectiveness of inter-regional trade in soybean markets using cointegration and multivariate vector error correction model (VECM) to characterize the short and long run links between local markets.

The first step of the analysis consists of analyzing the univariate time-series properties of the series using Augmented Dickey-Fuller (ADF) to identify the presence of stochastic trends (unit roots) in the data. We conduct a cointegration analysis following Johansen (1988) after testing for the presence of unit roots and autocorrelation, and checking stability conditions. This framework identifies both the long-run co-movement between prices, as well as the short-run dynamics. We estimate the following VECM for each market price:

$$\Delta P_{i,t}^{d} = \alpha_0 + \alpha_i ECT_{t-1} + \sum_{k=1} a_{11} \, \Delta P_{j,t-k}^{d} + \sum_{k=1} b_{11} \, \Delta P_{t-k}^{i} + e_{it} \qquad (1)$$

where ΔP_{it}^{d} is the contemporaneous first difference of domestic prices, $\Delta P_{j,t-k}^{d}$ is a vector that contains the remaining market prices, and ΔP_{t-k}^{i} is the vector containing the international soybean prices. ΔP_{t-k} refers to the lags of price differences and e_{it} are the error terms of the system of equations. ECT_{t-1} reflects the deviations of the system with respect to the long-run parity. Normalizing with respect to one of the domestic prices (i), the lagged error correction term is defined as a function of the remaining prices (j) and the international soybean price:

$$ECT_{t-1} = P_{i,t-1}^{d} - constant - \sum_{j=1} \beta_j \, P_{j,t-1}^{d} - \sum_{j=1} \gamma \, P_{t-1}^{i} \qquad (2)$$

From equation (1), the vector of parameters α_i are the coefficients that show how the prices in the system respond to disequilibrium from the long run parity. For example, should there be a policy shock, the sign of the error correction coefficients should be negative to guarantee that the prices return to the equilibrium.

We also analyze the direction of causality between variables within a bivariate framework using the Granger causality test. The price in one market would commonly be found to Granger-cause the price in the other market and vice versa among market pairs that are integrated of the same order (Chirwa, 2001; Nielsen, 2006). Finally, we test for long run effects if the error coefficients α in the ECT equal zero. We reject the null hypothesis for short run causality using an F-test when $\gamma_i = 0$ for all $d = 1,2, \dots \dots, m$ and $\beta = 0$. Mafimisebi (2012) noted that in the presence of bi-directional Granger causality, prices are said to be determined by a simultaneous feedback mechanism (SFM).

4. Results and Discussion

4.1 Descriptive Statistics

Table 1 shows the mean price of soybean for all the regional markets and the international market of soybean. The mean prices of soybean at all locations during the study period vary between 0.327-0.631 US$/kg. The average price of soybean per kilogram in Accra is 0.631 US$/kg followed by Kumasi (0.470 US$/kg), Bolgatanga (0.442 US$/kg), Techiman (0.433 US$/kg), Wa (0.390 US$/kg), Tamale (0.357 US$/kg), and Chicago (0.327 US$/kg). To compare the price dispersion across the mean values, we use the coefficient of variations across regional and international prices. We find that prices in Bolgatanga are 35% dispersed from the mean and followed by Bolgatanga (30%), Wa (28%), Kumasi (25%), Accra (24%), Techiman (23%), and Chicago (19%). The implication is that within the period of study, price of soybean did not fluctuate widely among markets analyzed. This shows that markets with improved market information have lower price dispersion, therefore, there is the need for improved information across the regional markets to decrease price dispersion and enhance price forecast for future planning. The results are consistent with the relative price ratio (ratio of the price differential to the mean value). A comparison of the relative price ratio and the price differential show that using the price differential to measure the level of dispersion may be misleading given that Tamale recorded a relative price ratio of 1.465 (most dispersed) but a price differential of 0.523 (third highest in comparison to all the regional and international markets). Similarly, the price differential in Wa is 0.430 (sixth position in the order of highest to the lowest) but the relative price ratio is 1.103 (third highest among the markets). We dropped the price series in Accra for the cointegration analysis due to the relatively high price differential and price dispersion compared to the other price series.

Table 1. Summary statistics for weekly soybean price data

Markets	N	Mean	SD	Min.	Max.	CV	Price difference	Relative Price Ratio
Accra	80	0.631	0.148	0.335	1.014	0.235	0.679	1.076
Bolgatanga	80	0.442	0.134	0.248	0.800	0.303	0.552	1.249
Kumasi	80	0.470	0.116	0.240	0.721	0.247	0.481	1.023
Tamale	80	0.357	0.124	0.189	0.712	0.349	0.523	1.465
Techiman	80	0.433	0.098	0.249	0.705	0.227	0.456	1.053
Wa	80	0.390	0.107	0.218	0.648	0.275	0.430	1.103
Chicago	80	0.327	0.063	0.236	0.466	0.194	0.230	0.703

Notes: SD, Min., and Max. refer to standard deviation, minimum, and maximum. CV refers to coefficient of variation

Figure 2 shows the fluctuations in the price series of the regional markets and the international market. The international price falls below all the regional price which is expected. Kumasi prices were above the other regional prices for most of the study period and followed by price series in Bolgatanga. Compared to the international price series, Tamale price series follow closely with some variations observed at irregular intervals. Most of the peak prices occurred between 2011 and 2012 while the period between 2014 and early part of 2015 witnessed significant low soybean prices. The prices peaked at the later part of 2015 and remained low for the rest of the study period (2016 and 2017).

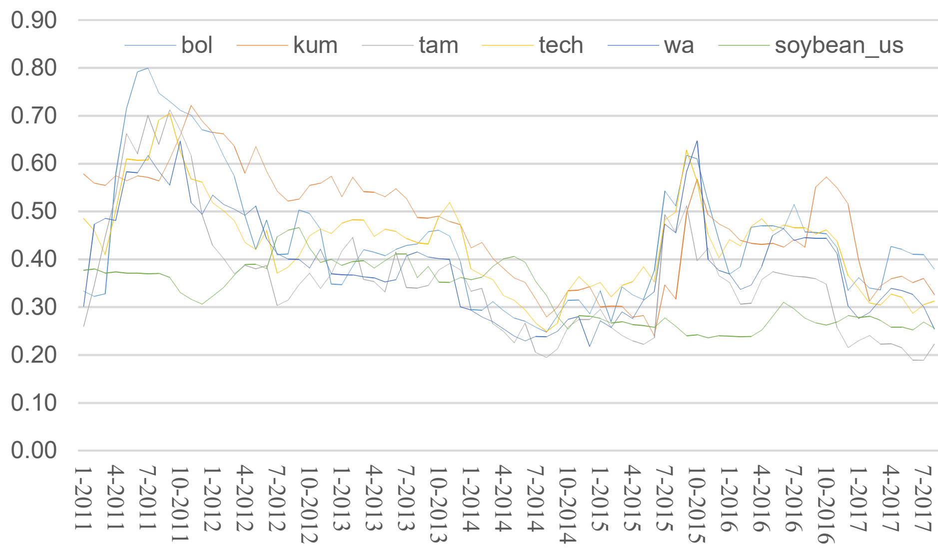

Figure 2: Domestic and international prices from 2011 to 2017

Table 2 shows the price spreads between regional markets. The study identifies five major and two minor trade routes among the six selected market locations following from the production volume of soybean and the transaction costs (transportation, search, and negotiation) which determine the volume and extent of trade. All the mean spread price were negative except Bolgatanga and Wa market pair. Tamale and Kumasi market pair are the farthest among the regional market pairs followed by Techiman-Accra market pair while Kumasi-Techiman record are the closest regional market pair. Generally, the farthest market pairs experience relatively high absolute mean price spread. For example, in absolute terms, Techiman and Accra recorded a mean spread of 0.198 while the closest market pair (Kumasi-Techiman) recorded a mean price spread of 0.037 in absolute terms. The coefficient of variation indicates that adjoining markets have higher price dispersion from the mean price which is contrary to our expectation given that information flow across such markets is rapid. The price per kilometer of distance travelled across the regional market pairs (Tamale-Techiman, Tamale-Kumasi, and Kumasi-Techiman) are the same despite significant difference in the distance travelled across the market pairs. Comparing Tamale-Kumasi (farthest market pair) and Kumasi-Techiman (closest market pair), we can conclude that prices in the former are less dispersed and information flow across the market pairs is fast. The ratio of mean soybean price to distance in Bolgatanga-Wa market pair is the lowest (0.0002) in absolute terms relative to the other regional market pairs. By scaling the ratio of the mean price spread to the distance by 0.0002, we observed that compared to Bolgatanga-Wa, Kumasi-Accra regional market pair record a relatively high price per kilometer followed by Techiman-Accra, Tamale-Bolgatanga, Tamale-Techiman, Tamale-Kumasi, and Kumasi-Techiman. Mostly, soybean prices are relatively high in the consumption regions due to the growing poultry industry and small-scale processing firms.

Table 2. Descriptive statistics for monthly price spreads

Regional Market Pairs	Distance (km)	Mean price spread (US$/kg)	Std. dev.	Min	Max	CV	Ratio of Mean Price to Distance	Column (7)/ 0.0002	Price Differential	Col (9)/Dist.	Column (10)/0.0012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Major routes											
Tamale-Techiman	257	-0.077	0.055	-0.226	0.093	-0.715	-0.0003	-1.39231	0.3190	0.0012	1.0202
Tamale-Kumasi	383	-0.114	0.099	-0.319	0.147	-0.871	-0.0003	-1.3832	0.4660	0.0012	1.0000
Kumasi-Techiman	127	0.037	0.081	-0.181	0.215	2.205	0.0003	1.353868	0.3960	0.0031	2.5627
Kumasi-Accra	248	-0.161	0.131	-0.447	0.180	-0.815	-0.0006	-3.01684	0.6270	0.0025	2.0779
Techiman-Accra	370	-0.198	0.071	-0.516	0.072	-0.657	-0.0005	-2.4868	0.5880	0.0016	1.3061
Minor routes											
Tamale-Bolgatanga	163	-0.085	0.071	-0.235	0.118	-0.832	-0.0005	-2.42331	0.3530	0.0022	1.7799
Bolgatanga-Wa	237	0.051	0.063	-0.157	0.211	1.234	0.0002	1.0000	0.3680	0.0016	1.2762

Note: Price spread is price for the first market listed minus price for the second market. CV refers to coefficient of variation. Min and Max represent minimum and maximum. Price differential is the difference between the maximum and minimum soybean price. Column 10 is computed as the ratio of the price differential to the distance.

Movement of soybean is normally from the north (supply) to the south (demand) except in the case of importation where the reverse holds. Imported soybean is mostly supplied from Accra to Techiman through Kumasi. Generally, it is expected that unidirectional movement of soybean will lead to few negative price spreads to offset large number of positive spreads and vice versa. Based on the results, all the market pairs experience negative price spreads to offset relatively large number of positive spreads. The major regional consumption markets, Kumasi and Accra resort to importation of meal and oil whenever domestic demand is below supply.

According to Myers (2013), inter-regional trading activity is intrinsically uncertain, and it is more likely for periods of remarkably large returns to be counterbalance by other periods of low or negative returns. In such circumstances, it becomes more imperative to ascertain whether the average spreads over time provide a reasonable return to inter-regional trade in the long-run. The long-run equilibrium relationship between regional prices and price spread adjustment to equilibrium is highlighted in detail using the Granger Causality test. Given that markets are part of a system and to also establish the correlation between two prices and the prices that are ruled out, we use the VECM and the Granger Causality test to analyze market integration within a system (or to better understand the cointegration structure among markets) and the causal relationships with respect to price determinants respectively.

4.3 Unit Root

After confirming that all series have unit roots in levels, the Johansen (1988) cointegration test is performed to determine whether the series have a long-equilibrium. First, the lag length determination tests are conducted to specify the number of auto and cross-regressive components in the short-run dynamics. Information criteria recommend at least one lag. The Final Prediction Error (FPE) and Akaike's information criterion (AIC), the Hannan and Quinn information criterion (HQIC) and (SBIC) Schwarz's Bayesian information criterion recommend 1 lag, while the Log-Likelihood Ratio (LR) suggest 3 lags. After testing for autocorrelation, we consider including the maximum number of lags, which is three.

4.4 Analysis of long run spatial equilibrium

Results of the VECM cointegration model is shown in Table 3. Specification of the error correction model was based on lag length criteria test. The results indicate that the model fits well and all the coefficients in the cointegrating equations are statistically significant implying that local prices respond to the long run price relationship between market pairs. Johansen rank test identifies the number of cointegrating vectors characterizing the data. With five local markets prices, the test indicates at most two cointegration vectors. Hence, it can be concluded that domestic prices of soybeans are cointegrated, therefore, we proceed to estimate the VECM.

Table 3 shows the VECM estimation results. Short run coefficients (α_i) represent the speed of adjustments from deviations from the long-run parity. It is worth-noting that at least one coefficient in each equation of the long run adjustment is negative and statistically significant, which confirms the hypothesis of cointegration. The negative sign on at least one of the error correction coefficients guarantee the stability of the price adjustments. This means that if there is a shock and prices go up, there should be at least one price going down to ensure price stability. The results suggest absence of serial correlation due to insignificance of the Lagrange multiplier test at a lag length of 10. To test for normality, we can conclude on the consistency and efficiency of the parameter estimate. The thumb of rule is that if the errors do not come from a normal distribution but are just independently and identically distributed with zero mean and finite variance, the parameter estimates are still consistent, but they are not efficient. We reject the null hypothesis of normally distributed errors and conclude that most of the errors are not skewed but kurtotic.

Table 3. VECM model estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	D_LSoybean_US	D_LKum	D_LTech	D_LTam	D_LWa	D_LBol
α_1	-0.0803**	0.116*	0.0109	0.280***	0.0470	-0.194**
	(0.0380)	(0.0641)	(0.0619)	(0.0932)	(0.0722)	(0.0758)
Constant	-0.00546	-0.00348	-0.00809	-0.00359	-0.0109	-0.00807
	(0.00651)	(0.0110)	(0.0106)	(0.0159)	(0.0124)	(0.0130)
Number of lags	2	2	2	2	2	2
Stability	Stable, 5 unit moduli imposed					
Lagrange-multiplier test (10 lags)	Chi2 = 31.59 (0.678)			No autocorrelation		
Normality	Chi2 = 8.34 (0.75)			Normality		
Observations	80	80	80	80	80	80

Notes: Numbers in parentheses are standard errors. *** Significant at 1% level, **Significant at 5% level, and *Significant at 10% level. D_LSoybean_US represents the first difference in the US Soybean price in logs -> D.($logPs_t$-$logPs_{t-1}$); D_LKum is the first difference in the Kumasi Soybean price in logs; D_LTech is the first difference in the Techiman Soybean price in logs; D_LTam is the first difference in the Tamale Soybean price in logs; D_LWa is the first difference in the Wa Soybean price in logs; D_LBol is the first difference in the Wa Soybean price in logs. The lag 2 refers to the model in levels so when using the first difference of the series we include only one lag.

To complement the error correction model and further understand the price relationship among the market prices, a Granger causality test was conducted to establish the response of a market to a market shock. Results of the Granger Causality test are reported in Table 1A in the appendix. Following from the results, we depict the causality results in figure 3. Markets that play leadership role in terms of information and transmission of prices are identified per the Granger causality test. However, the test is limited in terms of identifying the amount of information contributed by each market. More specifically, the Granger causality identifies the direction of price formation and the physical movement of the commodity to adjust for these price differential (spatial arbitrage). The figure shows what market comes first based on the dynamics of price changes. The arrows show when a price granger causes the other based on the statistical significance of the test results. The market (Chicago) on top of figure 3 indicates the market that moves first when there is a shock. The result confirms the null hypothesis 5 which states Ghana prices (Kumasi, Bolgatanga, Wa and Techiman) are fully integrated with international prices, but the reverse does not hold (this is confirmed by the test results in table 1A and illustrated in figure 3). The possible mechanism is the high levels of imports of grain, meal, and oil into Ghana. Markets that have leading role in price formation are Kumasi, Bolgatanga, and Wa because international markets affect them first. Tamale and Techiman have secondary role because they are not influenced by any price change in the international prices, but Tamale affects Kumasi indicating that Tamale may add some local market information to Kumasi that is not related to international markets. Based on the results, we confirm the null hypothesis 1 that Tamale is the centre of production in Ghana and serves as a central point of domestic price formation for the nation. The assumption being that grain flows will move from low price regions (in our case Tamale) to higher price regions (i.e. Bolgatanga), then the direction of causality would be parallel, meaning that Tamale leading prices in Bolgatanga.

Prices in Wa influences prices in Techiman and Bolgatanga although the later (Bolgatanga) is influenced by international prices. The results suggest that Wa contributes to the total price formation in the Bolgatanga. Our results confirm hypothesis 3 that among the regional markets, Tamale and Wa serve as pricing points for Bolgatanga. From the graph, Techiman is the only market that do not influence any of the regional markets. Techiman is the last market being affected by information shocks from both domestic and international prices thus likely to be a follower or price taker. We fail to accept the null hypothesis 2 that Techiman serves as an intermediary market outlet for the country.

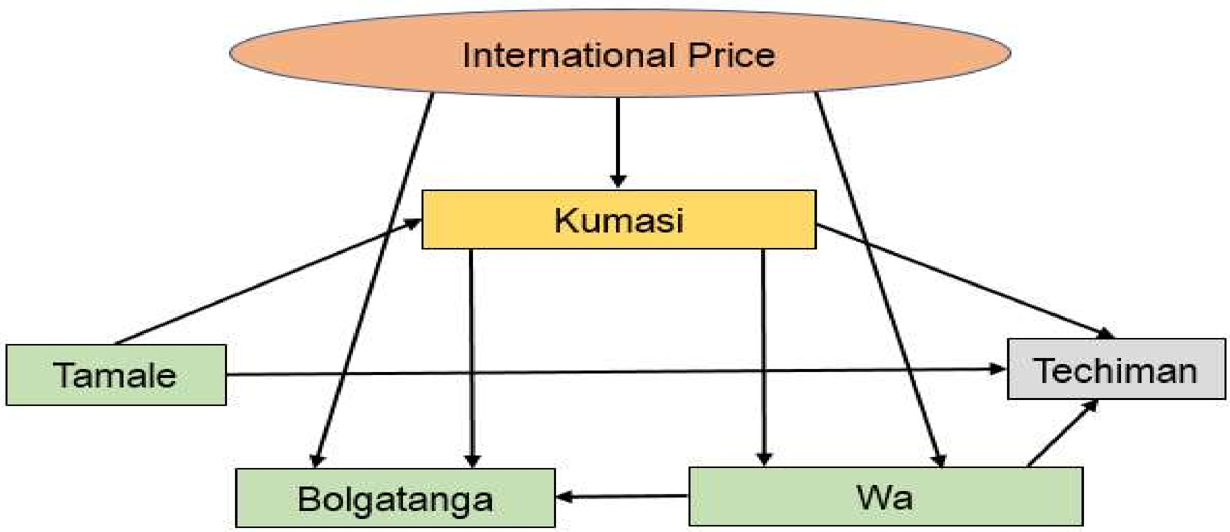

Figure 3. Summary of Granger-Causality test for regional soybean market (2011-2017)

5. Summary and Concluding Remarks

Soybean production is widely promoted in Sub Saharan Africa (SSA) as a means of improving rural household income and improving malnutrition. The intensive promotion of the crop has led to several studies on the soybean value chain in most developing countries. However, most of the research has focused largely on the production side of the supply chain with scanty information in terms of inter-regional trade. This study analyzed the effectiveness of long-run inter-regional trade in Ghana's soybean market using five regional markets and international soybean price. Such studies are relevant for gaining better understanding of the performance of regional markets and provide empirical evidence for effective policy formulation and investment decisions.

The results presented in this paper using monthly wholesale prices, show a strong evidence of the existence market integration among the regional soybean and international markets. We find evidence of international price influence on the prices in Bolgatanga, Kumasi, and Wa where the later influences prices in Techiman. Tamale is disconnected from international market dynamics but might have local market information which affects prices in Kumasi and Techiman. Tamale is the central point of production in Ghana and serves as a crucial pricing point for the nation. Similarly, Tamale and Wa serve as pricing points for prices in Bolgatanga. Despite Wa and Bolgatanga having a connection with international market dynamics, Kumasi contributes to the total price formation in the two regional markets. Kumasi is considered as a consumption region with increasing small scale and poultry industries that rely on both domestic and imported soybean meal and oil. Among the regional markets, prices in Techiman do not affect prices in the other regional markets, therefore, are Techiman may be described as price-taker.

In formulating pricing policy to increase soybean consumption in Ghana, Kumasi and Tamale markets must be targeted. Prices formed in these markets will be efficiently transmitted to the other regional markets with minimal distortions in the long-run. Strong evidence of price transmission across regional market prices is identified and prices adjust within the short-run to ensure long-run equilibrium. This information is necessary for formulating effective policy towards meeting the specific needs of these markets in delivering to the satisfaction of its target customers.

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Appendix

Table 1A: Granger causality tests

Equation	Variable dynamics	Chi-squared	p-value	Decision
lsoybean_us	lsoybean_us	5.93	0.0517	lsoybean_us does Granger cause lsoybean_us
lkum	lsoybean_us	7.89	0.0194	lsoybean_us does Granger cause lkum
ltech	lsoybean_us	2.33	0.3116	lsoybean_us does not Granger cause ltech
ltam	lsoybean_us	1.24	0.5383	lsoybean_us does not Granger cause ltam
lbol	lsoybean_us	4.95	0.0841	lsoybean_us does Granger cause lbol
lwa	lsoybean_us	10.42	0.0055	lsoybean_us does Granger cause lwa
lkum	Lkum	1.13	0.5693	lkum does not Granger cause lkum
ltech	Lkum	8.22	0.0164	lkum does Granger cause ltech
ltam	Lkum	4.13	0.1271	lkum does not Granger cause ltam
lbol	Lkum	16.08	0.0003	lkum does Granger cause lbol
lwa	Lkum	13.48	0.0012	lkum does Granger cause lwa
lkum	Ltech	0.7	0.7052	ltech does not Granger cause lkum
ltech	Ltech	0.88	0.6444	ltech does not Granger cause ltech
ltam	Ltech	1	0.607	ltech does not Granger cause ltam
lbol	Ltech	0.4	0.8186	ltech does not Granger cause lbol
lwa	Ltech	1.08	0.5833	ltech does not Granger cause lwa
lkum	Ltam	6.37	0.0413	ltam does Granger cause lkum
ltech	Ltam	5.88	0.0529	ltam does Granger cause ltech
ltam	Ltam	3.57	0.1682	ltam does not Granger cause ltam
lbol	Ltam	1.34	0.511	ltam does not Granger cause lbol
lwa	Ltam	2.77	0.2509	ltam does not Granger cause lwa
lkum	Lbol	1.32	0.5173	lbol does not Granger cause lkum
ltech	Lbol	0.87	0.6488	lbol does not Granger cause ltech
ltam	Lbol	3.86	0.1451	lbol does not Granger cause ltam
lbol	Lbol	2.66	0.2643	lbol does not Granger cause lbol
lwa	Lbol	2.72	0.2573	lbol does not Granger cause lwa
lkum	lwa	2.97	0.2263	lwa does not Granger cause lkum
ltech	lwa	5.05	0.0799	lwa does Granger cause ltech
ltam	lwa	4.26	0.1189	lwa does not Granger cause ltam
lbol	lwa	23.59	0.000	lwa does Granger cause lbol
lwa	lwa	3.43	0.1796	lwa does not Granger cause lwa

Note: The dynamics of each price are excluded from each of the equations to test Granger causality after VECM estimation.