Explaining Ghana's Recent Good Cocoa Karma: Smuggling Incentive Argument

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Abstract

The paper contends that the current boom in cocoa exports from Ghana is primarily in response to reversal in price incentives to smuggle Ghana cocoa to La Cote d'Ivoire and not due to productivity gains in the Ghana cocoa supply chain. Using recent data; ADF, Perron and KPSS tests of stationarity; Engle and Granger and Johansen co-integration tests; Granger causality tests; single and vector error correction models; as well as partial adjustment models, we estimate the Ghana cocoa supply response to determine the most pertinent factors that explain the cocoa boom. Different from previous research, the VECM and ECM models are modified to be more reflective of current conditions in the Ghana cocoa sector by including prices of relevant substitutes in cocoa production. Furthermore we carefully account for the time series properties of the data and address endogeneity problems that plague the estimation. For example, in testing for the order of integration of different series, we account for the possible existence of structural breaks. We find that the "price incentive to smuggle" argument adequately explains the current boom in Ghana cocoa supply response. This finding is important because it questions claims in the literature that substantial productivity gains in the cocoa sector in response to good policy is the main reason behind the Ghana cocoa export boom.

Introduction

Ghana's recent robust economic growth, occurring at the same time as the country's cocoa sector is booming, has attracted some interest in the economics literature (Zeitlin, 2005). However, establishing that productivity growth in the cocoa industry is the reason for Ghana's growth is non-trivial and is not the focus of this research. This is because economic growth is typically a complicated process that occurs along numerous dimensions with one single factor often not enough to explain growth. However, what is undeniable is the coincident good performance of Ghana's economy and its cocoa industry (Ghana Ministry of Agriculture 2005). Given current impressive concurrent cocoa export sector and economy-wide growth, after very dismal performance in the 1970-1990's period, the aim of the current research is to model and estimate the Ghana's cocoa supply to determine the reasons that explain Ghana's current good cocoa Karma. We model Ghana cocoa supply as a function of the smuggling incentive which Bulir (2002) defines as the ratio of real Ghana cocoa producer prices to real Cote D'Ivoire (CIV) cocoa producer prices. We contend that this research is important as it affords a mechanism to analyze the effect of smuggling of cocoa in or out of Ghana on the country's cocoa exports over time. The research is very pertinent given political event in CIV in the recent past. Specifically the CIV, Ghana's immediate neighbor and the largest cocoa producer in the world, has had a major conflict in 2001 and several major up risings in the recent past some degree of calm has been restored. Has the fundamental structure of Ghana cocoa supply changed presumably because of some exogenous productivity spurt in the cocoa sector or is the political situation in the CIV influencing export trends in Ghana.

The volume of Ghana's cocoa exports has expanded significantly in the last several years after many years of decline followed by a mediocre performance recovery (ICCO 2005, IMF country report 1995). Not surprisingly, cocoa prices paid to Ghanaian cocoa farmers have also appreciated both in nominal and real terms; The nominal price per bag of cocoa beans paid to farmers by Ghana Cocoa Marketing Board (COCOBOD) which was 70000 cedis in 1995, topped 9000000 cedis by 2004, representing an astronomical increase of 1186% although after exchange rate effects and inflation are accounted for this increase is less impressive (Ghana Ministry of Agriculture, 2005).

To explain the severe contraction in Ghanaian cocoa supply from 1960s to the 1995s (a 60% decline) Bulir (2003) appealed to the reversal in price-incentive to smuggle Ghana cocoa to CIV. He explained that distortionary effect of domestic taxes in Ghana widened the gap between the CIV and Ghanaian domestic prices, and ultimately created incentives to smuggle Ghana cocoa to the CIV (Bulir, 2003). Bulir argued that the monopoly position of CIV enabled that country to pay better domestic prices to its farmers. Rational Ghanaian farmers therefore smuggled their cocoa to CIV when the expected gain from smuggling Ghana cocoa to CIV outweighed the transportation and transaction costs that this risky adventure entails. Bulir used a co-integration model and a single equation error correction model to make his point. Given Bulir's argument, it seems reasonable to conjecture therefore that the ongoing political instability in the CIV presumably reversed price incentives to smuggle Ghana cocoa to CIV and more than anything else can explain the good times in the Ghanaian cocoa industry today.

This paper argues that because Ghana has been a relatively safe country in the West African sub–region than CIV for the past few years, price incentives to smuggle Ghanaian cocoa to the CIV should be drastically reduced if not reversed. Furthermore, over the last decade, the Ghana government has increased efforts to ensure that cocoa farmers get a lion share of cocoa export revenues (Ghana Ministry of Agriculture 2005). Some of the incentives the government has put in place include across the board reduction in cocoa tax rates and the encouragement of the formation of cocoa associations for example, the Kuapa initiatives. By exploiting the fact that opportunity cost of smuggling Ghana cocoa to CIV has sky-rocketed (due to the real danger of being either killed or robbed by smuggling to the CIV because of the war) as against receiving a non-random, safe domestic price from the COCOBOD, Ghanaian cocoa farmers should substitute for the latter. Ghanaian cocoa exports should therefore climb as more Ghanaian farmers substitute towards selling to COCOBOD to take advantage of better prices. A further boost to Ghanaian cocoa exports will be the contribution to total Ghana exports of CIV farmers smuggling cocoa to Ghana because of declining differential in prices between CIV and domestic Ghana producer prices as Ivory Coast market share has plummeted causing it to lose market power and reducing its ability to guarantee higher domestic prices to its own its. In other words, the amount of Ghana-CIV cocoa smuggling could be driven to zero and smuggling may actually go in the reverse direction (from CIV to Ghana) following the price incentive reversal and the substantial increase in uncertainty in the CIV cocoa chain. If this is true Ghanaian cocoa exports should increase significantly both in absolute terms and relative to CIV, which is what we see. After testing for, and correcting for stationarity using the KPSS, ADF and Perron tests, I test for structural break using traditional Chow Tests and the Zivot Andrews (1992) or the ZA test to verify whether the Ghanaian cocoa sector changed in a significant way before and after the war in CIV[1]. I also perform co-integration and Granger causality tests to investigate the relationship between word cocoa and domestic Ghana and CIV producer and CIV prices. To isolate the most important determinant of the export boom in Ghana, I build on the error correction models by Awudu and Reider (1994) and Bulir (2002).

The model used in this paper is therefore a hybrid of the models used by these authors. The difference apart from more recent data and augmenting their model with relevant substitutes in production is that I carefully account for the time series properties of the data. To illustrate, I test for structural breaks caused by for example the CIV war in 2001 using both the ZA test and the Chow test. I also test for stationarity using both the Perron (1989) test and the ADF test. Furthermore in testing for unit root I specifically account for structural breaks in the data. We find that the final model and procedure employed does a satisfactory job in explaining the supply response of Ghanaian cocoa and the boom in exports, than other current postulated explanations.

Section II reviews the literature on Ghanaian cocoa supply response; critiques previous supply models for Ghanaian cocoa, and provide a brief overview of the Ghanaian

[1] Ghana is the second largest exporter of cocoa beans and shares a border with CIV, the world's largest cocoa exporter on its western border. Not surprisingly, the war in CIV most likely had non-trivial consequences for the Ghana cocoa sector.

cocoa production process. Section III describes the data, and explains the theory and procedures used and outlines Awudu et al and Bulir's models as well as my modification of the model to account for more recent trends. The VECM model specification I use and the reason why I include the VECM is also explained. Section IV presents and discusses the results, and Section V concludes.

Relevant Literature

Although models of cocoa supply in Ghana is found more frequently in the literature than models of other perennials in the economics literature, the sum total of models of perennials in general including cocoa models remains unimpressive (Bulir, 2002). The biological lag between the planting decision date and output date presents unique challenges for econometric modeling not only for cocoa, but also for all perennials. Empirical problems also arise because of incomplete, unrecorded or missing data pertaining to plantings, removals and re-planting, yield variations and yield composition (King, French and Minami, 1985). The lack of popularity of models for perennial crop supply response in the economics and agricultural is therefore not surprising[2] Cocoa trees take time (specifically up to six[3] years) to yield the first harvest after planting (Awudu and Reider, 1995). The cocoa supply modeling literature has therefore evolved as different analysts have tried to obtain more accurate forecast models by taking into account not only the lag but also other exogenous factors that affect output; for example, cocoa output price instability, cocoa production variability (probably caused by bad weather and also the availability of inputs into production (or rather the lack thereof) have all received considerable attention in the literature (King, French and Minami, 1985). The earliest

[2] We recognize the challenge presented by the need to define an expectation formulation mechanism. For simplicity we assume that the expected price of the domestic price is the world price
[3] New fast maturing varieties can produce fruit in as little as two years but the stock of trees is still of the old variety as cocoa trees can produce beans every year for up to 40 years after the first crop. Other perennials may take more time to bear their first fruit

literature on Ghana cocoa supply response comprised mainly of models that investigated the response of farmers to economic incentives for example Bateman (1976 and 1990) and Brempong-Gyimah (1992). More recently Teal and Vigneri (2004) and Zeitlin (2005) have all analyzed Ghana cocoa. Ales Bulir notes that Ghana cocoa supply models in the economics literature fall into three broad groups (Bulir, 2003). The first flavor of models approach cocoa supply response as a "technological function" of the stock of cocoa trees and fertilization efforts. ere The second and more common category of Ghana cocoa supply models were partial adjustment models[4]. The analysis by Bethelemy and Morrison (1987) and Jaeger (1992) fall into this category. Partial adjustment models were sometimes used in combination with Nerlove supply models (Nerlove, 1979) although prominent economists, including Nerlove himself have harshly criticized these models because of unrealistic assumptions. At the time of these critiques Partial Adjustment (PA) models did not account for possible stationarity of the data series (although now they do). Unfortunately OLS on non-stationary data produces spurious regressions Engle and Granger (1987). Partial adjustment models also assumed a fixed supply based on stationary expectations limiting their usefulness in the context of dynamic optimization[5] (Hallam and Zanobi 1993).

As more powerful statistical methods surfaced in the empirical literature research moved from partial adjustment models to error correction models that test for stationarity and employ co-integration techniques. Co-integration solves the problem of spurious regression and determines whether there is a long-term relationship between non-stationary series integrated of same order Engle and Granger (1987). Error-correction models also correct yet another short-coming of the partial adjustment model in that they make it feasible to estimate both long and

[4] See model I in Section II for an example
[5] Ghana cocoa supply response modeling is obviously an exercise in dynamics so this assumption of stationary expectations is especially problematic.

short run supply response in the same model (Hallam and Zanobi 1993). More recent models therefore test for and correct for stationarity and employ error–correction and co-integration methods for example Abdulai and Reider (1994). The contribution this paper makes is to ensure that unit root tests are only applied to data that do not incorporate structural breaks since a structural break can induce a trend that can bias unit root test towards accepting the null of non-stationarity. Tests of structural breaks are executed with the ZA test that does not assume the break point *ex ante* ad therefore avoids biasing the test result *ex post*.

The last group of models that Bulir identifies recognizes the significant explanatory power of the price incentive to smuggle Ghanaian cocoa to Cote d'Ivoire for Ghana cocoa supply response and vice versa. Bulir (2002-2003)'s models cocoa supply response as a function of the price differential between the Ghanaian and CIV producer price (smuggling incentive is defined as a ratio of deflated US dollar denominated CIV domestic producer price to deflated US dollar denominated Ghana producer price) and is the best example to date in my opinion. In the price-incentive to smuggle flavor of models, Ghanaian farmers are assumed to respond to relative prices in the short run. After analyzing opportunity costs, they decide whether or not to harvest the cocoa, smuggle it to CIV or sell to the local COCOBOD (That is they have to decide whether the prevailing domestic Ghana cocoa producer price is preferable to smuggling). By contrast, long run planting decisions are a function of the international cocoa price so world price is the expectation of the local cocoa producer prices. The model used in this paper follows the approach just described.

Data, Methods and Theory

The data for the project was obtained from different sources. Ales Bulir kindly provided the data covering the period 1977 to 1995 used in his original paper for the variables included in his original model. Since maize production is recognized as the main substitute to the production of cocoa by Ghanaian farmers, I obtained data on the average yearly price of a 100kg maize bag sold in Ghana from the Statistics Research Institute (SRID) of the Ghanaian Ministry of Agriculture. The maize price data was then appropriately deflated by the Ghana CPI series. Ghana cocoa producer price data and cocoa supply data for the period 1995 – 2005 was obtained from the Ghanaian ministry of Agriculture and also from FAO country reports. Real Ghana cocoa producer price data was generated by deflating the nominal producer prices with the Ghana CPI (which reflects the rural consumer basket). The deflated data was then converted to equivalent dollar value using the exchange rate for each year. The average annual world price data from 1977 to 2005 was obtained from the ICCO website. Deflated world cocoa producer price data was generated by deflating the nominal producer prices with the US CPI (which was assumed to represent the world basket of goods). FAO provided the CIV data for the 1995 -2004 period. Real CIV producer price data was generated by deflating the nominal producer prices with the CIV CPI (which reflects the rural CIV consumer basket). The deflated data was then converted to equivalent dollar value using the exchange rate for each year. Ghanaian and CIV Exchange rate and CPI data for the period 1977 to 2005 was obtained from the BMI Index of the University of Illinois at Urbana Champaign.

Structural-break tests: It is possible that the underlying structure of the Ghanaian cocoa supply function (here supply response is assumed identical to total export volume) might have changed precisely because of exogenous factors such as the war in the CIV. To ensure parameter constancy, we use the ZA test to avoid bias in the estimators coming from incorrectly imposing the break date used in testing for structural break. The ZA test has null of unit root with an alternate of stationarity with a one time break in the series. The ZA test results were used to identify the temporal location of the most likely structural break date after which the **Chow (1960)** test was applied to verify parameter constancy. For the Chow test, we defined a dummy, which takes a value of 1 for the period before 1999, and 0 otherwise to avoid bias in the estimators coming from incorrectly imposing constant parameters. The results of the structural break tests (Table 1) are discussed in the results section

Stationarity tests: The ADF test was used to test for unit roots the results are displayed in Table 2 in the results section. All variables are tested for stationarity (Table 1). Furthermore, apart from the Smuggling incentive variable, all other variables listed below are in logs: Average annual Ghana cocoa supply, Ghana cocoa producer price, and international cocoa price. Although the ADF test is the primary test used for checking stationarity of the data, it is obviously limited in some respects especially when the data is~ I (1). The ADF test has a null of unit root so suppose the test has low power (low type 1 error), then ADF cannot reject the null and we get non-stationarity most of the time. A complementary test is the KPSS test due to Kwiakowski, Phillips, Schmidt and Shin (1992). The KPSS test has a null of stationarity therefore if your data is actually stationarity then you will not likely make any errors (Bart, H., Hans Frances, P., Ooms M (1998)). However the real value of the KPS test is when the data is actually non-stationary. In this case even if you fail to reject Ho: non-stationarity with ADF, you will reject Ho: stationarity with KPSS. Table 2 compares the results of the ADF and KPSS tests of unit root

ii. *Co-integration*. Co-integration techniques help us avoid spurious regressions. Spurious regressions result when OLS is executed on non-stationary variables Engle and Granger (1987). The results of such spurious regressions have no statistical meaning therefore spurious regressions must be avoided at all cost. To illustrate co-integration, suppose two series X and

Y are individually non-stationary and integrated of the same order say integrated of order one or I (1). If there exist a linear combination of these two series that is stationary i.e. I (0) then X and Y are co-integrated. Since world cocoa prices are assumed to be the expectation of domestic cocoa producer prices, world cocoa price data is used in the co-integration relationship with Ghana cocoa supply and not domestic cocoa producer prices. We test for co-integration relationships and Granger causality between the smuggling incentive, Ghana cocoa supply response, world cocoa, substitute maize price and domestic cocoa producer prices in a multivariate framework. Granger causality tests are relevant here given co-integration to predict the direction of causation in the long run relationship. Possible Co-integration and Granger Causality relationships include: i) International Price and Producer Price of Cocoa ii) Smuggling Incentive and Cocoa Supply response iii) Maize Price and Cocoa Supply (Substitute relationship) and iv) Producer Price and cocoa supply response. If co-integration relationships are established for the pairs of variables in the list above, then we surmise that the following Granger Causality relationships will be manifest. International prices Granger causes the domestic producer price, the Smuggling incentive Granger causes Cocoa Supply Response, Average Maize Producer Price Granger causes Cocoa supply response and finally Ghana Cocoa Producer prices Granger causes supply response. The results are presented in Table 3 and Table 4 and are discussed in the results section. All models specified are presented next:

Mathematical Presentation of Models

Model i: Partial Adjustment models

$A_t^c = \alpha + A_{t-1}^c + \beta_1 P_t^c + \beta_2 P_t^m + \beta_3 D_t + \varepsilon_t$

A_t^c = Cocoa output

A_{t-1}^c = Lagged cocoa output

P_t^c = Domestic Ghana Cocoa producer Price

P_t^m = Maize producer price (represents substitutes, maize is main competition)

D_t = Dummy Variable (= 1 if recorded after 1999). Table 5 in the result section has the regression output for the partial adjustment specification of the model

Model ii: Awudu and Reider (1994). Single Equation Error Correction Model

$\Delta A_t^c = a_0 + a_1 \Delta P_t^c + a_1 \Delta M_t^s - \gamma (A_{t-1}^c - b_1 P_{t-1}^c - b_2 M_{t-1}^s) + U_t$
ΔM_t^s = Change in manufacturing goods supply
ΔP_t^c = Change in Cocoa prices
ΔA_t^c = Change in cocoa supply
γ = Error correction parameter that captures the speed of the adjustment to disequilibrium conditions. Table 6a in the result section has the regression output for Awudu & Reider's specification of the of the EC model

Model iii: Bulir, Ales (2003) Error correction with Smuggling Incentive

Δ Supply$_t$ = $\alpha + \sum_{i=0}^{i=2} \beta 1i \Delta$ Producer$_{t-i}$ + $\sum_{i=0}^{i=2}$ Smuggling Incentive $_{t-1}$ + γ (Supply$_{t-1}$ – δ_1 International price $_{t-1}$ – δ_2 Smuggling incentive $_{t-1}$) + ε where γ is the error correction parameter that captures the speed of the adjustment to disequilibrium conditions. Because international prices are used as a proxy for expectation of domestic producer prices, international prices do not enter the short run portion of the error correction model. Similarly domestic producer prices do not enter the long run version of the model. Table 6b in the result section has the regression output for Ales Bulir original specification of the model with the complete available data set

Model iv: Hybrid: Error correction with reduced smuggling incentives and dummy

Δ Supply$_t$ = $\alpha + \sum_{i=0}^{i=2} \beta 1i \Delta$ Producer$_{t-i}$ + $\sum_{i=0}^{i=2} B_{2i}$ Smuggling Incentive $_{t-1}$ + $B_3 \Delta PM_t^s$
γ (Supply$_{t-1}$ – δ_1 International price $_{t-1}$ – δ_2 Smuggling incentive $_{t-1}$ - $\delta_3 PM_t^s$) + D_t + ε where
ΔPM_t^s = Change in Price of Maize
ΔP_t^c = Change in Cocoa prices
ΔA_t^c = Change in cocoa supply
γ = Error correction parameter that captures the speed of the adjustment to disequilibrium conditions
D_t = Dummy variable = 1 for 1999, 0 otherwise
Table 6c in the result section has the regression output for the hybrid specification of the model (but with the
complete available data set)

Discussion of Results

Over all, the result from the research exercise was consistent with our research hypothesis. The "Price Incentive to Smuggle Ghana cocoa to CIV" variable is statistically and negatively related to Ghana cocoa supply response in the short run[6]. This makes sense given we had defined the smuggling incentive variable as CIV price / Ghana price. That is as the price mark

[6] Refer to results in Table 6.

up of the CIV price of the Ghana price declines, Ghanaian cocoa export booms. However some surprises also emerged which begs for closer analysis of the data. Table 1 reports the result of our structural break test. Due to the war in the CIV we hypothesized that if there was a change in the smuggling incentive data, it probability occurred around 1991. As Table 1 illustrates however, we rejected the null of structural break occurring at 1991. We carry out ADF tests to check for the stationarity of the series we used in the exercise, the results are all presented in Table 2. All the series are integrated of order 1 (i.e. I(1)). They are therefore non-stationary in the levels but stationary in the first differences. For two series to be co-integrated, they must necessary be integrated of the same order. Fortunately, the main variables used: average real price of a 100kg maize bag sold in Ghana, Ghana cocoa supply, average annual real producer price of Ghana cocoa converted to dollars for each year at the prevailing exchange rate, average annual real international price of cocoa and the smuggling incentive defined as the ratio of real CIV cocoa producer price in dollars to the corresponding Ghanaian price are all integrated of order 1 and as mentioned earlier stationary in the first difference. Table 3 reports pair-wise tests of co-integration for the variables. From the results the real international price of cocoa is co-integrated with Ghana cocoa supply. This is consistent with what other researchers have found For example, (Bulir 2003) explains that the international price is the expectation of the domestic cocoa producer price. For this reason, it has a long run or equilibrium relationship with Ghana cocoa supply. In order words, the international price, but the domestic price of cocoa is expected to be co-integrated with Ghana cocoa supply response. From Table 3, it's clear that the domestic Ghana producer price fails the co-integration test at 5%. Furthermore, the real Ghana cocoa producer price is co-integrated with the international cocoa price which is another result found by both Awudu and Reider (1994) and Bulir (2003). Lastly the smuggling

Incentive is co-integrated with cocoa supply. To establish the direction of causality between the variables pairs that were found to be co-integrated, we carried out Granger causality tests reported in Table 4. Unfortunately some of the Granger causality test results are inconclusive. For example, we were not able to confirm that the Smuggling Incentive Granger causes Ghana cocoa supply. We also executed partial adjustment model in the spirit of Awudu and Reider (1995). We found that the smuggling incentive was statistically significant at 5% . Table 5 contrast the results from the single equation error correction model using the specifications by Awudu and Reider (No smuggling Incentive and data is not up to date) Bulir (No series for average maize price and uses data only through 1995) and the hybrid model we proposed that used the most recent data. The results are not identical but similar. The Awudu and Reider specification confirmed the result obtained by the authors: The elasticity of supply of Ghana cocoa supply with respect to the domestic cocoa producer price is positive while the elasticity of supply of Ghana cocoa supply with respect to the maize price is negative. The results from the Bulir specification of the model and the hybrid specification are similar. The international cocoa price in positively statistically significantly related to cocoa supply in the long run wile the cocoa producer price correlated to supply response in the short run. So as the producer price of cocoa increases, Ghanaian cocoa farmers respond by supplying more cocoa both in the short and long run. Given the extensive lag time between planting and harvesting cocoa, it is unlikely the response in the short run is an acreage response. Rather the negative smuggling incentive variable provides the clue: As CIV producer prices decline relative to Ghana COCOBOD prices, Ghanaian farmers cease smuggling cocoa to CIV, CIV farmers smuggle cocoa into Ghana and no Ghanaian cocoa farmer leaves cocoa un-harvested. Table 6.1 contains the stationarity test for the single equation error correction variables. Stationarity of the error correction model is a necessary condition that has to be satisfies before a single equation error correction model can be carried out. All the models have error-correction terms that pass this test.

As pointed out in the theory, the single equation error correction model can lead to misleading results if there are more than two variables suspected to be co-integrated. Johansen's multivariate co-integration analysis is more appropriate in this case. Table 7 displays our results from the Johansen (1993)'s multivariate co-integration test. The trace statistic and the corresponding critical values are displayed. The null of 4 co-integration vectors is not rejected when we specify 5 variables. Successive elimination isolates Ghana cocoa producer price as not part of the co-integrating relationship. This is just what we expect as farmers respond to increasing producer price immediately and not necessarily in the long run. Table 8 reports our results from the VECM specification of the model. The international price is neither correlated with cocoa price in the long run nor the short run. Ghana cocoa price is correlated to cocoa supply in the short run. The smuggling incentive is statistically significant both in the long and short run and has the expected negative sign.

Section V. Conclusion and Future Work

The smuggling Incentive and the average price of maize are both necessary in explaining the current boom in the Ghana cocoa industry. Any research does not consider these two variables or does not use the most complete available data set is not using all relevant information so estimators will likely be inefficient. Despite the encouraging results of this research more needs to be done to explain the boom in Ghana cocoa. A full investigation of the possibility of structural breaks is vital. Furthermore, there may be more relevant variables that were omitted. However, since the primary use of the model is forecasting this is not a huge problem if the model works reasonably well which does because the errors from the model output is close to white noise and the deviations form actual output is small.

Appendix

Definition of variables (L at the end of a variable definition means the log of the variable): DATE = Time Series (Range = 1978 - 2005), PM = Nominal price of 100kg maize bag, GCPI = Ghana CPI, GER = US Ghanaian Cedi Exchange Rate, GSUP = Supply of Ghana Cocoa (= total export), NGCP = Nominal Ghana Cocoa Prices, NICP = Nominal International Cocoa Price, USCPI = US CPI, DINTCP = NICP/USCPI, CIVCPI = CIV CPI, CIVER = US dollar CFA Exchange Rate, CIVCP = Nominal CIV Cocoa producer Prices, NICP = Nominal International Cocoa Price, USCPI = US CPI, G$RPM = Real Maize Price, GSUP = Ghana Cocoa Supply, GHCP = Dollar Value of Deflated Domestic Ghana Cocoa Producer Prices, SMUG = Smuggling Incentive = CIVCP – GHCP

Table 1: Chow Test of Structural Break Tests (Using Short Run Relationship between Variables)

Table 1	**D1=1 if break occurred after 1999; 0 otherwise**	
SS_R	6.30E+10	
SS_{UR}	2.91E+10	
K	16	**CONCLUSION**
J	6	D1 is irrelevant
T-K	14	No Structural Change
F-Stat	2.75	
Fcrit(J, T-K)=F(6,14)	4.76	

Table 2: Results of Stationarity tests

Table 2	Stationarity	Tests			
VARIABLES	Test Statisitc	1% Crit Value	5% Crit Value	MODEL CHOICE	10% Critical Value
1) GSUP	0.74	-2.65	-1.95	NC NT 2nd Lag	-1.6
1ST DIFF GSUP	-4.6	-2.65	-1.95	NC NT 1st Lag	-1.6
Conclusion	***1st DF***	***Stationary***			
2) DINTCPL	-2.4	-2.65	-1.95	NC NT 1st Lag	-1.6
1ST DIFF DINTCPL	-3.2	-2.65	-1.95	NC NT 1st Lag	-1.6
Conclusion	***1st DF***	***Stationary***			
3) GHCPL	-1.78	-2.65	-1.95	C T 1st lag	-1.6
1ST DIFF DINTCPL	-4.18	-2.65	-1.95	C T 1st lag	-1.6
Conclusion	***1st DF***	***Stationary***			
4) GDRPML	-1.86	-2.65	-1.95	NC NC 1st lag	-1.6
1ST DIFF DINTCPL	-4.7	-2.65	-1.95	C T 1st lag	-1.6
Conclusion	***1st DF***	***Stationary***			
5) SMUG	0.06	-2.65	-1.95	NC NC 8th lag	-1.6
1ST DIFF DINTCPL	-4.2	-2.65	-1.95	C T 8th lag	-1.6
Conclusion	Conclusion	***1st DF***	***Stationary***		
DEFINITIONS					
GSUP	Log of Ghana	Cocoa Supply			
DINTCPL	Log of World	Cocoa Price	Deflated		
GHCPL	Log of Ghana	Cocoa Producer	Price	Deflated	
GDRPML	Log of Ghana	Naize Producer	Price	Deflated	
SMUG	Smuggling	Incentive= CIV	Price - Ghana	Price	

Table 3: Results of Co-integration Tests

Table 3	Co-Integration	Tests		
VAR-PAIRS	Test Statisitc	1% Crit Value	5% Crit Value	MODEL CHOICE
1) DINTCPL& LGSUP				
1ST DIFF LGSUP	-4.6	-2.65	-1.95	
1ST DIFF DINTCPL	-1.78	-2.65	-1.95	C T 1st lag
Linear Combination	-3.6	-4.38	-3.6	C T 2nd Lag
CONCLUSION	CO-INTGRATED			
2) DINTCPL&GHCPL				
1ST DIFF DINTCPL	-3.2	-2.65	-1.95	NC NT 1st Lag
1ST DIFF GHCPL	-1.78	-2.65	-1.95	C T 1st lag
Linear Combination	-1.27	-2.66	-1.95	NC NT 1st Lag
3) GHCPL&LGSUP				
1ST DIFF LGSUP	-4.6	-2.65	-1.95	
1ST DIFF GHCPL	-1.78	-2.65	-1.95	C T 1st lag
Linear Combination	0.54	-2.6	-1.95	NC NT 1st Lag
CONCLUSION	**NOT CO-INTEGRATED**			
4)SMUG & LGSUP				
1ST DIFF LGSUP	-4.6	-2.65	-1.95	NC NT 1st Lag
1ST DIFF SMUG	-4.2	-2.65	-1.95	C T 8th lag
Linear Combination	-2.35	-2.6	-1.95	NC NT 4th lag
COCLUSION	**CO-INTEGRATED**			
DEFINITIONS				
GSUP	Log of Ghana	Cocoa Supply		
DINTCPL	Log of World	Cocoa Price	Deflated	
GHCPL	Log of Ghana	Cocoa Producer	Price	Deflated
G$RPML	Log of Ghana	Naize Producer	Price	Deflated
SMUG	Smuggling	Incentive= CIV	Price - Ghana	Price

Table 4: Results of Granger Causality Analysis

Table 4a	Granger		Causality
VARIABLES	DECISION	Theory Says	Test Statisitc=F(J,T-K)
1) DINTCPL & GHSUP	REJECT H_o	Reject Ho:γi=0	**1.6**
DINTCPL granger causes GHSUP NO			
GSUP granger causes DINTCPL NO	REJECT H_o	Accept Ho:γi=0	2.7
Conclusion INCONCLUSIVE			
2) DINTCPL & GHCPL	REJECT H_o	Reject Ho:γi=0	1.5
DINTCPL granger causes GHCPL YES			
GHCPL granger causes DINTCPL NO	REJECT H_o	Accept Ho:γi=0	2.89
Conclusion INCONCLUSIVE			
3) GHCPL & GHSUP	REJECT H_o	Reject Ho:γi=0	2.5
GHCPL granger causes GHSUP YES			
GHSUP granger GHCPL NO	Accept Ho:γi=(	Accept Ho:γi=0	1.25
Conclusion **One Way Causality**			

Source	Author		Calculations
Table 4b	Granger		Causality
VARIABLES	DECISION	Theory Says	Test Statisitc
4)SMUG & GSUP SMUG Granger Causes GHSUP YES	ACCEPT	Reject Ho:γi=0	-0.7
GHSUP Granger Causes SMUG NO	ACCEPT	Accept Ho:γi=0	0.6
CONCLUSION **INCONCLUSIVE**			

Table 5: Partial Adjustment model results

Table 5	Dependent Variable	Cocoa Output		
PARTIAL ADJUSTMENT	Robust Estimation			
Variable Name	Test Statisitc	95% CI	P-value	Coeff
1st DIFF Cocoa output	2.04*	-0.005-0.98	0.05	0.49
Domestic Ghana Cocoa producer Price	1.61	-0.04-0.36	0.122	0.16
Maize Producer Price	1.98*	-0.33-0	0.05	-0.16
R^2	0.4			
F-Static	4.8			
* Means significant at 5% significance				

Table 6: Single Equation Error Correction Model Results: Table 6a: Awudu and Reider Error Correction Model (Vector Error Correction Model), Table 6b: is Bulir (2003)'s Error Correction Model with Smuggling Incentive (VEC) Table 6c: is the results of the hybrid Vector Error Correction Model (HECM)

Table 6 VARIABLES	Error Correction Models EQUATION 1 (A&R) 6a	EQUATION 2 (Bulir Ales) 6b	EQUATION 3 (HYBRID) 6c
Short Run Dynamics			
GHCPL, 1st DIFF	-0.07	0.09*	**0.09***
SMUG, 1st DIFF		-0.006	**0.005***
GDRPML, 1st DIFF	0.12		**0.01**
Error Correction Term	0.18	0.42*	**0.42***
Long-Run Eqm Relationship			
DINTCPL, 1st Lag		0.15	**0.09**
GDRPML, 1st Lag	-0.16*		**-0.005**
SMUG, 1st Lag		-0.0008	**-0.006***
GHCPL, 1st Lag	0.14*		
Durbin Watson			**2.1**
R^2	0.3		**0.96**
Prob > F			**0**
rho			**0.78**
*Significant at 5% Level	**Significant at 1%	***Significant at 10*	
Source:	Author's Calcuation		

Table 6a1 A&W VARIABLES	*Stationarity* **Test Statisitc**	*Tests* **1% Crit Value**	**5% Crit Value**	**MODEL**
Error Correction Term	-3.7	-4.38	-3.6	NC NT L2
Conclusion		***Stationary***		

Table 6b1 Bulir VARIABLES	*Stationarity* **Test Statisitc**	*Tests* **1% Crit Value**	**5% Crit Value**	**MODEL**
Error Correction Term	4	-4.38	-3.6	NC NT L2
Conclusion		***Stationary***		

Table 6c1 HYBRID VARIABLES	*Stationarity* **Test Statisitc**	*Tests* **1% Crit Value**	**5% Crit Value**	**MODEL**
Error Correction Term	-3.95	-4.38	-3.6	NC NT L2
Conclusion		***Stationary***		

Table 7: Johansen's Trace Test of Co-Integration

MODEL I VARIABLES	GSUP GHCPL SMUG DINTCPL GDRPML	
GSUP, DINTCPL, GDRPML, SMUG	H_o:Rank=# of Co-integrating Vectors	2 Lags
Johansen's Trace	Test For # of Co-Integration Vectors	
Rank	**$\lambda_{trace=}$T ∑ (sum over i, i = r+1 to n) log (1-λi)**	$\lambda_{critical}$
0	66.14	47.21
1	37.3	29.68
2	19.17	15.41
3	6.04	3.76
Accept Null: 4	2	2.9
5		

Table 8: VECM:1977-2004 with 1 Lag	**Unrestrictd Consant, No trend**
VARIABLES	
Short Run Dynamics	
DINTCPL	-481909
GHCPL, 1st DIFF	401605.3*
SMUG, 1st DIFF	-41945.13 *
GSUP, 1st Diff	1*
GDRPML, 1st DIFF	459809.5
Error Correction Term	
Long-Run Eqm Relationship	
DINTCPL, 1st Lag	-43664
GDRPML, 1st Lag	0
SMUG, 1st Lag	-6516.9*
GHCPL, 1st Lag	-87078
GSUP, 1st Diff, 1st Lag	-0.23*
*Significant at 5% Level	

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