REGIONAL INTEGRATION IN WEST AFRICA: COSTS, TRADEOFFS AND INTEGRATION BETWEEN GHANAIAN AND BURKINABE FRESH TOMATO MARKETS

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Abstract

Trade flow difficulties across international borders in Sub-Saharan Africa represent a fundamental disincentive to cross-border arbitrage, price transmission and market integration. Despite the above observations, little research has so far undertaken a disaggregated view of the benefits of cross-border trade between neighbouring countries in Africa by comprehensively studying the price dynamics, transaction cost, rents to arbitrageurs and the spatial integration of the markets involved. The major objective of this paper is therefore to cast light on these issues by examining the drivers of the cross-border trade between Ghanaian consumer and Burkinabe producer markets of fresh tomato and what these imply for the integration of markets across the border. Our findings reveal a high level of tradability, rents to arbitrageurs and above 10% transmission of prices between the two markets across the border between Ghana and Burkina-Faso. The findings have theoretical and practical relevance for cross-border trade in West Africa.

Key Words: Markets, Transaction costs, Fresh Tomato, Ghana, Burkina-Faso, JEL Codes: C32, Q11, Q13, Q17, Q18

Introduction

Agricultural commodity markets (also known as food markets) are important institutions and hubs of social networks in Africa. In this sense, markets in Africa are arenas comprising not only of systems, institutions, procedures, social relations and infrastructures whereby participants engage in exchange of goods and services (Oguntade, 2013), but they also serving as social and political platforms. Markets in Africa especially maintain important social ties, linking rural and urban populations and neighbours across borders in a mutually rewarding exchange. Whereas the national borders artificially created by Africa's colonial powers split up Africans from the same tribes or traditional states, markets across these borders keep the people connected.

The push for market liberalisation globally and intra-regional trade between African countries is based on two reasons: 1) the fact that the price

mechanism in functioning markets ensures economic efficiency and leads to *Pareto* optimal allocation of scarce resources, and 2) that the functioning of markets ensure smooth trade flows and exchange of food products between surplus and deficit countries (Ihle, Amikuzuno, & Von Cramon-Taubadel, 2010; Abunyuwah 2008 & Baulch, 1997). These processes minimise price volatility, food insecurity, hunger and poverty.

This means, without trade flows and integration of markets across borders, commodities and price signals will not be transmitted from surplus producing countries/regions to deficit areas; prices will be more volatile; agricultural and food producers for instance will not specialise according to long-run comparative advantage, and the intended gains from regional integration may not even be realised (Baulch 1997 in Abunyuwah, 2008). In addition, intra-regional trade between

African countries creates employment and prosperity especially within border towns, while Africa's smallholder farmers will only, permanently adopt the improved technologies required to achieve productivity growth if the markets for their products are integrated (UNCTAD, 2013).

The conventional pattern of trade by African countries is characterised by the exports of raw material and primary food products overseas to countries with which they have historical, colonial links, and conversely imports of finished products from the latter. Following market reforms, the creation of platforms for regional and monetary integration, the rise of China, India and Brazil; and improvements in ICT infrastructure, a new order of trade regimes within regional and sub-regional economic blocks that aims at improving sub-regional supply chains and meeting regional development partnership agreements have emerged in Africa. The ongoing process of globalisation and domestic market reforms under WTO establishments even appear to have assumed diminished importance under this new trading pattern (Amikuzuno & Donkoh, 2012).

The pronounced seasonal arbitrage of fresh tomato between Ghana and her northern neighbour, Burkina-Faso, is one of the most intensive cross-border trades in agricultural commodities in Africa. This trade has been reported as one of the most intensive cross-border trades in agricultural commodities in Africa (IRIN Africa, 2009). The quantum (circa 35,000 tonnes per season) of trade in fresh tomato between the two countries has grown rapidly in the last 15 years. Itinerant wholesale arbitrageurs crossing the border from Ghana to the Central Province of Burkina Faso to purchase the commodity, drive this trade. From December to May annually, Ghana's North-Eastern Region and Burkina-Faso's Central Province supply almost all the fresh tomato consumed in much of West Africa and all of Ghana via the arbitrage activities of itinerant wholesale traders.

By efficiently utilising innovations in information and communication technology (ICT), improvements in transport and market infrastructure and the protocol of free trade between West African countries, these market queens are able to profitably maintain a supply chain between consumers in Ghana and producers in Burkina-Faso through the long distance arbitrage and trade flows of tomato across the border separating the two countries. They do so by developing closer "market ties" between producers and consumers, and reorganising the local or cross-border trade regimes in ways that create space for tradability and economically beneficial arbitrage.

Given the high transaction cost, official corruption at roadway checkpoints, difficulties posed by the currencies and exchange rate, as well as practical inconvenience of cross-border trade in West Africa (Amikuzuno & Donkoh, 2012), the motivation for playing this role by the market queens has raised some concerns. These include: 1) what motivates closer relationships between producers and consumers , 2) whether economic benefits or rents to arbitrage are adequate enough to warrant trade flows even in the period of the food price crises and global climate change, 3) whether the arbitrage activities of traders ensure price transmission and integration between the Burkinabe producer and Ghanaian consumer markets, and 4) whether any lessons for promoting multi-commodity intra-regional trade and regional integration in Africa could be learnt from this, single commodity cross-border trade.

Various empirical studies have demonstrated the economic benefits of intra-regional trade (UNCTAD, 2013; Amikuzuno & Donkoh, 2012; Ihle et al, 2010). For instance, it is estimated that a full exhaustion of the trade potential with neighbours would raise African domestic trade by 173%. In the Southern African Economic Union (SACU), a general realisation of the lowest transportation cost would generate economic benefit effects of 1.6% annually; while the volume of trade within the West African Economic Monetary Union (WAEMU) would grow by 300% if all interconnecting roads were metalled (UNCTAD, 2013)). Generally, these studies demonstrate that even though the setting up of economic blocs such as the WAEMU and SACU was motivated by economic considerations, they have failed to bring about the upswing hoped for on the African domestic market (UNCTAD, 2013).

Whereas Amikuzuno & Donkoh (2012) appears similar in theme to the current study, the authors examined the effects of the border between Ghana and Burkina Faso on the transmission of price signals between producer and consumer markets of fresh tomato. The sole model applied in this study is the switching vector error correction model (SVECM). The current study however focuses on the drivers of cross-border trade between Ghanaian consumer and Burkinabe producer markets of fresh tomato, and estimates the trade-offs to market queens with respect to gains or losses in transactions costs, and market margins. Here the standard VECM (rather than the SVECM) among others is applied to additionally examine the spatial integration of the markets involved. Whereas the focus of Amikuzuno and Donkoh (2012) was entirely on price dynamics, the current study focuses on the factors that motivate arbitrageurs to engage in cross border arbitrage of fresh tomato between the Ghana and Burkina Faso.

In the above regard, this study is among the first to undertake a disaggregated view of the benefits of cross-border trade between neighbouring countries in Africa by comprehensively studying the price dynamics, transaction cost, rents to arbitrageurs and the spatial integration of the markets involved. The major objective of this paper is therefore to cast light on these issues by examining the cross-border trade between Ghanaian consumers and Burkinabe producer markets of fresh tomato. The goal is to improve our understanding of the potential contribution of cross-border arbitrage activities, price transmission and market integration to Africa's intra- and inter-regional integration efforts.

Conceptual framework and research methodology

The conceptual framework
Across borders, integration in commodity markets is achieved through arbitrage, trade flows and price transmission. In the absence of barriers to trade between states, it is expected that price transmission and integration between their domestic markets will improve. Thus, free or unregulated trade should increase the transmission of price signals of tradable commodities from consumers to the producers of such commodities in the domestic markets of the states involved. Evidence of price transmission may be an assessment of the potential impact of cross-border, inter-state or intra-regional trade on the price and trade movements of homogenous commodities between the states or within the regional economic blocs involved (Robinson, 1995, in Padilla-Bernal & Thilmany, 2003).

Now the question is how do changes in commodity prices in one state affect the domestic prices of the same commodity in its trading partner? The local (domestic) price of a commodity in the domestic market P^l may be stated as:
$$P^l = P^m R(1 + tm) + C^{ij} \dots\dots\dots\dots\dots\dots\dots(1)$$

Where P^m is the import (foreign/international) market price of the commodity, R is the exchange rate, tm is a proportional import tariff or tax, and C^{ij} is the transfer costs of importing the commodity from the state i to the state j. The P^l and P^m are assumed to be expressed in a common currency.

Alternatively, the import price of an exportable commodity P^m can be expressed as:
$$P^m = P^l R(1 - t_x) - C^{ij} \dots\dots\dots\dots\dots\dots\dots(2)$$
Where tx *is the* proportional export tariff or tax, and the other variable notations are as already defined above.

In a country with unregulated trade for a given commodity, a price shock on P^l first triggers, through the commodity's border price, changes in the import price (P^m) of the commodity in markets close to the country's ports, borders and hub of market information such as urban markets with highly organised network of traders and reliable telecommunication facilities. These markets then lead the commodity's prices in interior markets in the price discovery or market clearing process. The rate of price discovery however depends on whether the market is perfectly competitive and price transmission mechanisms within the stated country for the commodity are strong or weak (Badiane & Shively, 1997).

For a price shock on P^m, the effect is first transmitted through border prices of the commodity to its local price. The rate of transmission of price shocks in this case also depends on the degree of integration between domestic and border markets

for the commodity. The interdependency between the international and domestic prices of the given commodity is particularly more pronounced if a perfectly competitive market exists between the trading partners and the supply chains for the commodity in the domestic scene are not mutually exclusive.

The main hub of our analysis examines the price linkage between a foreign producer market (i.e. Ouahigouya) and five major, domestic tomato markets in Ghana. We state, following the Law of One Price (LOP) and the Enke-Samuelson-Takayama-Judge (ESTJ) model, the contemporaneous relationship between the two prices, P_t^m and P_t^l as:

$$P_t^l = P_t^m + D_t^{lm} \quad \text{……………………………} \quad (3)$$

Where D_t^{lm} is the imported and local price differential and is equivalent to C^{ji} above. The price differential represents transaction cost incurred by and rents/profit margins to the arbitrageurs (market queens). According to the LOP, perfect price transmission between the producer and consumer markets holds only if (3) is met.

Methodology

In this study, we use the standard Vector Error Correction Model (VECM)[1], a very useful technique that provides a stylized picture of the relationship between the import and local prices of the commodity. The VECM also provides a methodological framework within which gradual, rather than instantaneous price transmission can be tested; meaning it takes into consideration discontinuity of trade, here due to seasonality in tomato production in Burkina-Faso and other factors that may impede price transmission over time (Rapsomanikis et al, 2003). In addition the model includes unit root test that determines the special time series properties of the data, while cointegration analysis is a prerequisite for applying the VECM (Engel and Granger, 1987).

As noted above, if the import and local prices for the commodity, denoted P_t^m and P_t^l, are time series variables that contain stochastic trends and are integrated of the same order e.g. I(d), then they can be said to be cointegrated if a long run, equilibrium relationship between the two prices can be stated as: $P_t^m - \beta P_t^l - \varepsilon_t \square I(0)$. We use Johansen vector autoregressive (VAR) approach to test for the existence of a cointegration relationship between P_t^m and P_t^l.

If the imported and local prices, P_t^m and P_t^l, are cointegrated, the VECM representation of price transmission between the two is specified by

stating the changes in each of the contemporaneous prices ΔP_t^m and ΔP_t^l, as a function of the lagged short term reactions of both prices, $\mathbf{\Delta P_{t-k}^m}$ and $\mathbf{\Delta P_{t-k}^l}$, and their deviations from equilibrium at period $t-1$ as follows:

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[1] Since we use the standard version of the VECM, we only briefly present its theoretical framework here. Interested readers may see Lütkepohl and Krätzig (2004) for details.

$$\begin{pmatrix} \Delta P_t^m \\ \Delta P_t^l \end{pmatrix} = \begin{pmatrix} a^m \\ a^l \end{pmatrix} + \begin{pmatrix} \alpha^m \\ \alpha^l \end{pmatrix} (P_{t-1}^m - \beta P_{t-1}^l) + A_1 \begin{pmatrix} \Delta P_{t-1}^m \\ \Delta P_{t-1}^l \end{pmatrix} + \dots + A_k \begin{pmatrix} \Delta P_{t-k}^m \\ \Delta P_{t-k}^l \end{pmatrix} + \begin{pmatrix} \mu_t^m \\ \mu_t^l \end{pmatrix} \dots\dots\dots\dots\dots (4)$$

Where ΔP_t^m and ΔP_t^l are a vector of first differences[2] of the import and local prices respectively; a^m and a^l are a vector of constant terms that denote long-run, inter-market price margins; the cointegrating equation $(P_{t-1}^m - \beta P_{t-1}^l)$, is the error correction term; so named because it depicts deviations from the long run relationship or 'errors' that are 'corrected' by the price transmission process, β is the cointegrating vector[3]; α^m and α^l are called the loading or error correction coefficients since they measure the extent to which P_t^m and P_t^l "error correct" i.e. adjust towards restoring the long run equilibrium relationship between them[4]. The α^m and α^l are also known as the elasticity of price transmission or the speeds of price adjustment by the import and local prices respectively, to deviations from long-run equilibrium. The coefficients A_k *(2 x 2)* are matrix of coefficients quantifying the intensity of the response of the contemporaneous price differences to their lagged values i.e., they express the short-run reactions of the matrix of prices $\mathbf{P_t}$ to random shocks. Finally, the $\mathbf{\mu_t^m}$ and $\mathbf{\mu_t^l}$ are white noise error terms and k is the number of lags included in the model.

Equation (4) can be reformulated as follows:

$$\begin{pmatrix} \mathbf{\Delta P_t^m} \\ \mathbf{\Delta P_t^l} \end{pmatrix} = \begin{pmatrix} \mathbf{a^m} \\ \mathbf{a^l} \end{pmatrix} + \begin{pmatrix} \mathbf{\alpha^m} \\ \mathbf{\alpha^l} \end{pmatrix} \hat{e}_{t-1} + \sum_{t=1}^{k} \Gamma \begin{pmatrix} \mathbf{\Delta P_{t-k}^m} \\ \mathbf{\Delta P_{t-k}^l} \end{pmatrix} + \begin{pmatrix} \mathbf{\mu_t^m} \\ \mathbf{\mu_t^l} \end{pmatrix} \dots\dots\dots\dots\dots\dots\dots(5)$$

Where $\hat{e}_{t-1}(=(P_{t-1}^m - \beta P_{t-1}^l))$ is the error correction term and $\Gamma (= A_1 + A_2 + \dots + A_k)$ is a 2x2 matrix of short run coefficients relating current price changes to past price changes. Commonly $0 < |\alpha_i| < 1$, such that the closer the α_i is to one in absolute terms, the faster the deviations from price equilibrium become corrected, and vice versa.

The existence of cointegration between P_t^m and P_t^l implies Granger causality (Granger, 1987). Furthermore, since cointegration between variables does not automatically imply causality between them, the evidence of causality between the variables must be provided by Granger causality analysis. The Granger causality models applied in this study are specified in equations (6) and (7).

$$P_t^m = \sum_{k=1}^{n} a_k P_{t-1}^l + \sum_{k=1}^{n} b_k P_{t-1}^m + \varepsilon_{1t} \tag{6}$$

$$P_t^l = \sum_{k=1}^{n} a_k P_{t-1}^l + \sum_{k=1}^{n} b_k P_{t-1}^m + \varepsilon_{2t} \tag{7}$$

The equation (6) postulates that, P_t^m is dependent on P_{t-1}^l and P_{t-1}^m; conversely, equation (7) postulates the same (theoretically) for P_t^l. The ε_{1t} and ε_{2t} are uncorrelated error terms. A proof of causality between the import and local prices implies that the variability of either price overtime can be explained by varying episodes of the other over the same period of time. The variant of the Granger causality tests run in this paper is based on the vector error correction model (VECM).

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[2] The I(1) price series need to be differenced in order to achieve stationarity.

[3] Because this analysis is bivariate, this is actually a scalar.

[4] Where the prices are expressed in their natural log values, the α^m and α^l are the elasticity of the import price with respect to the local price and the elasticity of the local price with the respect to the import price respectively.

Datasets

Our analysis uses a unique 5-year long (01.2008 to 04.2013) set of time series data collected twice weekly in the import market (Ouahigouya) in Burkina-Faso and the five key, tomato markets - Navrongo, Tamale, Techiman, Kumasi and Accra, in Ghana. The Ghanaian tomato markets include two producer markets - Techiman and Navrongo, which also supplies Ghana's fresh tomato in the same production period- January to May, as the Burkinabe market[5]. The graphical plots of the general trends and the seasonal spikes of the resulting prices are shown in Fig. 1a and 1b respectively.

The graphical analysis of the price trends in the six markets show the normal pattern of variability pertaining to prices of perishable and seasonally-produced, agricultural commodities like tomato. Overall, it can be seen from Fig 1a and 1b, that all price series are very much related in terms of co-movement over the period of study. Whereas Accra, the biggest tomato market, follows a similar variability pattern for much of the time in the period of the analysis, fresh tomato prices in Accra tend to largely lead the rests of the prices over the entire period. This is expected since Accra is the largest consumer market for fresh tomato in Ghana, while its farthest location (longest distance) from the cross-border producer market implies higher transaction costs and arbitrage risks, constitutes major components of the price for perishable commodities in Sub-Sahara Africa.
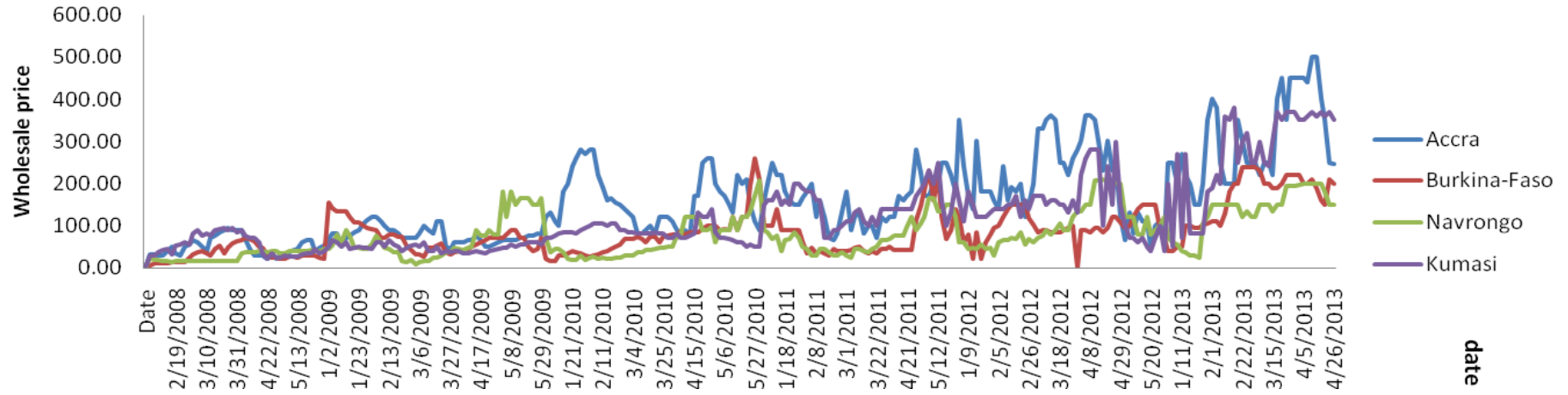
The plots demonstrate that price variability in West African agricultural commodities markets, especially for perishable produce like tomato may be very drastic. Price variation up to about 80% has been observed within weeks in the marketing system under analysis. Apart from the seasonal nature of these price variations, we suspect that collusive behaviour between traders as well as temporary shocks to transfer costs may also contribute to high price spreads between producing and consuming areas in Ghana. Prices in the wholesale markets fluctuate considerably over the year, reflecting not only the spatial-temporal variation in production, influenced by weather patterns, access to irrigation, and supply from Burkina Faso; but also associated costs of importing tomatoes from Burkina Faso such as tariffs, arbitrage delays, the exchange rate, border officials' corruption and harassments etc. Prices in the urban markets are also heavily influenced by market entry restrictions.

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[5] It is estimated that Navrongo supplies about 40% of fresh tomato within this January to May season.
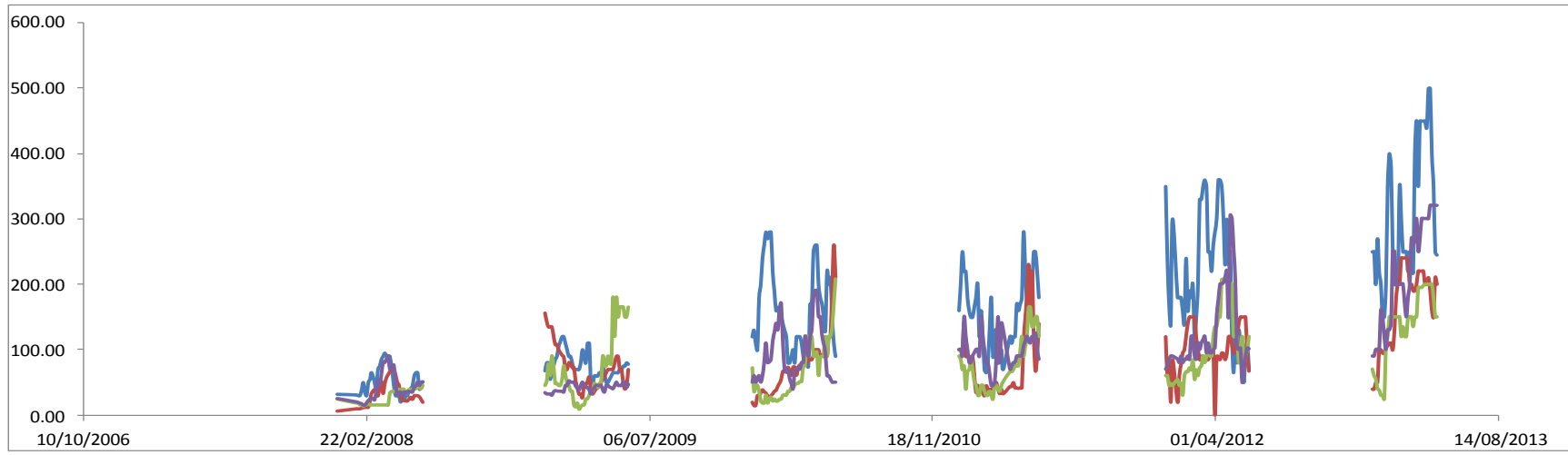
Fig. 1a: Semi-weekly Farm Gate and Wholesale Prices (GHC/Crate) in the Burkinabe Producer and Ghanaian Markets in General Trend and Seasonal Spikes (1a) and, (1b) from 01.2008 to 04.2013.

Fig 1a.

Source: Own Data

Fig 1b

Examining the price dynamics above, the spikes representing high prices within the 5-month production season occurs around April/May when production in Navrongo is depleted.

Since our data is time series, we conducted unit root test on the data to examine its level of integration and thus its usefulness for the main analysis using the Johansen cointegration and VECM models. The results of this test are presented in Table 1.

Table 1: Results of ADF Unit Root Test on the Prices

Price Series	Price Levels		First Difference	
	Test-Statistic	*No. of Lags*	*Test-Statistic*	*No. of Lags*
Ouahigouya	-3.71	2	-10.27	2
Navrongo	-3.04**	3	-11.71	1
Tamale	-2.74**	3	-7.10	6
Techiman	-2.30**	1	-10.40	2
Kumasi	-2.20**	2	-12.95	1
Accra	-2.22**	5	-9.78	4

The asterisk ***, **, * denote statistical significance (rejection of Ho) at the critical values -3.43, -2.86, -2.57 for the 1%, 5% and 10% levels respectively. The No. of lags is determined by the Akaike Information Criterion (AIC)

Source: Own Data

Except the series of Ouahigouya, the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979) performed with seasonal dummies to cater for the seasonal nature of the data fails to reject the null hypothesis of a unit root in each of the price series in levels, and rejects this null hypothesis for the first differences of each price series. Therefore, we reject the null hypothesis of no unit roots in the series and conclude that overall, the series used for the analysis is I(1) i.e. integrated to the level one in their levels.

Results
Tradability[6], Transaction Cost and Arbitrageur Margins

Without tradability characterised by active arbitrage and the physical flow of the tomato from Ouahigouya to the Ghanaian markets, then price transmission between and the integration of the markets involved cannot be possible. In this case, the markets involved will be either segmented or imperfectly integrated. In addition to tradability and trade flow in tomato, transaction cost plays a major role in determining price transmission, market integration and the activities and rents of arbitrageurs. The mere physical observation of trade between the producer and the Ghanaian markets is a *prima facie* evidence that the markets are interconnected by trade and, possibly integrated. This is especially so since arbitrageurs do not accrue zero marginal returns (Table 2).

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[6] In terms of market integration, a product is "tradable" between two markets if the good is actually traded or if market intermediaries are indifferent about exporting and not exporting the good from one location or country to the other (Abunyuwah, 2008).

Table 2: Transaction Cost, Average Wholesale Prices and Arbitrageur Profit Margins in GHC

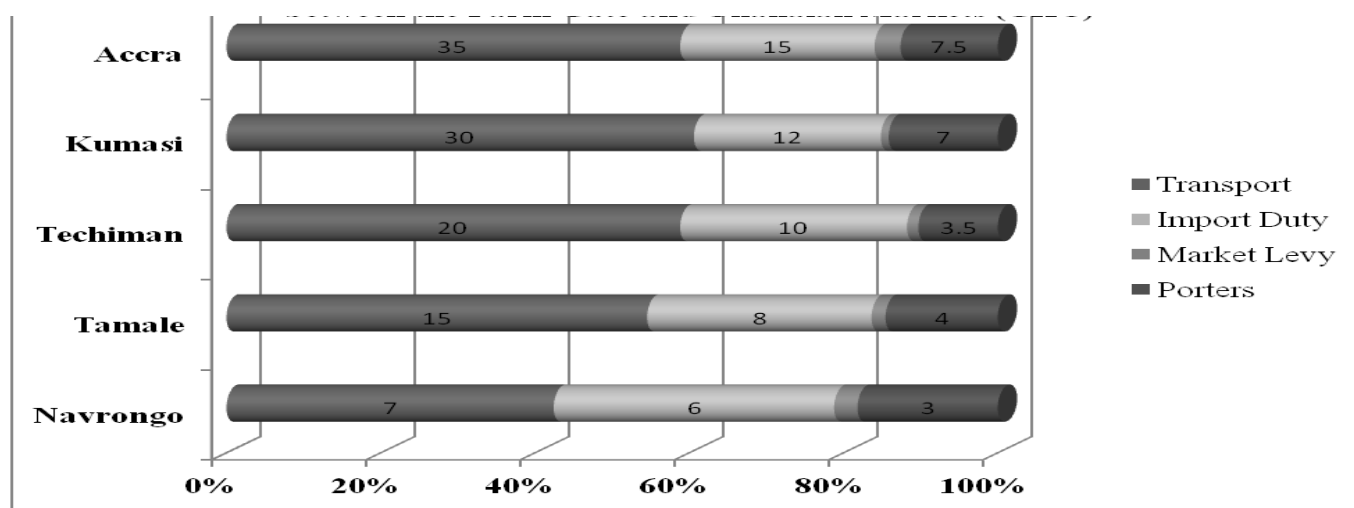| Trade Flow: Ouahigouya -	Distance (Km)	Transaction Cost	Wholesale Price	Profit Margin
Navrongo	331.91	14.44	77.91	7.98
Tamale	495.97	27.44	99.17	16.23
Techiman	668.9	37.94	110.91	17.48
Kumasi	771.07	51.44	121.17	14.23
Accra	925.27	60.44	158.27	42.33

Source: Own Data

The "official" transaction costs required to move a crate of tomato between Ouahigouya and the Ghanaian markets include the costs of transportation, import tariffs, market levy and porters charges including the costs of loading and offloading the commodity in crates into trucks. The estimated costs range from GHC14.14 for nearest market, Navrongo, with a distance of about 332 Km to GHC60.44 for the furthest market, Accra, with a distance of about 925 Km. As expected, the farther the market, the higher the transaction costs. This is because the greatest proportion of this cost is transportation cost (Fig. 2).

Besides the trade policy environment and other market distortions, high transactions cost may deter arbitrage, cause price/rent variations between two market points, and ultimately determine the behaviour of the long-run relationship between same markets in the face of economic uncertainties (Abunyuwah, 2008).

Fig. 2: Categorisation of Transaction Cost of Tomato for the Arbitrage from Ouahigouya to the

Ghanaian Markets (GHC)

If this is the case in intra-regional trade, they may be implications for regional economic integration. With transportation costs being over 50% of the transaction cost of moving a crate of tomato from Ouahigouha to each of the Ghanaian markets, it implies that transportation costs are more of an impediment to regional trade in West Africa than tariffs and non-tariff trade obstacles.

The results also demonstrate that over the period of the study, the wholesale arbitrageurs of tomato from Ouahigouya to selected Ghanaian markets make considerable profits over and above the associated transaction costs. In contrast to the transaction costs, the non-zero arbitrageurs' margins ranging from about GHC8.00 for itinerant wholesale traders based in Navrongo to about GHC42.00 for those in Accra are incentives that bind the producer to the consumer tomato markets. If rent to trade was below transaction cost, it will be a disincentive to arbitrageurs. In this case, trade may cease, price signals will not be transmitted from the producer to the consumer markets, and the markets involved will not be integrated i.e. there will be market segmentation.

The results in Table 2 seem to generally suggest that the higher the distance and transaction cost between Ouahigouya and the Ghanaian markets, the higher the amount of profits accruing to the traders. This may be so because non-measurable elements of transaction cost such as risk premium and corruption at highway checkpoints increase with the distance between the producer and consumer markets.

Price Transmission, Cross Border Market Integration and Causality

One of the simplest and premier methods for examining the integration of markets is the cointegration method. In this analysis, we apply the Johansen trace test for cointegration (Johansen, 1991) to determine whether the markets under study are spatially integrated via the co-movement of their prices over time.

If two price series, here P^m and P^l, in two spatially separated markets contain stochastic trends and are integrated of the same order, say I (d), the markets are said to be cointegrated if there is a linear relationship between the price series. The results of the pair-wise cointegration analysis between the producer and consumer markets are presented in Table 3.

Table 3: Cointegration between the Burkinabe and Ghanaian Tomato Markets

Trade Flow Ouahigouya -	Null Hypothesis ($H0$)	Test-Statistic	No. of Lags	Evidence	Cointegration Coefficient ($\hat{\beta}$)
Navrongo	$r = 0$	36.17***	3	Cointegration	-0.756
	$r = 1$	8.47*			
Tamale	$r = 0$	35.18***	3	Cointegration	-0.935
	$r = 1$	6.50			
Techiman	$r = 0$	35.66***	3	Cointegration	-0.572
	$r = 1$	6.69			
Kumasi	$r = 0$	27.74***	3	Cointegration	-0.767
	$r = 1$	4.98			
Accra	$r = 0$	32.60***	2	Cointegration	-0.824
	$r = 1$	9.02			

The asterisk ***, **, * denote statistical significance (rejection of Ho) at the critical values -3.43, -2.86, -2.57 for the 1%, 5% and 10% levels respectively. The No. of lags is determined by the Akaike Information Criterion (AIC)

Source: Computed from Own Data

The results reveal in all cases at least one significant, cointegrating vector (r = 1) between the market pairs. Thus we reject the null hypothesis that there is no cointegrating vector (r = 0) in favour of the alternative hypothesis that there is one cointegrating vector for each of the five pairs of producer market/consumer market prices.

This implies that a common stochastic process, possibly the effective flow of the commodity and/or trade information, seems to determine price dynamics between the markets. As a result, tomato prices between the markets do not drift apart in the long run, but always converge towards long run equilibrium following random, short run shocks on prices.

The evidence of at least one cointegrating vector between market pairs has economic meaning if we compute the magnitude of the cointegration relation ($\hat{\beta}_1$) between the pair of markets. The cointegration relation, computed from the long run equilibrium condition: $ECT_t = P_t^c - \beta_1 P_t^s - \beta_0$, measures the long run effect of a change in a commodity's price in a given market on its price in another. The estimated cointegration coefficients in Table 3 are all high and statistically significant. The coefficients range from -0.572 (57.2%) to -0.935 (93.5%)[7] and appear to suggest that the markets pairs involved are highly cointegrated in the long run. The negative signs of the coefficients mean that a rise in the farm gate price may likely reduce cointegration and thus price transmission between the pair of markets trading with each other.

The evidence of significant cointegrating vectors between the net producer and net consumer tomato market pairs is a necessary condition for using the VECM to determine the speed of price transmission between the market pairs. The results of the estimated VECM are presented in Table 4.

Table 4: Estimated Speeds and Half-lives of Price Transmission

Trade Flow Ouahigouya -	Import Price (α^s)	Half-life (λ^s)	Local Price (α^c)	Half-life (λ^c)
Navrongo	-0.136*** (-3.728)	4.74	0.108*** (3.356)	6.06
Tamale	-0. 137*** (-4.377)	4.70	0.079*** (3.629)	8.42
Techiman	-0.178*** (-5.075)	3.54	-0.025 (-1.136)	-
Kumasi	-0.122*** (-4.177)	5.33	0.050* (1.879)	13.51
Accra	-0.142 *** (-4.594)	4.53	0.055* (1.876)	12.25

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[7] These estimates are elasticity values since the analysis is done with the log values of the prices.

The results show estimated speeds of price transmission and their corresponding half-lives for market pairs involving Ouahigouya and the five Ghanaian tomato markets. Two forms of the speed of price transmission (adjustment) parameter are estimated in each VECM equation - α^s which measures the response to price shocks by the producer market to correct disequilibrium and α^c measuring the price adjustment by the consumer markets to correct disequilibrium following shocks. The two parameters represent the dynamic interactions between Ouahigouha and, Navrongo, Tamale, Techiman, Kumasi and Accra pair-wise for the entire period of the study. The price adjustment half-lives λ^s and λ^c, for the producer and consumer markets respectively, measure the time required by the producer market (in the case of λ^s) or the consumer for (λ^c) to correct half of the deviations from equilibrium.

All but one of the estimated speeds of price transmission are high, ranging from a minimum of 0.05 (5%) as the speed of transmission from Kumasi to a maximum of 0.178 (18%), the adjustment of the producer market with respect to Techiman. In particular, the speeds of price transmission by the producer market ($\hat{\alpha}^s$) ranging from -0.122 (12%) to -0.178 (18%) are higher and generally more statistically significant than the speeds of transmission of the Ghanaian consumer markets, where only Navrongo, the closest Ghanaian Market to Ouahigouha shows significant adjustment over 10% .

This means that overall, the consumer markets, except Navrongo are completely weakly exogenous; allowing more of the effects of price shocks at the farm gate to be transmitted across the border than price shocks in the Ghanaian markets to do same. This may be a reflection of arbitrageurs vested behaviour and/or misuse of imperfect market information flow between the producer/consumer market pairs to impose imperfect market equilibrium

conditions. A possible solution may be to create competitive markets and improve price information flow between the markets.

The estimated half-lives, λ^s, for the speeds of price transmission by the producer market range from about 4 semi-weeks for Ouahigouya-Techiman to 5 semi-weeks for Ouahigouya-Kumasi, whereas the half-lives λ^c, for the consumer markets computed for only the statistically significant adjustment speeds[8] are 6, 8, 14 and 12 semi-weeks respectively for Navrongo, Tamale, Kumasi and Accra respectively. This, in consonance with the results of the speeds of price transmission, means that disequilibrium and unexploited arbitrage opportunities persist a little longer in the consumer markets than in the producer market.

Finally, the results of the granger causality model (Table 5) reveal that in all but one of the cases, there is evidence of uni-directional or one-way causality effects from the producer to the consumer market or vice versa. In the economic sense, this means that the markets use information from each other when forming their own price expectations; and arbitrageurs as well as producers respectively take the price level in the producer or consumer market into consideration when determining the price of tomato in the respective markets.

We observe that in some cases, causality is instantaneous even when Granger causality is absent; suggesting that price signals may be transmitted instantaneously under special circumstances. As we note above, price and market information may be used by both tomato producers and arbitrageurs in the price determination process, but the flow of this information may be imperfect or incomplete.

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[8] Note that the estimated half-lives make economic sense for only significant adjustment speeds; hence no half-life (λ^c) estimates exist for Techiman.

Table 5: Causality between Ouahigouya and the Ghanaian Markets

Market Pair	Test Statistic	Market Pair	Test Statistic	Evidence
Ouahigouya →Navrongo	2.17**	Navrongo→Ouahigouya	1.45	One-way
Ouahigouya→Tamale	0.54	Tamale→Ouahigouya	2.03**	One-way
Ouahigouya →Techiman	2.64**	Techiman→Ouahigouya	1.60	One-way
Ouahigouya→Kumasi	0.57	Kumasi→Ouahigouya	0.61	No Causality
Ouahigouya→Accra	0.99	Accra→Ouahigouya	2.39**	One-way

Conclusions

The results of the above analysis show that the semi-weekly prices of fresh tomato largely co-move over the period of the investigation. Overall, the net consumer markets are weakly exogenous (i.e. they either do not react at all or react weakly to deviations from their long-run equilibrium with the net producer markets). The net producer market on the other hand exhibit stronger and significant response to deviations from this equilibrium. This weak exogeneity of the consumer markets may be attributed to the use of market power by traders to create price transmission asymmetry – the transmission of especially positive price changes at the farm gate to retail and consumer markets while withholding positive price changes in the consumer markets from reaching the farm gate.

In conclusion, some evidence of the link between international borders and distance on the one hand, and the speed of price transmission on the other has been obtained using prices of tomato at the production centre at Burkina-Faso with prices on Ghanaian tomato markets. These results suggest that though borders in West Africa do not completely curtail cross-border trade, price transmission and consequently market integration, they nevertheless weaken these processes.

Whether the observed, reducing effects are solely border and distance dependent or whether other micro drivers including poor communication, marketing, transportation, exchange rate, language and other practical difficulties are involved, is however difficult to unravel. What is clear from the findings is that more can be done to improve the speed of price transmission between Ghanaian and Burkinabe tomato markets. Such an improvement is necessary to ultimately lead to an enhanced welfare for tomato producers and consumers in both countries and a high level of regional integration between the WAEMU member countries.

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Appendix A: Plots of Individual Market Prices

Plot of Time Series 1986.3−2040.5, T=273

Kumasi

Tamale

Techiman

Navrongo