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Border effects on spatial price transmission between fresh tomato markets in Ghana and Burkina-Faso: Any case for promoting trans-border trade in West Africa?

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## **“Will the ‘BRICs Decade’ continue? – Prospects for trade and growth”**

23-24 June 2011 | Halle (Saale), Germany

### **Border Effects on Spatial Price Transmission between Fresh Tomato Markets in Ghana and Burkina-Faso: Any Case for Promoting Trans-border Trade in West Africa?**

#### **Abstract**

Cross-border trade in food commodities within sub-regional economic blocks in Sub-Saharan Africa (SSA) is believed to be faster, cheaper, more convenient and welfare-enhancing than overseas trade between SSA countries and the USA, EU and the BRIC countries. The difficulty of commodity arbitrage across international borders SSA is however a fundamental constraint to price transmission, market integration and the realisation of the welfare-enhancing role of cross-border trade in Africa. This study examines the impact of border and distance on price transmission between tomato markets in Ghana and Burkina-Faso. The analysis applies a regime-switching vector error correction model to estimate semi-weekly, wholesale prices of tomato in four tomato markets in Ghana and a production centre in Burkina-Faso. Estimated parameters of price transmission contain evidence of border and distance effects. This is expected since high transfer costs, including cross-border tariffs are incurred by traders in moving tomato across the border. Moreover, the perishable nature of tomato, and the poor quality of roads and transportation facilities may imply additional costs of risks to arbitrageurs. The findings have both theoretical relevance and practical implications for facilitating cross-border trade in West Africa, especially for trade between landlocked countries like Burkina-Faso and coastal ones like Ghana.

**Key Words: Price Transmission, Border, Tomato, Ghana, Burkina-Faso**

**JEL Codes: C32, Q11, Q13, Q17, Q18**

## 1. Introduction

Agricultural trade in the emerging economies of Brazil, Russia, India and China (BRIC) as in many other developing countries is undergoing a tremendous, directional shift. The old trading order is characterised by the conventional exports of raw material and primary food products usually by developing countries overseas to countries with which they have historical, colonial links and conversely imports of finished products from the latter to the developing countries. The emerging order of trade regimes tends to be within regional and sub-regional economic blocks and bilateralism and aims at improving sub-regional supply chains and meeting regional development partnership agreements. The ongoing process of globalisation and domestic market reforms under WTO establishments even appears to have assumed diminished importance under this new trading pattern.

The new trend comes not as a surprise to many economic analysts. With the deadlock on WTO Doha Round of negotiations, the agricultural sectors of many low income WTO member countries have been left opened to the vagaries of international economic shocks. The agricultural sectors of Sub-Sahara African (SSA) countries have particularly become extremely susceptible to shocks from the global economic and food price crises. The crises-related effects on agricultural markets in SSA countries have been compounded by the increasing need for high quality standards in products, sanitary and phytosanitary norms and changing demand in the markets of SSA's traditional trading partners.

While the changing scenario of agricultural trading systems is unabated, it is unclear how successful this new system of trade will be. The question is does the new system offer great opportunities for the agricultural sectors of developing countries or does it represent a likely case in which the production and exports of developing countries have become more vulnerable to the risks and uncertainties of regionalism. Whatever the case may be, what is clear is the fact that the future of the new system will largely depend on the incentives cross-border trade, including efficient price transmission and market integration between sub-regional trading partners.

The transmission of price signals between spatially separated markets plays an important role in explaining market performance, their degree of integration or isolation, and the speed at which price signals are transmitted between surplus, producer markets and deficit, consumer markets for a given commodity.

Knowledge on the extent of price transmission is useful in guiding production and consumption decisions, and in stimulating inter- and intra-regional trade flows needed to buffer the price and welfare effects of local supply and demand shocks (von Cramon-Taubadel and Ihle, 2009). If no barriers to trade exist, prices of a given commodity at geographically separated locations should be so strongly linked that price shocks in individual markets within a given country evoke responses in the corresponding markets of its trading partners.

The seasonal arbitrage of fresh tomato between Ghana and her northern neighbour Burkina-Faso represents one of the largest and strongest cross-border trades in agricultural commodities in West Africa. Between January and June yearly, about 35,000 tonnes of fresh

tomato are imported from Burkina-Faso into Ghana via the arbitrage activities of itinerary female traders called *market queens* (IRIN Africa, 2009)<sup>1</sup>. While there exists a free flow of tomato across the border of the two countries because of the absence of formal trade restrictions, the presence of the international border may nonetheless impose important costs in the form of tariffs, arbitrage delays, corruption and harassment of traders by border officials, the cost of changing exchange rates and communication barriers between Ghanaian traders and Burkinabe tomato producers. This means, tomato price formation in this period (hereafter called the Burkina-Faso regime) is affected not only by demand-supply shocks in Ghana and the above listed costs to trade, but also by price dynamics in Burkinabe tomato markets.

Most empirical research on spatial or temporal price relationships in agricultural markets tends to examine the underlying factors likely to drive arbitrage, price transmission and integration between markets. For example, von Cramon-Taubadel (1998), Abdulai (2000), Meyer and von Cramon-Taubadel (2004) test the implications of market power on asymmetric price transmission in selected markets. Moser et al (2006) examine the role of crime rate, remoteness and lack of information in the sub-regional integration of rice markets in Madagascar. Recently, Jensen (2007) and Aker (2008) shed light on the importance of information flow on stochastic price processes in spatially separated markets in India and Niger respectively. Stephens et al. (2008) and Ihle et al (2010) also examine the possibility of mechanisms, other than physical trade flow, causing stochastic price adjustments in periods during which no direct trade takes place between spatially separated markets.

Whereas the above studies, among others, immensely contribute to our understanding of the performance of agricultural produce markets, their common limitation include a failure to consider the existence of political impediments such as regional or national borders to arbitrage and spatial price transmission. This study intends to add to our understanding of price transmission by extending the analysis to examine whether or not price transmission between fresh tomato markets in Ghana and Burkina-Faso displays evidence of distance and border effects. We fundamentally seek to determine the nature of price dynamics in Ghanaian tomato markets in the season of supply from Burkina-Faso and in the season without tomato imports from Burkina-Faso.

Specifically, we intend to address the following objectives:

- 1) To determine the speed of price transmission between four, major fresh tomato consumer markets in Ghana and the producer market when Burkina-Faso is the major source of tomato in the Ghanaian fresh tomato market by estimating cross-country price transmission parameters.
- 2) To determine the speed of price transmission between the four consumer tomato markets in Ghana and the producer market when Ghana's fresh tomato supply source is local by estimating within-country price transmission parameters, and
- 3) To check whether the distance and international border between markets in the two countries matter for price transmission by comparing the estimated cross – and within-country price transmission parameters.

With respect to the above objectives, the analysis is performed under two major, seasonally depended, tomato production regimes – a Burkina-Faso regime of fresh tomato supply to Ghanaian markets from January to May and a non-Burkina-Faso (Techiman) regime of fresh

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<sup>1</sup> This is only the recorded volume of trade; the non-recorded component may be as high.

tomato supply from June – December, yearly. We therefore use a regime-dependent vector error correction model (VECM) and a semi-weekly, wholesale level dataset of prices from Burkina-Faso and Techiman as tomato-producing markets and Tamale, Kumasi and Accra as tomato consuming markets, for the analysis.

Our task is to quantify the degree of inter-market price adjustment; hence market integration, subject to regime disparities in fresh tomato supply levels, inter-market trade flows, prices and transaction costs between the selected Ghanaian tomato markets connected by trade to production areas in Burkina-Faso. In this way, our analysis is spatiotemporal in nature since it examines price transmission across space (market locations) and over time (season-to-season). The estimated parameters are therefore expected to serve as indicators of border and distance effects on the integration of the markets under study, and to be applied in evaluating the potential of cross-border trade in agricultural commodities within the Economic Community of West African States (ECOWAS).

The findings may therefore inform current and future policy strategies for promoting sub-regional trade, market integration and efficiency. In addition, identifying how inter-market price relationships for tomato deviate with and without imports from Burkina-Faso may be useful in formulating policy options for tackling the seasonal gluts and price hikes in Ghanaian tomato markets, and for engaging in the Economic Community of West African States (ECOWAS) protocol for the cross-border trade in agricultural commodities in the sub-region. In the long run, this will guide policy towards improving the welfare of actors, viz. producers, traders, transporters and consumers in exporting and importing countries in the tomato industry in the sub-region.

## 2. Literature Review

Many empirical studies have often endeavoured to attribute the degree of inter-market price relationships over time or space to fundamental market- and price-related factors or variables, called the “forcing variables” of market integration (Padilla-Bernal et al, 2003).

It is generally agreed among economists that free trade promotes an efficient allocation of resources, and that policies that impede trade reduce a country’s standard of living. It has also been revealed that trade contributes to economic growth (Frankel and Romer 1999, Feyrer 2008). Debate continues, however, on the degree to which national borders affect the integration of markets across countries sharing a common border. Therefore, understanding the impact of border effects on the performance of cross-border markets for a homogeneous commodity, especially food staples cannot be underestimated.

Fundamentally, the existence of a border between a pair of markets has two implications *ceteris paribus* for the transmission of price signals between the market pair: 1) a minimal effect due to efficient arbitrage activities and a free flow of the commodity and market information over space (such as in a functioning trade zone with a common currency and low or zero tariffs), or 2) varying degrees of negative effects resulting from tariff and non-tariff measures, border formalities and costs due to corruption, collusive behaviour of traders etc (Ihle, von Cramon-Taubadel and Zorya, 2010). The second effect is likely to be the case for commodities with a low inter-temporal (harvest-delivery) gap such as fruits and vegetables; and in developing countries where storage (mechanical refrigeration) and processing facilities

for extending the inter-temporal period are lacking, and the political impediments mentioned above exist.

Goodwin et al (2002) associate price transmission between markets with improvements in transportation and telecommunication, factors which boost the connectivity of buyers to sellers and reduce commodity or buyer search costs. According to Barrett (2001), the observance of trade flows between markets is important for their integration and efficiency. In fact, increased trade flows between markets may imply increased integration and equilibrium between them (Padilla-Bernal et al, 2003).

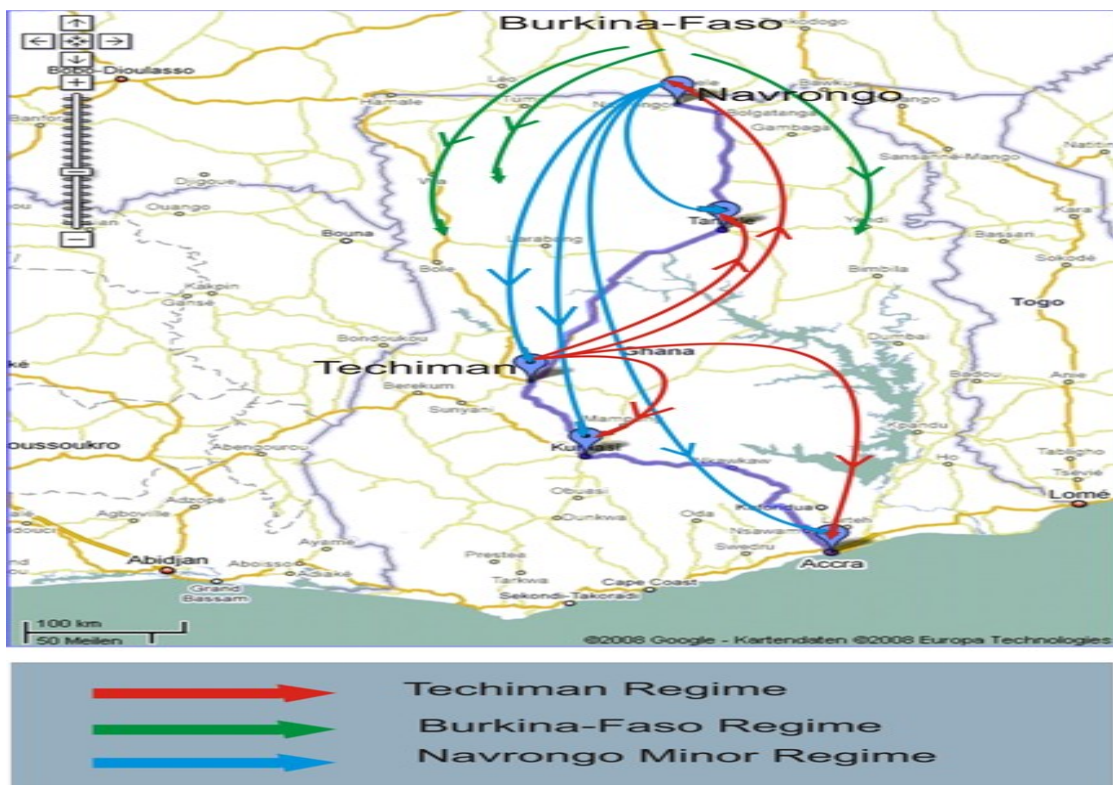
Miljkovic (1999) in Padilla-Bernal et al (2003) identify several reasons that often explain lack of integration between markets, namely noncontinuous trade flows, pricing to market, and the geographical separation of markets. All these studies measure different responses emanating from different levels of shocks associated with the underlying determinants of integration viz. transaction costs, thresholds, trade and information flows, distance etc.

A few studies in the literature also measure price adjustment parameters subject to seasonal shifts in output and prices (Parrott et al, 2001; Goodwin et al 2002 and Goetz and von Cramon-Taubadel, 2006). These studies, unlike ours, however either focus on non-perishable commodities or are based in temperate, industrial countries where political (border) impediments to arbitrage and limitations to storage/mechanized refrigeration and processing are minimal. Our study is in this regard therefore a unique addition to the price transmission literature.

### 3. Study Setting and Data

The markets under study and the pattern of trade flow between them is depicted in Fig. 1.

**Fig.1: Map of Ghana showing the target Markets and pattern of seasonal Trade Flow**



Four major, Ghanaian tomato markets and a key production centre - Po in the Central Province of the Republic of Burkina-Faso are considered under the analysis. The Ghanaian markets include one net producer market - Techiman which supplies a substantial share of Ghana's fresh tomato in the rainy season – June to December, and three net consumer markets namely Tamale, Kumasi and Accra located in the three largest cities of Ghana.

Due primarily to differences in the weather conditions between Ghana's major producer market – Techiman and that of Burkina-Faso – Po, fresh tomato supply to the Ghanaian tomato market is seasonally-switching. The producer market in Po is located in the Sudan Savannah zone of Burkina-Faso and dependent on irrigated production. It is a prominent (exporting about 60%) source of tomato supply in the dry season (December - May) to Ghanaian markets, while Techiman (and surrounding areas) located in the southern, forest region of Ghana, using a rain-fed production system, supplies the marketing system with tomato in the rainy season (June- December). Alongside the Po supply season is another major supply and trade flow regime – Navrongo, which supplies an estimated 40% of fresh tomato within the dry season.

From the above description, three trading regimes can be identified in Ghana's tomato marketing system in terms of supply and trade flows, namely the Navrongo and Techiman regimes with domestic sources of supply, and the Po regime representing fresh tomato imports from Burkina-Faso.

Examining the total average and the standard deviation of prices under each regime in Table 1, it can be observed that in the overall, average standard deviation of prices in the Po regime is higher ( $GH\text{¢}36.00$ ) than that of the Techiman ( $GH\text{¢}29.00$ ) and Navrongo ( $GH\text{¢}28.00$ ) regimes. The observed regime-disparities in the above descriptive statistics may likely influence actual price adjustment processes in Ghana's tomato marketing system.

**Table1: Some Regime-Dependent Descriptive Statistics of the Price Series**

<i>Market</i>	<i>Average and Standard Deviation of Prices (GH¢/Crate)</i>					
	<b>Navrongo Regime<sup>1</sup></b>		<b>Po Regime</b>		<b>Techiman Regime</b>	
Navrongo	29	19	73	45	54	30
Tamale	43	26	61	35	43	27
Techiman	57	29	57	28	37	26
Kumasi	60	26	68	23	44	21
Accra	101	40	83	45	69	40

Source: Own Computations.

<sup>1</sup>The values in the first column under each regime are the mean values while those in the second are standard deviations

It should be noted however that there are never wholly exclusive delimitations defining each of the three regimes and alternating supply regimes may exhibit common points of convergence. Our definitions here depend on the patterns of supply from the production areas, while observing that the length of regimes may vary with supply patterns, which in turn may be seasonally determined. The near-periodicity in the occurrence of the supply patterns

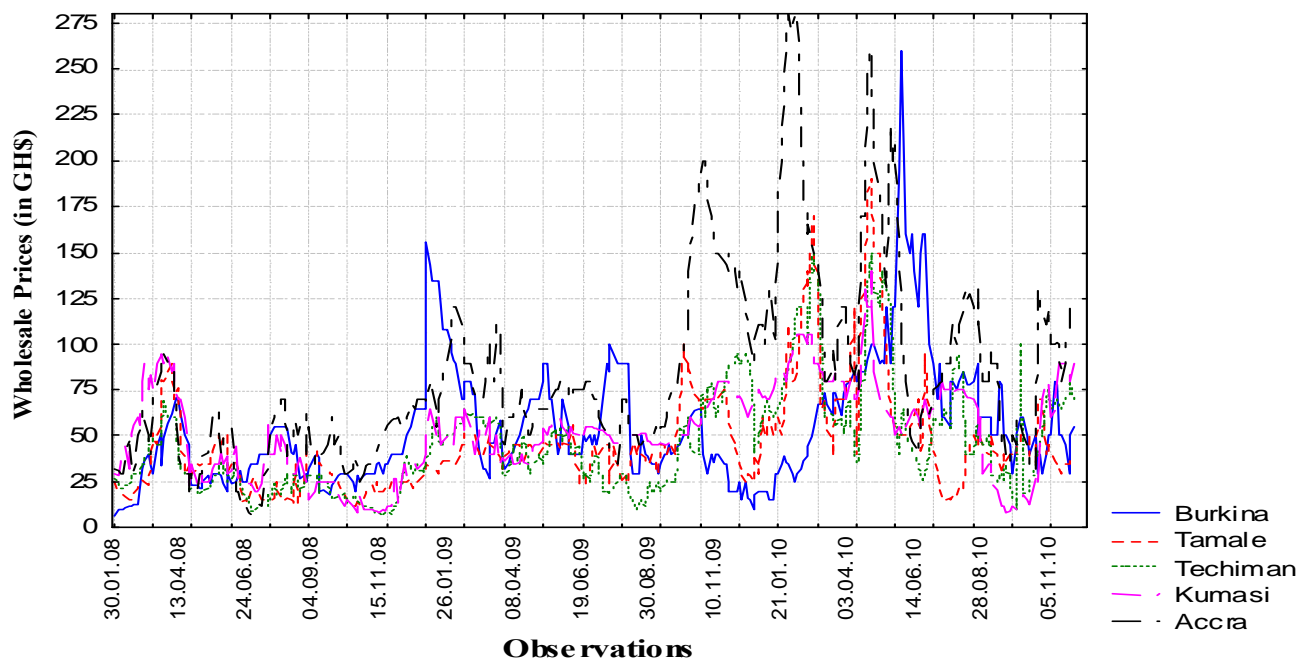
nevertheless provides a practical basis for our classification of the trading regimes as defined above.

From the above description, we hypothesized that border and distance effects do influence the integration of the markets under study. We expect these effects to delineate the inter-market arbitrage process into three regimes, defined by the sources of tomato supply and trade flow regimes – the domestic, Navrongo and Techiman regimes and the cross-border Po regime. That is, changing supply levels from the three sources act as shocks to market equilibrium and solicit different responses, depending on the patterns of trade flow and switching in the source of supply as illustrated in Fig. 1.

The complete data used for the analysis comprises a three-year long (spanning seven tomato production seasons), semi-weekly, wholesale level price series from 3.2007 and to 3.2010 with 348 observations. The series is generated through self-conducted market surveys administered continuously for the seven tomato production seasons in the five tomato markets – Navrongo, Tamale, Techiman, Kumasi and Accra. Prices are quoted for the best quality of tomato available at the time of the survey in the given market. Since the Navrongo regime occurs simultaneously with the Po regime and supplies just about 40% of the total supply in the dry season, and since our interest is only to examine within-country and cross-border price transmission processes, we drop Navrongo and use only the Techiman (hereafter called the non Burkina-Faso) and Po (hereafter called the Burkina-Faso) regimes in the major analysis.

Though the survey yields data comprising wholesale level prices, trade flows, transaction costs and other descriptive information on fresh tomato markets in Ghana, only the price series, expressed in nominal terms of the Ghana cedi per a maxi-crate of fresh and ripped tomato, is explicitly used in this analysis. The additional information however provides a context for discussion the empirical results. Fig. 2 depicts a graphical plot of the price series.

**Fig. 2: Wholesale Level, Semi-Weekly Prices of Fresh Tomato in Ghana and Burkina-Faso (1.2008 - 9.2010)**



Source: Own Computations.



The graphical analysis of fresh tomato prices in the five markets show the normal pattern of variability pertaining to prices of perishable commodities. It appears that the markets of Kumasi, Techiman, Tamale and Burkina (Po) represent price series that are very much related in terms of co-movement. Whereas Accra 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 of the analysis. This is expected since Accra is the largest consumer market for fresh tomato in Ghana, while its farthest location (longest distance) from the domestic and cross-border production centres implies higher transaction costs and arbitrage risks, major components of the price for perishable commodities in Sub-Sahara Africa.

#### 4. Methodology

The main model applied to analyse our high frequency data is the vector error correction model (VECM) which focuses on prices and trade regimes instead of price margins and transaction costs. The model allows the estimation of regime-dependent adjustment parameters, permitting inferences on the reactions of prices to deviations from long-run equilibrium and enabling the estimation of price adjustment coefficients for periods with and without the Po supply regime. In this way, we obtained evidence on the nature of price transmission in the absence of tomato supply and direct, physical trade flows of fresh tomato from Burkina-Faso and in the presence of same. In this section, we specify the VECM used to analyze the data.

If the prices on the net producer market  $s$  and the net consumer market  $c$  are cointegrated, we may denote the equilibrium relationship between the net consumer prices series  $P_t^c$  and net producer price series  $P_t^s$  as:  $P_t^c - \beta_1 P_t^s - \beta_0 = v_t$ . If  $v_t$ , the error term, is assumed to follow an autoregressive (AR) process, then  $v_t = \alpha v_{t-1} + \varepsilon_t$ . This means the equilibrium relationship between  $P_t^c$  and  $P_t^s$  can be expressed as:

$$P_t^c - \beta_1 P_t^s - \beta_0 = \alpha v_{t-1} + \varepsilon_t \quad (1)$$

The equation (1) implies that the long run relationship or cointegration between  $P_t^c$  and  $P_t^s$  is a function of the autoregressive process  $v_{t-1}$ . In the above linear representation,  $v_{t-1}$  represents deviations from long run equilibrium, and is called the error correction term (ECT), while  $\alpha$  measures the response of  $P_t^c$  and  $P_t^s$  to deviation from equilibrium following random shocks to the markets i.e. price transmission.

We derive the VECM from equation (1) by specifying changes in each of the contemporaneous prices,  $\Delta P_t^c$  and  $\Delta P_t^s$ , as a function of the lagged short term reactions of both prices,  $\Delta P_{t-k}^c$  and  $\Delta P_{t-k}^s$ , and their deviations from equilibrium at period  $t-1$  (i.e.  $ECT_{t-1}$ ) as follows:

$$\begin{aligned} \Delta P_t^c &= \delta_1 + \alpha^c [ECT_{t-1}] + \sum \beta_k^c \Delta P_{t-k}^c + \sum \beta_k^{cs} \Delta P_{t-1}^s + \varepsilon_t^c \\ \Delta P_t^s &= \delta_2 + \alpha^s [ECT_{t-1}] + \sum \beta_k^{sc} \Delta P_{t-k}^c + \sum \beta_k^s \Delta P_{t-1}^s + \varepsilon_t^s \end{aligned} \quad (2)$$

Where  $\Delta \mathbf{P}_t = (\Delta \mathbf{P}_t^c \ \Delta \mathbf{P}_t^s)'$  is a vector of first differences of prices in the markets  $c$  and  $s$ ; the  $\beta_k$ ,  $k = 1, \dots, n$ , are  $(2 \times 2)$  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, and  $\varepsilon_t$  is assumed to be a white noise error term. The equation (2) can be reformulated as:

$$\Delta \mathbf{P}_t = \alpha_0 + \alpha_1 \mathbf{ECM}_{t-1} + \sum_{i=1}^k \Gamma_i \Delta \mathbf{P}_{t-1} + \varepsilon_t \quad (3)$$

Where  $\Gamma_i$ ,  $i = 1 \dots k$ , is a  $k \times k$  matrix of short run coefficients which quantify the short term responses of the contemporaneous price differences to their lagged values ( $k = 2$  in our pair-wise analysis) and the other variables are as already defined above.

The error correction term,  $ECT_t$ , so named because it depicts deviations from the long run relationship or 'errors' that are 'corrected' by the price transmission process, is a continuous and linear function of the deviation of  $\mathbf{P}_t$  from the long-run equilibrium relationship following a shock on  $P_t^s$  or  $P_t^c$ ; the  $\delta_1$  and  $\delta_2$  denote long-run inter-market price margins. The coefficients  $\alpha^c$  and  $\alpha^s$ , called the loading or adjustment parameters, are the elasticity of price transmission or the speeds of price adjustment by the net producer and net consumer markets respectively, to deviations from long-run equilibrium where  $\varepsilon_t = 0$ . The closer a value of  $\alpha$  approaches one in absolute terms; the faster deviations from equilibrium become corrected.

## 5. Results and Discussion

### 5.1 Preliminary Unit Root and Cointegration Tests

Following the traditional approach of time series analysis, we first test for a random walk or stationarity in the individual price series by hypothesising unit roots in the levels and first differences of each price series using the KPSS test. We estimate the random walk with only a drift but without a trend because visually examining the graphical plot of the series in Figures 2 reveals the unlikelihood of a non-zero expected mean in the levels of the series. The plots however show no obvious persistent trending behaviour. Therefore, we omit a deterministic trend but include a drift in both the KPSS test for unit root and in the Johansen's test for cointegration. The chosen lag lengths in both tests are based on the Akaike Information criterion (AIC).

The Jmulti software was used for the preliminary analyses (cointegration and unit root tests) while the Gauss software was used to run the VECM. The results of the unit root test are presented in Table 2. From the unit root results, we strongly reject the null hypothesis of no unit roots (i.e. the series is stationary) in the level of the prices series at the 1% and 5% significance levels, but cannot reject the null hypothesis of no unit roots at the first difference of the price series. Therefore, the series under study are (first) difference stationary processes i.e. they have unit root or are I (1), and fresh tomato prices in Ghana are non-stationary in levels but their first differences are stationary.

**Table 2: Results of KPSS Unit Root Tests on the Price Series**

<i>Series</i>	<i>Test Statistics (Levels)</i>		<i>Test Statistics (First Diff.)</i>	
	<b>Statistic</b>	<b>No. of Lags</b>	<b>Statistic</b>	<b>No. of Lags</b>
Po	2.015**	3	0.078	2
Tamale	2.177**	3	0.037	2
Techiman	5.055**	1	0.022	2
Kumasi	1.694**	3	0.039	2
Accra	4.793**	2	0.017	2

Source: Own computations

The asterisks \*\* and \* denote rejection of the null hypothesis at the 1% and 5% significance levels. The respective critical values at the 1% and 5% significance levels are 0.347 and 0.463 for both the test at the levels and first difference of the series.

With the proof that the price series are non-stationary in their levels, we proceed to test for cointegration between the net producer/net consumer market pairs using the Johansen's, maximum likelihood VAR approach. The results of the cointegration test between the market pairs are presented in Table 3.

The results provide evidence in favour of cointegration between the tomato market pairs under study. The null hypothesis of  $r = 0$ , implying an absence of a cointegration relation is rejected for all the market pairs at both the 1% and 5% significance levels. We cannot however reject the null hypothesis of one cointegrating relation, i.e.  $r = 1$  between pairs of net producer/net consumer markets, especially at the 1% significance level. This means, there exists at least one stationary cointegration relation ( $r = 1$ ) between the pairs of net producer and net consumer price series measured semi-weekly, and by implication in the tomato marketing system in Ghana and between the Ghanaian tomato markets and Po in Burkina-Faso.

The findings imply that similar stochastic processes, possibly induced by efficient information flow or seasonal effects, drive the behaviour of prices in the system of markets (Motamed et al, 2008). Therefore tomato prices in the producer and consumer markets do not drift apart in the long run. The proof of cointegration is also evidence for a common domestic tomato market in Ghana, where inter-market prices adjust to achieve long-run, market equilibrium. Perhaps the seasonal nature of tomato production, with either the Po/Navrongo or Techiman market being a major source of supply to the other markets in the system per season, and recent improvements in roads, means of transportation and information flow via mobile phones, explains this outcome. Whatever the case may be, the evidence of at least one cointegrating relation between the market pairs provides an ideal setting for us to use the VECM to explore border and distance effects on price transmission and market integration between the selected markets.

**Table 3: Johansen's Test of Cointegration**

<i>Market Pair</i>	<i>Test Statistic (Trace Test)</i>	
	<b>Ho: r = 0</b>	<b>Ho: r = 1</b>
Po - Accra	26.38**	11.84*
Po - Kumasi	27.91**	9.07
Po - Techiman	20.46*	9.37
Po - Tamale	33.64**	11.62*
Techiman -Accra	50.04**	7.91
Techiman -Kumasi	32.45**	8.00
Techiman -Tamale	31.48**	8.63

Source: Own Computations.

The asterisks \*\* and \* denote rejection of the null hypothesis of no cointegration vector at the 1% and 5% levels respectively. The critical values for  $r = 0$  and  $r = 1$  at the 1% and 5% significance levels are 24.69 and 12.53 and 20.16 and 9.14 respectively.

## 5.2 Results of the Vector Error Correction Model

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 effects of price shocks on price adjustment. In this section, the results of the estimated regime-dependent VECM are presented and their implications discussed.

### 5.2.1 Price Transmission between Tomato Markets in the Burkina-Faso Regime

The results of the econometric estimation of the VECM for the supply-destination market pairs under the Burkina-Faso regime are presented in Table 4.

Significant speeds or magnitude of price transmission, which measures the response to price shocks by the source market<sup>2</sup> in Burkina-Faso ( $\alpha^s$ ) show varying degrees of price relationships. They range from -0.051 (5.1%) between Po and Accra separated by the longest geographical distance with a border effect, to -0.169 (16.9%) between Po and Kumasi interconnected by an effective transportation and trader networks, and having also a border component. The corresponding half-lives of adjustment, the time needed for half the deviations of price adjustment parameters from their equilibrium levels (following shocks) to be eliminated, vary from about 4 semi-weeks (12 days) for Po - Kumasi to about 13 semi-weeks (one month) for Po - Accra.

<sup>2</sup> In the present analysis, Navrongo prices proxy Burkinabe prices given the close proximity of Navrongo to the border. An ideal case would be to use actual tomato prices of the cross-border market in Burkina. Analysis in this dimension is currently being considered.

**Table 4: Estimates of Price Adjustment Speeds and Half-Lives in the Burkina-Faso Regime**

<i>Market Pair</i>	<i>Price Adjustment Parameters and Half-lives</i>			
	$\alpha^s$	$\lambda^s$	$\alpha^c$	$\lambda^c$
Po – Accra	-0.051*** [-2.318]	13.24	0.035** [2.063]	19.46
Po – Kumasi	-0.169*** [-3.275]	3.74	0.030 [0.992]	-
Po – Tamale	-0.157*** [-2.326]	4.06	0.036 [0.649]	-
Po – Techiman	-0.032 [-1.264]	-	0.031** [2.064]	22.01
<b>Average<sup>3</sup></b>	<b>-0.126</b>	<b>7.01</b>	<b>0.033</b>	<b>20.73</b>

Source: Own Computations.

The asterisks \*\* and \*\*\* denote significance at the 5% and 1% level respectively.

Half-lives, measured in semi-weeks, are only computed for significant speeds of price transmission (adjustment parameters).

Price transmission by the net-consumer markets ( $\alpha^c$ ) in this regime show significant although weak relationships between only two of the market pairs: Po – Techiman (0.031 or 3.1%) and Po – Accra (0.035 or 3.5%). These speeds of price adjustment correspond to half-lives of about 22 and 19 semi-weeks respectively.

Under the Burkina-Faso regime overall, the results demonstrate that price adjustment processes that correct deviations from long-run equilibrium relationships are bidirectional, in other words prices on both markets respond to deviations from their common equilibrium, for only Po – Accra. The exceptions are Kumasi and Tamale, which do not respond to deviations from their long-run equilibriums with the source market. In addition, the source market tends to respond more rapidly to correct deviations from equilibrium, as indicated by the average adjustment parameter of about -0.126 (13%) for the adjustment by the source market as against the average of 0.033 (3.3%) for the adjustment by the two consumer markets with significant adjustment parameters.

### **5.2.2 Price Transmission between Tomato Markets in the Non-Burkina-Faso Regime**

The results of the econometric analysis under the non-Burkina-Faso regime are presented in Table 5. They provide evidence of strong and significant speeds of price transmission, hence the existence of long-run price equilibria for all four cases involving the net producer market under this regime- Techiman and the other destination markets. The price adjustment parameters by the producer market ( $\alpha^s$ ) range from 0.109 (about 11%) for Techiman-Tamale

<sup>3</sup> Though averages here have no econometric importance, they are computed here just for comparative purposes.

to about 0.212 (21%) for Techiman-Accra, and averaging 0.154 (15.4%). The corresponding adjustment half-lives range from about 3 to 6 semi-weeks, averaging 4 semi-weeks (12 days).

For the most part, like under the previous regime, the significant price responses from the net consumer markets ( $\alpha^c$ ) that correct deviations from equilibria are fewer and weaker than is the case for the net producer market. The significant adjustment speeds are 0.121 (12.1%) for Techiman – Accra, and 0.071 (7.1%) for Techiman – Tamale. Two of the four pairs – that of the producer market- Po and Kumasi do not respond to price shocks and hence do not obey the expected bidirectional adjustment of prices following shocks to equilibrium.

**Table 5: Price Adjustment Speeds and Half-Lives in the non-Burkina-Faso Regime**

<i>Market Pair</i>	<i>Price Adjustment Parameters and Half-lives</i>			
	$\alpha^s$	$\lambda^s$	$\alpha^c$	$\lambda^c$
Techiman – Accra	-0.212*** [-4.537]	2.91	0.121*** [2.636]	5.37
Techiman – Kumasi	-0.113*** [-3.156]	5.78	0.046 [1.340]	-
Techiman – Tamale	-0.109*** [-3.416]	6.00	0.071*** [2.122]	9.41
Techiman - Po <sup>4</sup>	-0.183*** [-3.196]	3.43	0.046 [0.821]	-
<b>Average Adjustment</b>	<b>0.154</b>	<b>4.53</b>	<b>0.096</b>	<b>7.39</b>

Source: Own Computations.

The asterisks \*\* and \*\*\* denote significance at the 5% and 1% level respectively.

Half-lives, measured in semi-weeks, are only computed for significant speeds of price transmission (adjustment parameters). Student t-values are in the parenthesis.

The adjustment parameters between 11 and 21% of the source market ( $\alpha^s$ ) under the non-Burkina-Faso (Techiman) regime are overall and on average higher than the corresponding estimates under the Burkina-Faso regime. Moreover, despite the largely weak response of the consumer markets ( $\alpha^c$ ) to shocks to equilibrium, the market pairs again demonstrate stronger individual and average responses under the non-Burkina-Faso regime than under the Burkina-Faso regime.

The empirical results hint at the likelihood of border and distance as underlying factors having a negative impact on price transmission between tomato markets in Ghana. The results are thus consistent with the nature of cross-border trade in the ECOWAS region. As noted earlier, even though the ECOWAS protocol on trade excludes any form of trade restrictions on member countries, practical impediments to smooth arbitrage processes exist

<sup>4</sup> Actual, physical direct flow of tomato between Techiman and Po does not really exist. Po is therefore proxied by Navrongo, which though in Ghana, it is located near the border to Burkina-Faso.

at the borders. The results in this way are of high theoretical and practical relevance; they demonstrate the extent of the integration of tomato markets between Ghana and Burkina-Faso and in the ECOWAS trade block in general. This allows policy makers to adopt the necessary steps to promote cross-border trade in the sub-region.

## **6. Conclusion and Outlook**

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 under both the Burkina-Faso and non-Burkina-Faso regimes are weakly exogenous i.e. they either do not react at all or react weakly to deviations from their long-run equilibria with the net producer markets. The net producer markets on the other hand exhibit stronger and significant response to deviations from these equilibria.

From this revelation it can be concluded that an increase in geographic distance and presence of borders between markets appear to weaken, all other things being equal, the speed of price transmission between markets separated by the borders. Transfer and transaction costs will generally increase with distance, making arbitrage more costly and increasing the average time required to complete a transaction (Ihle et al, 2010). Also the crossing of borders by traders in low income countries usually involves formal (and sometimes informal) costs, as well as delays. This effect is suspected to be particularly important in the West Africa Sub-region due to high costs incurred by traders at borders, the cumbersome nature of customs procedures and little transparency and automation of such procedures.

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, it nevertheless weakens these processes. Whether the observed, reducing effects are solely border and distance dependent or whether other underlying factors including poor communication, marketing, transportation, exchange rate, language and other practical difficulties, 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 producer in both countries. A methodological improvement of this analysis would be to extend the geographic coverage to consider more markets in Burkina-Faso and Ghana. Including in such analysis other factors such as concessionary trade conditions, not reflected in the prices would be useful.

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