Grain price adjustment asymmetry: the case of cowpea in Ghana

By

Langyintuo, Augustine S.

Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.

Grain price adjustment asymmetry: the case of cowpea in Ghana

Augustine S. Langyintuo*

Alliance for a Green Revolution in Africa (AGRA), Eden Square, Block 1, 5th Floor
P O Box 66773, 00800 Westlands, Nairobi, KENYA

* Corresponding author:
Dr. Augustine S. Langyintuo
Tel: + 254 20 3675 309
Fax: + 254 20 3675 269
E-mail: Alangyintuo@agra-alliance.org

Grain price adjustment asymmetry: the case of cowpea in Ghana

Abstract

Patterns in price adjustment in response to information are important to market practitioners. This study looks at cowpea real wholesale price adjustment patterns in Bolgatanga, Wa, Makola and Techiman markets in Ghana. Using Techiman as the central market, a threshold autoregressive test for asymmetric price adjustment rejected the null hypothesis of symmetric adjustment for only the Bolgatanga-Techiman price series. An autoregressive conditional heteroskedastic regression indicates that wholesalers in Bolgatanga market respond differentially to price signals from Techiman than those in the other two markets. This suggests that policies targeting cowpea traders must recognize the differential responses by wholesalers to information.

Keywords: Africa, Ghana, wholesalers, market information, autoregressive conditional heteroskedasticity, threshold autoregressive

JEL Classification: D82, D43

Grain price adjustment asymmetry: the case of cowpea in Ghana

Introduction

Market regulators and those involved in marketing are interested in knowing the response of local market prices to movement of prices in a central market. For instance, is price volatility the same (symmetric) with upward versus downward movements or is it greater or smaller (asymmetric)? If markets are perfectly competitive, prices adjust symmetrically. On the other hand, asymmetric price adjustment can result with oligopolistic behavior of middlemen, or inventory changes (Maccini, 1978; Blinder, 1982), or level of market concentration and interventionist attitude of governments (Scherer & Ross, 1990; Roberts, Stockton & Struckmeyer, 1994). Irrespective of the adjustment process, theory suggests that at a given level, market price adjustment patterns would be similar at various markets because of structural similarities. For example, wholesalers throughout a region may react to price changes in the same way and retailers may react in a different way.

Previous price adjustment studies on maize in Ghana (Alderman & Shively, 1996; Alderman, 1993; Shively, 1996; Bidane & Shively, 1998; Abdulai, 2000) indicated that wholesalers had similar price adjustment patterns throughout the country. Possibly, this is because Ghana is self-sufficient in maize production and hence pricing decisions are internal. In contrast, Ghana is not self-sufficient in cowpea production and has to import mainly from Burkina Faso and Niger, through the informal sector, to satisfy domestic demand (Langyintuo, et al., 2003). Initial point of entry is Bolgatanga in the Upper East region (Map 1) where wholesalers take delivery of the grains. This means that cowpea pricing policies in Burkina Faso and Niger probably have the greatest influence in that region than in any other region. One would expect differences in price adjustments among wholesalers or retailers in the Upper East region and those in the rest of the country because of differences in their market information management processes.

This study looks at price adjustment patterns in the cowpea market in Ghana. It is hypothesized that at the wholesale level price adjustment patterns are similar throughout the country. Threshold autoregressive tests are used to examine this hypothesis. The extent to which traders respond to information is examined using autoregressive conditional heteroskedastic regression analysis. It is hoped that the results will contribute to the growing literature on grain price adjustment patterns in developing economies.

Commodity markets integration and price adjustment processes

Two commodity markets are said to be spatially integrated if, when trade takes place between them, price in the importing market equals price in the exporting market plus the transportation and other transfer costs of moving the product between the two markets (Tomek & Robinson, 1990). The most widely used approach to assessing the short- and long-run integration of commodity markets is cointegration and error correction model (Alexander & Wyeth, 1994; Alderman, 1993; Dercon, 1995; Abdulai, 2000; Kuiper et al., 2003). The approach measures whether two markets are integrated in the long term by assessing whether their prices wander within a fixed band. The usual two-step residual-based test, due to Engle and Granger (1987), assumes perfect competition and hence symmetric price adjustment. The Engle and Granger relationship that defines the relationship between the price in a given local market P_t^l and the price in the central market P_t^c at time *t* is given by:

$$P_t^l = a_0 + \alpha_1 P_t^c + \varepsilon_t \qquad \ldots (1)$$

where ε_t is a random error term with constant variance that can be contemporaneously correlated. If ε_t, the marketing margin, is stationary in the test for market integration, then long-run market integration can be said to prevail between the series, that is cointegrated (Dwyer & Wallace, 1992). Short-run market integration tests, on the other hand, aim to establish whether prices in different markets respond immediately to this long-run relationship (Alexander & Wyth, 1994). The errors from the above equation are differenced and regressed on the lag values as in equation (2) below to obtain ρ.

$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \upsilon_t \qquad \ldots (2)$$

where υ_t is white noise. Rejection of the null hypothesis of no cointegration indicates that the residuals are stationary with mean zero (Engle and Granger, 1987).

To account for possible asymmetric adjustments as a result of imperfect competition, the model developed by Enders and Granger (1998), which builds on equations (1) and (2), can be employed. Enders and Granger (1998) observed that the standard procedure to estimate ρ in (2) serves as an attractor whereby its pull is strictly proportional to the absolute value of ε_t. The change in ε_t is a product of ρ and ε_{t-1}, irrespective of whether ε_{t-1} assumes a positive or negative sign implicitly assuming symmetric adjustments. To account for asymmetric adjustments, Enders and Granger (1998) therefore let the deviations from the long-run equilibrium in equation (2) behave as a Threshold Autoregressive (TAR) process as:

$$\Delta\varepsilon_t = I_t \rho_1 \varepsilon_{t-1} + (1 - I_t)\rho_2 \varepsilon_{t-1} + \upsilon_t \qquad \ldots (3)$$

where I_t is the Heaviside indicator function such that:

$$\Delta\varepsilon_t = \begin{cases} 1 & if \ \ \varepsilon_{t-1} \geq 0 \\ 0 & if \ \ \varepsilon_{t-1} < 0 \end{cases} \qquad \ldots (4)$$

The long-run equilibrium value of the sequence is $\varepsilon_t = 0$ if the system is convergent. If ε_{t-1} is above its long-run equilibrium value, the adjustment is $\rho_1 \varepsilon_{t-1}$, while the adjustment is $\rho_2 \varepsilon_{t-1}$ if ε_{t-1} is below its long-run equilibrium. If the adjustment is symmetric $\rho_1 = \rho_2$, thus implying that Engle-Granger approach is a special case of (3) and (4).

Equation (3) can be modified to include lagged changes in the ε_t sequence to obtain a *p*th-order process as:

$$\Delta\varepsilon_t = I_t \rho_1 \varepsilon_{t-1} + (1 - I_t)\rho_2 \varepsilon_{t-1} + \sum \psi_i \Delta\varepsilon_{t-1} + \upsilon_t \qquad \ldots (5)$$

When specified this way, it is possible to use diagnostic checks of the residuals (such as the autocorrelogram of the residuals and Ljung-Box tests) and various model selection criteria (such as Akaike Information Criteria (AIC) or Bayesian Information Criteria (BIC)) to determine the appropriate lag length.

Rather than state (3) with the Heaviside indicator of (4) which depends on the level of ε_{t-1}, an alternative specification that allows the decay to depend on the previous period's change in ε_{t-1} is possible. One may thus consider the Heaviside indicator according to the following rule:

$$I_t = \begin{cases} 1 \ \ if \ \ \Delta\varepsilon_{t-1} \geq 0 \\ 0 \ \ if \ \ \Delta\varepsilon_{t-1} < 0 \end{cases} \qquad \ldots (6)$$

The choice of (3) and (6) is particularly useful when adjustment is asymmetric to the degree that the series exhibits more "momentum" in one direction than the other (Enders and Granger, 1998). Such models termed momentum-threshold autoregression (M-TAR) models, exhibit little decay for positive values of $\Delta\varepsilon_{t-1}$ but substantial decay for negative values of $\Delta\varepsilon_{t-1}$ if $|\rho_1| < |\rho_2|$. This implies that increases tend to persist but decreases tend to revert quickly toward the attractor. The F-statistics for the null hypothesis using the TAR and the M-TAR specifications are known, respectively, as Φ and Φ^*. Their distributions are determined by the number of lags in the augmented equation (5), the number of variables and the type of deterministic elements included in the cointegrating relationship. Appropriate critical values are tabulated in Enders and Granger (1998).

Sources of the data

Data for the analysis were monthly cowpea wholesale prices between July 1998 and June 2009 from Techiman, Makola (in Accra), Bolgatanga and Wa markets in the Brong Ahafo, Greater Accra , Upper East and Upper West regions of Ghana, respectively obtained from the Policy Planning, Monitoring and Evaluation Division (PPMED) of the Ghana Ministry of Food and Agriculture (PPMED, 2009), deflated by the consumer price index (CPI). In Ghana, the Techiman market may be regarded as the national grain market where grains are aggregated and distributed to all parts of the country. Consequently, in this study as in previous grain price integration studies in Ghana (Alderman & Shively, 1996; Alderman, 1993; Shively, 1996; Bidane & Shively, 1998; Abdulai, 2000), the Techiman market was used as the central markt.

Cowpeas are produced mainly in the Northern, Upper East and Upper West regions of Ghana sufficient to meet only 42% of the national demand (PPMED, 2009; Langyintuo, et al., 2003). Grains are sold to merchants in the Techiman market soon after harvest where part is distributed and part stored for resale later in the year to all consuming regions (including the producing ones who later become consuming regions). Additional grains are imported from Niger and Burkina Faso (Langyintuo, et al., 2003) using Bolgatanga as the main import-point market where grains are sometimes re-packaged and then shipped to Techiman for distribution. This means that traders in Bolgatanga also depend directly on Niger and Burkina Faso for their cowpea supply after the domestic supplies are exhausted. Small quantities of grains from Burkina Faso also enter the Ghanaian markets via the Wa market.

Figure 1 shows that the real prices trend exhibit a gradual decline over time. The Makola market consistently experienced the highest pieces but no consistency in the market showing the lowest prices. It is unclear why prices in Bolgatanga were abnormally low between October 2006 to December 2007.

Order of integration of cowpea wholesale price series in Ghana

A test for unit roots on the data series (Sargan & Bhargava, 1983; Dickey & Fuller, 1979, 1981) failed to reject the null hypothesis of unit root and test on the residuals confirmed that the series are integrated to the order one, I(1) (Table 1). Table 2 shows that the Engle-Granger test rejected the null hypothesis of no cointegration at the 1% level for Bolgatanga and Wa, and 5% level for Makola. The implications of the the values of α_0 for Makola, Bolgatanga and Wa are that the absolute price margins linking the Techiman central market and the local markets of Bolgatanga, Wa and Makola are respectively ¢0.47/kg, ¢0.30/kg and ¢0.56/kg.

Empirical results of cowpea price adjustment

Following the rejection of the null hypothesis of no cointegration the data were tested for asymmetric adjustment using specifications (3), (4), and (6). Estimates of the TAR results by equations (3) and (4) are presented in the top portion of Table 3. Various lagged forms were estimated but the AIC and BIC both chose one lagged form. Comparing the estimated Φ_μ of 23.10, 14.43 and 14.51 for Techiman-Wa, Techiman-Makola, and Tehiman-Bolgatanga respectively, with the critical values of 4.64 and 6.57 at the 5% and 1% levels, respectively, (Enders and Granger 1998), the null hypothesis of $\rho_1 = \rho_2 = 0$ can be rejected, confirming that prices are cointegrated.

The estimated ρ_1 and ρ_2 which give the rate of adjustment in prices towards equilibrium given positive and negative deviations, respectively, are -0.27 and -0.43 for the Techiman-Wa series. This suggests that approximately 27% of a positive deviation from the long-run relationship between the two price series is eliminated within a month while for a negative deviation, it is about 43%. Corresponding percentage deviations for the Techiman- Makola series are 33% and 59%, respectively. Tests for asymmetric adjustment (last column of Table 3) failed to reject the null hypothesis of $\rho_1 = \rho_2$ in both pairs implying that neither price movement is stickier than the other. The estimates of ρ_1 and

ρ_2 for the Techiman-Bolgatanga series are -0.15 and -0.41 implying that for a positive deviation from the long-run relationship between the two price series, 15% is eliminated within a month but for a negative deviation, the adjustment is 45%. The test for asymmetric adjustment rejected the null hypothesis of symmetric adjustment ($\rho_1 = \rho_2$) in favor of asymmetric adjustments processes of the Bolgatanga market prices series to changes in Techiman market prices series. Positive deviations are stickier than negative ones. This means that wholesale traders are more reluctant to reduce prices if they experience a positive price shock than to increase prices for a negative price shock.

The possible reason for these results is the degree of freedom with which merchants can manipulate their stocks. Since wholesale traders in Wa and Makola rely mostly on Techiman for their cowpea supplies, any price change in Techiman market are transmitted instantaneously to Wa and Makola. In contrast, price changes in Techiman are not transmitted instantaneously to Bolgatanga market because the latter is an import-point market for cowpea from Niger and Burkina Faso meant for the Ghanaian markets. Consequently any price changes in Techiman take time to filter to Niger and Burkina Faso and back. When price increases in Techiman, traders in Bolgatanga are happy to exploit the relatively lower prices in Niger and Burkina Faso until they adjust to the new price levels. For a price decrease in Techiman, traders in Bolgatanga have shorter periods of adjustment because by the time Niger and Burkina Faso start to experience the decrease, Techiman prices would have re-adjusted and so will those in Bolgatanga.

For the Techiman-Bolgatanga market price series, M-TAR were estimated because they followed asymmetric price adjustments. The Φ_μ values for the M-TAR model presented in the second portion of Table 3 reject the null hypothesis that $\rho_1 = \rho_2 = 0$, similar to the TAR results. The test for symmetric adjustment, that is, $\rho_1 = \rho_2$, however, could not be rejected suggesting that the observed asymmetry does not exhibit more momentum in one direction than the other.

Price variability at the market level

An autoregressive conditional heteroskedastic regression (ARCH) model was specified and estimated as in equation (1) to test the hypothesis that the local price volatility is invariant to price changes. The estimated residuals from (1) were squared and regressed on their lagged values and the lagged values of the local and central market prices. A Lagrange multiplier test for ARCH(l) errors failed to reject the null hypothesis of homoskedasticity at the 5% level in the variance for all the markets.

The estimated results presented in Table 4 indicate that with the Wa and Makola series, an increase in local market prices reduce local price variability while an increase in Techiman market price increases price variability in the local markets. The results suggest that when there is an increase in the local market price relative to Techiman (the source), traders tend to reduce inventories locally to exploit the higher price in the local markets and re-stock from Techiman where price is relatively lower. This thus reduces price volatility locally. On the other hand, when price in Techiman increases relative to the local price, traders are reluctant to sell grains procured from Techiman at a higher price on the local market where the price is lower. They, therefore increase their inventories thus triggering higher local prices and hence higher price volatility.

In contrast, Table 4 indicates that variability in Bolgatanga market price increases when previous local market price increases but decreases when previous market price in the Techiman market increases. This suggests that when local price increases relative to central market price, traders increase stocks in anticipation for higher prices in subsequent markets. When they take delivery of the grains from Niger and Burkina Faso, they are reluctant to supply to the Techiman market but rather increase their inventories in Bolgatanga. This results in the higher volatility locally. On the other hand, when the Techiman market price increases, traders reduce inventories to exploit the higher price thereby reducing local price volatility. These results thus confirm the differential response to market signals among wholesalers.

Summary and conclusions

A threshold autoregressive (TAR) model was used to test the hypothesis that at the wholesale level in Ghana, cowpea price adjustment patterns are similar throughout the country. The model employs monthly cowpea wholesale prices deflated by the CPI between July 1998 and June 2009 from Techiman, Makola (in Accra), Bolgatanga and Wa markets, respectively. With Techiman as central market, the series were observed to be cointegrated.

The TAR test for asymmetric adjustment failed to reject the null hypothesis of symmetric adjustment for the Techiman-Wa and Techiman-Makola series but rejected the null hypothesis of equal adjustment for theTechiman-Bolgatanga series in favor of asymmetric adjustment. In the latter case, only 15% of any increase is eliminated within a month compared with 41% for a decrease, implying that price increases are stickier than decreases. The differential price adjustment between Bolgatanga on one hand and Wa and Makola on the other was confirmed by the autoregressive conditional heteroskedastic regression model results. Whereas variability in Bolgatanga market prices increase when previous local market prices increase but decrease when previous market price in the Techiman (central) market increase, the opposite is true for the other markets.

The above results failed to support the initial hypothesis that wholesalers respond to information similarly. The fact that wholesalers at the import-point market, directly involved in the importation and distribution of cowpea, respond differently to information compared with all others contradict the symmetric behavior of maize wholesalers observed by Abdulai (2000). The relatively greater impacts of foreign grain pricing policies on cowpea compared with maize wholesalers might be a factor for these results. This asymmetric information from foreign policies is possibly greatest in the import-point markets than all other parts of the country, hence the differential response of traders to market information. This means that any market policy targeting wholesalers in similar informal grain markets must recognize the differential response of wholesalers to information to ensure the desired impacts.

References

Abdulai, A., 2000. Spatial price transmission and asymmetry in Ghanaian maize market. Journal of Development Economics. 63 (3) 327-349.

Alderman, H., 1993. Intercommodity price transmittal: analysis of markets in Ghana. Oxford Bulletin of Economics and Statistics 55 (1), 43-64.

Alderman, H., Shively, G., 1996. Economic reform and food prices: evidence from markets in Ghana. World Development 24 (3), 521-534.

Alexander, C., Wyeth, J., 1994. Cointegration and market integration: an application to the Indonesian rice market. Journal of Development Studies 30 (2), 303-328.

Badiane, O., Shively, G.E., 1998. Spatial integration, transport costs, and the response of local prices to policy changes in Ghana. Journal of Development Economics 56 (2), 411-431.

Blinder, A.S., 1982. Inventories and sticky prices: more on microfoundations of macroeconomics. American Economic Review 72 (3), 365-400.

Dercon, S., 1995. On market integration and liberalization: method and application to Ethiopia. Journal of Development Studies 32 (1), 112-143.

Dwyer, G.P., Wallace, M.S., 1992. Cointegration and market efficiency. Journal of International Money and Finance 11 (4), 318-327.

Enders, W., Granger, C.W.J., 1998. Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates. Journal of Business and Economic Statistics 16 (3), 304-311.

Enders, W., Siklos, P.L., 1998. The term structure: testing for an equilibrium with asymmetric adjustment, Mimeo. Iowa State University Working Paper.

Engle, R.F., Granger, C.W.J., 1987. Cointegration and error correction: representation, estimation and testing. Econometrica 55 (2), 251-280.

Kuipera, W. E, Lutz, C. van Tilburg, A., 2003. Vertical price leadership on local maize markets in Benin. Journal of Development Economics, (71) , 417-433.

Langyintuo, A. S., Lowenberg-DeBoer, J., Faye, M., Lambert, D., Ibro, G., Moussa, B., Kergna, A., Kushwaha, S., Musa, S., Ntoukam, G., 2003. Cowpea Supply and Demand in West and Central Africa. Field Crops Research. 82 (2-3), 215-231.

Maccini, L.J., 1978. The impact of demand and price expectations on the behavior of prices. American Economic Review 68 (1), 134-145.

PPMED (Policy Planning, Monitoring and Evaluation Division). 2009. Estimates of production of selected crops in Ghana. Ministry of Agriculture, Accra, Ghana.

Roberts, J.M., Stockton, D.J., Struckmeyer, C.S., 1994. Evidence on the flexibility of prices. Review of Economics and Statistics 76 (1), 142-150.

Scherer, F.M., Ross, D., 1990. Industrial Market Structure and Economic Performance. 3rd Edn. Houghton Mifflin, Boston.

Shively, G.E., 1996. Food price variability and economic reform: an ARCH Approach for Ghana. American Journal of Agricultural Economics 78 (1), 126-136.

Tomek, W. G., Robinson, K., L., 1990. Agricultural Product prices, Third Edition. Cornell Inuversity Press, Ithaca.

Table 1: Test of order of integration on individual series with constant and trend

	T-Test	Φ -Test	
Market	$\rho^* = 0$	$\alpha = \rho^* = \beta = 0$	$\rho^* = \beta = 0$
Bolgatanga	-3.0935	3.3471	4.7848
Wa	-2.3096	2.4320	3.0391
Makola	-2.6513	2.6807	3.5293
Techiman	-3.1251	3.5632	5.2065
Critical values (10%)	-3.130	4.030	5.340

Note: The general form of the equation run was:

$\Delta P_t = \alpha + \beta t + \rho^* P_{t-1} + \sum_{j=1}^{n} \rho_j \Delta P_{t-j} + \varepsilon_t$. Where $\rho^* = \rho - 1$. Reject the null hypothesis of unit root if the t-test statistic is smaller than the critical value.

Table 2: Engle –Granger cointegration results ($P_t^L = \alpha_0 + \alpha_1 P_t^C + \mu_t$; $P^c = Techiman$) (n = 132)

Market	α_0	α_1	Φ	Adjusted R-square	AIC[1]	BIC[2]	Engle-Granger test[3] ($\rho_1 = 0$)
Bolgatanga	0.466	0.853	85.23	0.39	445.39	456.92	-5.009
	(0.27)	(9.23)					
Wa	0.304	0.645	129.27	0.49	316.64	328.17	-3.985
	(2.90)	(11.37)					
Makola	0.560	0.926	226.43	0.63	338.12	349.65	-3.750
	(4.22)	(15.05)					

Note: In parenthesis are the t-ratios

1 AIC (Akaike Information Criterion) is calculated as: n*log(SSR) + 2*k [where n = number of observations; SSR = sum of squared residuals; k = number of regressors].

2 BIC (Baysian Information Criterion) BIC is calculated as: n*log(SSR) + k*log(n) [where n = number of observations; SSR = sum of squared residuals; k = number of regressors].

3 Critical values of the Engle-Granger test for no cointegration are -3.5 and -3.95 for the 5% and 1% levels, respectively.

Table 3: Results of the symmetric and asymmetric adjustment in cowpea prices

Market	ρ_1	ρ_2	AIC	BIC	Φ_{μ}^{a}	$\rho_1 = \rho_2$
			Threshold Autoregressive (TAR) model			
Wa	-0.267	-0.428	238.29	244.04	14.430	1.419
	(-2.709)	(-4.639)				(0.236)
Makola	-0.330	-0.593	288.00	293.75	23.098	2.940
	(-2.742)	(-6.219)				(0.088)
Bolgatanga	-0.146	-0.411	307.54	313.30	14.510	6.030
	(-2.094)	(-4.963)				(0.015)
			Momentum Threshold Autoregressive (M-TAR) model			
Bolgatanga	-0.145	-0.382	321.26	327.05	6.654	2.261
	(-1.309)	(-3.405)				(0.132)

Notes: Figures in parenthesis in columns 2 and 3 are the t-statistics for the null hypotheses: $\rho_1 = 0$ and $\rho_2 = 0$, but in column 6 they are significant levels for the corresponding F statistics of the null hypothesis that the adjustment coefficients are equal.

[a]Sample values for the test statistics of the TAR and M-TAR are, respectively Φ_{μ} and Φ_{μ}^{*}. [Critical values of Φ_{μ} are 4.99, 5.98 and 8.21 for the 10, 5 and 1%, respectively. Those for Φ_{μ}^{*} are respectively 5.43, 6.45 and 8.75; (Enders and Siklos, 1998)].

Table 4: The ARCH model results

	α_0	μ_{t-1}^2	P_{t-1}^l	P_{t-1}^c	F-statistic
Techiman - Wa	0.0215	0.3766	-0.0044	0.0360	10.272
	(0.526)	(4.469)	(-2.835)	(4.227)	
Techiman - Makola	0.0748	0.2508	-0.0004	0.0028	2.878
	(1.063)	(2.333)	(-3.006)	(2.041)	
Techiman - Bolgatanga	0.0162	0.6840	0.1706	-0.1694	93.415
	(0.214)	(12.720)	(3.889)	(-3.038)	

Note: In parenthesis are the t-statistics

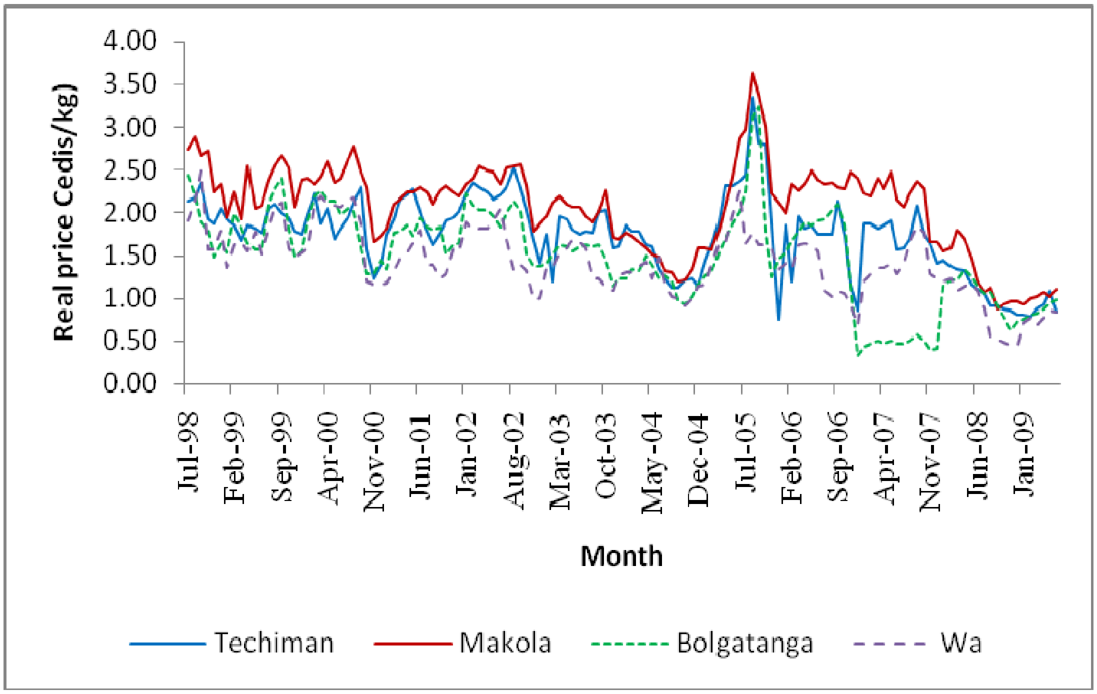

Figure 1: Real cowpea price series in selected markets in Ghana

Map1: Map of Ghana showing locations of study markets